REPORT OF THE

50th NATIONAL CONFERENCE ON WEIGHTS AND MEASURES 1965

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

MISCELLANEOUS PUBLICATION 272

THE NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards is a principal focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. Its responsibilities include development and maintenance of the national standards of measurement, and the provisions of means for making measurements consistent with those standards; determination of physical constants and properties of materials; development of methods for testing materials, mechanisms, and structures, and making such tests as may be necessary, particularly for government agencies; cooperation in the establishment of standard practices for incorporation in codes and specifications; advisory service to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; assistance to industry, business, and consumers in the development and acceptance of commercial standards and simplified trade practice recommendations; administration of programs in cooperation with United States business groups and standards organizations for the development of international standards of practice; and maintenance of a clearinghouse for the collection and dissemination of scientific, technical, and engineering information. The scope of the Bureau's activities is suggested in the following listing of its three Institutes and their organizational units.

Institute for Basic Standards. Applied Mathematics. Electricity. Metrology. Mechanics. Heat. Atomic Physics. Physical Chemistry. Laboratory Astrophysics.* Radiation Physics. Radio Standards Laboratory:* Radio Standards Physics; Radio Standards Engineering. Office of Standard Reference Data.

Institute for Materials Research. Analytical Chemistry. Polymers. Metallurgy. Inorganic Materials. Reactor Radiations. Cryogenics.* Materials Evaluation Laboratory. Office of Standard Reference Materials.

Institute for Applied Technology. Building Research. Information Technology. Performance Test Development. Electronic Instrumentation. Textile and Apparel Technology Center. Technical Analysis. Office of Weights and Measures. Office of Engineering Standards. Office of Invention and Innovation. Office of Technical Resources. Clearinghouse for Federal Scientific and Technical Information.**

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*Located at Boulder, Colorado, 80301.

**Located at 5285 Port Royal Road, Springfield, Virginia, 22171.

Report of the 50th National Conference on Weights and Measures 1965

Sponsored by the National Bureau of Standards
Attended by Officials From the Various
States, Counties, and Cities, and
Representatives From U.S. Government,
Industry, and Consumer Organizations
Washington, D.C., June 21, 22, 23, 24, 25, 1965.

Report Editor: L. J. Chisholm

United States Department of Commerce
John T. Connor, Secretary

National Bureau of Standards
A. V. Astin, Director

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REPORTS OF STANDING COMMITTEES:

REPORTS OF ANNUAL COMMITTEES:

OFFICERS AND COMMITTEES

OFFICERS

(As elected by the Forty-Ninth National Conference to serve during the Fiftieth)

President: A. V. Astin, Director, National Bureau of Standards. Executive Secretary: M. W. Jensen, Chief Office of Weights and Measures, National Bureau of Standards.	*Ex officio*

Chairman: V. D. Campbell, Chief, Division of Weights and Measures, Department of Agriculture, State of Ohio.

Vice Chairmen:

- L. Barker, Commissioner, Department of Labor, State of West Virginia.
- J. E. Bowen, City Sealer of Weights and Measures, Newton Centre, Massachusetts.
- J. H. Lewis, Chief, Weights and Measures Section, Department of Agriculture, State of Washington.
- W. I. Thompson, County Superintendent of Weights and Measures, Monmouth County, New Jersey.

Treasurer: C. C. Morgan, City Sealer of Weights and Measures, Gary, Indiana.

Chaplain: R. W. Searles, Deputy County Sealer of Weights and Measures, Medina County, Ohio.

OFFICERS

(As elected by the Fiftieth National Conference to serve during the Fifty-First)

A. V. Astin, *President* M. W. Jensen, *Executive Secretary*	*Ex officio*

J. F. True of Kansas, *Chairman*
E. H. Black of California, *Vice Chairman*
L. L. Elliott of Massachusetts, *Vice Chairman*
M. Jennings of Tennessee, *Vice Chairman*
J. L. Littlefield of Michigan, *Vice Chairman*
C. C. Morgan of Indiana, *Treasurer*
R. W. Searles of Ohio, *Chaplain*

EXECUTIVE COMMITTEE

(As elected by the Fiftieth National Conference)

A. V. Astin M. W. Jensen J. F. True E. H. Black L. L. Elliott M. Jennings J. L. Littlefield C. C. Morgan R. W. Searles	*Ex officio*

A. J. Albanese of Connecticut.
L. A. Gredy of Indiana.
J. G. Gustafson of Minnesota.
M. L. Kinlaw of North Carolina.
R. K. Sharp of Oklahoma.
F. F. Thompson of Louisiana.
L. W. Vezina of Virginia.
A. W. Weidner, Jr. of New York.
W. W. Wells of the District of Columbia.
E. C. Westwood of Utah.

STANDING COMMITTEES

(As constituted at the conclusion of the Fiftieth National Conference, the personnel of each of the standing committees are as listed. The remaining term of office for each committee member, in years, is shown in parentheses following each entry.)

EDUCATION*

S. H. Christie, Jr. of New Jersey, Chairman (2).
J. T. Daniell of Michigan (1).
L. A. Gredy of Indiana (3).
A. D. Rose of California (4).
J. F. Madden of New York (5).

LAWS AND REGULATIONS*

L. Barker of West Virginia, Chairman (3).
J. L. Littlefield of Michigan (1).
M. Jennings of Tennessee (2).
H. L. Goforth of Illinois (4).
J. F. Lyles of Virginia (5).

SPECIFICATIONS AND TOLERANCES*

G. L. Johnson of Kentucky, Chairman (2).
H. J. McDade of California (1).
J. F. McCarthy of Massachusetts (3).
H. D. Robinson of Maine (4).
C. H. Stender of South Carolina (5).

COMMITTEES ACTING ONLY DURING THE FIFTIETH ANNUAL CONFERENCE

Nominations: D. M. Turnbull of Washington, *Chairman;* H. E. Crawford of Florida; R. E. Meek of Indiana; J. I. Moore of North Carolina; H. D. Robinson of Maine; C. H. Stender of South Carolina; R. Williams of New York.

Resolutions: G. L. Johnson of Kentucky, *Chairman;* E. W. Ballentine of South Carolina; P. DeVries of New Jersey; H. P. Hutchinson of the District of Columbia; C. L. Jackson of Wisconsin; H. E. Sandel of California; R. K. Slough of Ohio.

Auditing: A. L. Little of Arkansas, *Chairman;* I. R. Frazer of Indiana; N. P. Tilleman of Wisconsin.

* M. W. Jensen, Executive Secretary of the Conference, is *ex officio* nonvoting secretary to each committee.

COMMITTEE MEETINGS, MONDAY, JUNE 21, 1965

All day Monday was set aside for meetings, both open and executive, of the Conference committees. Announcements of these meetings were carried in the National Conference Announcement and in the Conference Program.

The Conference committees that met on Monday morning were the Executive Committee and the Committee on Laws and Regulations. The Committee on Education and the Committee on Specifications and Tolerances met on Monday afternoon.

All final reports of the Standing and Annual Committees can be found beginning on page 178.

Dr. A. V. Astin, Director of the National Bureau of Standards and President of the Conference, addressed the delegates and then cut the ribbon to open the Exposition.

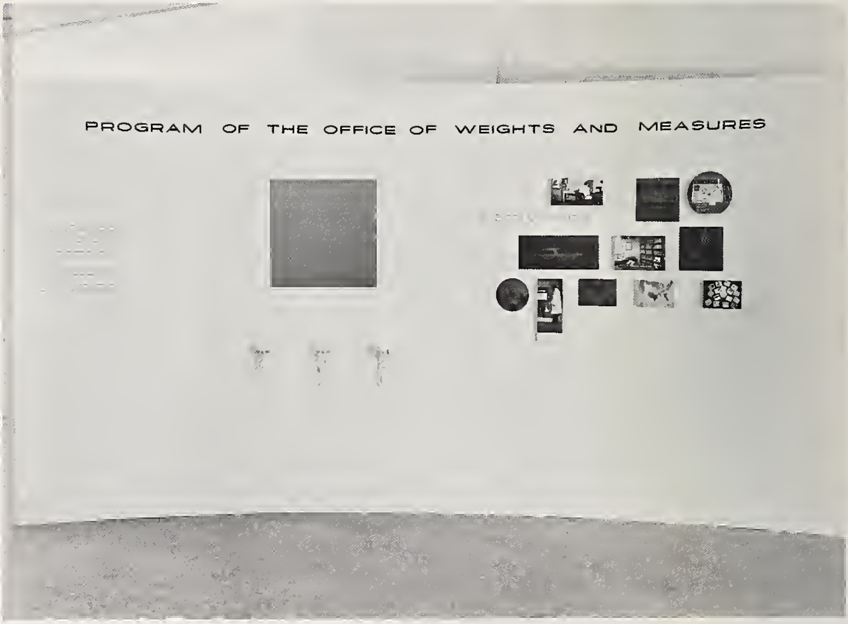
Views of the NBS Exhibit.

Exhibit Entrance.

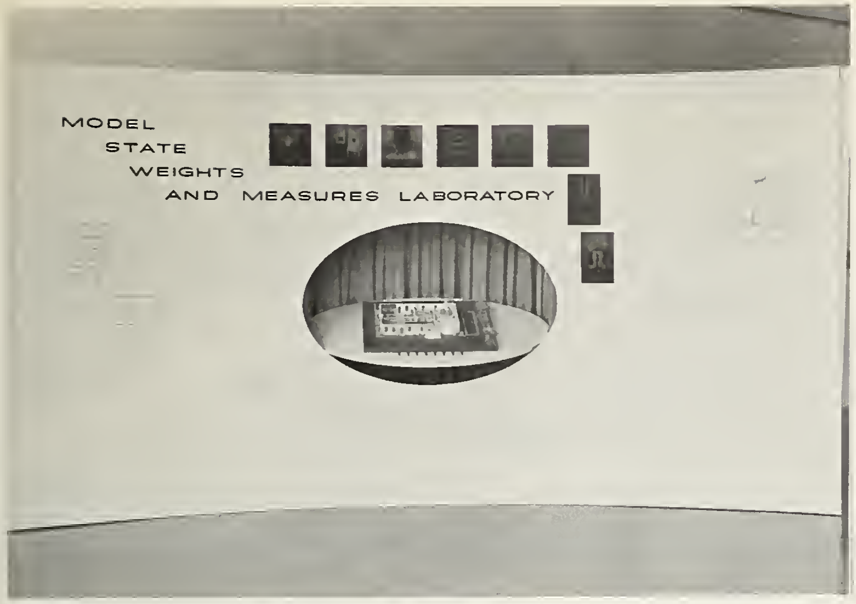
Center area of NBS Exhibit is graced by Evelyn Meyer, designer of the exhibit.

Views of the NBS Exhibit.

International (Metric) System Historical Display.



The OWM program pictured and explained through earphones.



Recommended to the States: A Model Laboratory and its accessory equipment.

A mural of weights and measures history, from caveman to contemporary times.

LIST OF EXHIBITORS

Company

Aero Chatillon Corp.
Wm. Ainsworth & Sons, Inc.
American Meter Controls, Inc.
American Petroleum Institute
Arenco Machine Company, Inc.
Cardinal Scale Manufacturing Co.
Cereal Institute, Inc.
Chemical Specialties Manufacturers Assn.
The Coca-Cola Co.
Dairy Industry Committee
Detecto Scales, Inc.
Encyclopedia Britannica
The Exact Weight Scale Co.
Fairbanks Morse Weighing Systems Division
H. J. Fuller & Sons, Inc.
Gilbert & Barker Mfg. Co.
Glass Container Manufacturers Institute, Inc.
W. & L. E. Gurley
Halmor Services, Inc.
Hi-Speed Checkweigher Co., Inc.
The Hobart Mfg. Co.
Howe-Richardson Scale Co.
Kaleel-Martin, Inc.
Liqui-Box Corp.
Liquid Controls Corp.
Lockheed Electronics Co.
The Lufkin Rule Co.
Martin-Decker Corp.
The Measuregraph Co.
Mettler Instrument Corp.
Millers' National Federation
Edward G. Moody & Son, Inc.
National Confectioners Assn.
Neptune Meter Co.
Ohaus Scale Corp.
Paper Cup and Container Institute
Penn Scale Mfg. Co., Inc.
Society of the Plastics Industry Inc.
Potter Aeronautical Corp.
The Procter & Gamble Co.
Rockwell Mfg. Co.
Sanitary Scale Co.

Company

Sartorius Balance Division
Brinkmann Instruments, Inc.
August Sauter, Inc.
Scientific Glass Apparatus Co., Inc.
Seraphin Test Measure Co.
A. O. Smith Corp.
Spinks Scale Co.
Streeter Amet Division
Goodman Mfg. Co.
Sun Oil Co.
Swab Wagon Co., Inc.
Thurman Mfg. Co.
Tokheim Corp.
Toledo Scale Division
The Torsion Balance Co.
Henry Troemner, Inc.
U.S. Slicing Machine Co., Inc.
Veeder-Root, Inc.
Voland Corp.
The Wayne Pump Co.
Symington Wayne Corp.
John Wood Co.
Bennett Pump Division

State Governments

Maryland
Southern Weights and Measures Assn.
Wisconsin

Federal Government

U.S. Department of Agriculture
Meat Inspection Service
Milk Marketing Orders
Packers and Stockyards
Poultry Division
U.S. Department of Commerce
National Bureau of Standards
U.S. Department of Health, Education, and Welfare
Food and Drug Administration
U.S. Post Office Department

Canadian Government

Department of Trade and Commerce
Standards Branch

REPORT OF THE FIFTIETH NATIONAL CONFERENCE ON WEIGHTS AND MEASURES

AFTERNOON SESSION—TUESDAY, JUNE 22, 1965

(V. D. CAMPBELL, CHAIRMAN, PRESIDING)

The invocation was delivered and the memorial service for departed members was conducted by the Conference Chaplain, Rev. R. W. Searles of Ohio.

Mr. J. F. True of Kansas led the delegates in the Pledge of Allegiance.

ADDRESS

by JOHN T. CONNOR, *Secretary of Commerce, U.S. Department of Commerce*

Dr. Astin, Ladies and Gentlemen, I am delighted at my first opportunity to address this Conference, which coincides with its 50th Anniversary. I welcome you to Washington most cordially. It is my privilege to bring you the following message from the President of the United States:

> It gives me a great deal of satisfaction to send my congratulations to the Golden Anniversary, National Conference on Weights and Measures.
>
> Weights and measures administration in the United States, as represented by the local, State, and Federal officials gathered here, is one of the finest examples of the creative Federal system we are trying to foster. It is an eloquent proof of the vitality and effectiveness we can achieve in any program when we utilize the full talents and capabilities of all levels of government. Through this constructive partnership, we maintain a uniformity of weights and measures, the language of trade and commerce, which has been and will continue to be a bulwark of our country's economic growth.
>
> For many years the main meeting ground for all those engaged in weights and measures administration has been this National Conference. Your energy and dedication have resulted in significant contributions to the welfare of the American public.

I would like to elaborate on the President's theme, for I consider it one of the most significant concepts of our time.

No one has expressed more forcefully than President Johnson that building a great American society depends upon the wholehearted cooperation of all its components—the national, State and local governments, the business community, labor, the academic world, professional societies, and the other groupings of our people.

While the spirit of cooperation for mutual benefit has been a powerful force for progress since the beginning of our country, many do not realize its full significance, and too often there has been bickering among groups over who was contributing most to the advancement of our national welfare. I think today there is a growing recognition that human society can attain true maturity and well-being only when we all cooperate in its development, and that this cannot be achieved by any one group in a spirit of belligerent isolation.

There is no place for segmented thinking in this day of universal problems and universal concern. The success of our society depends upon its pluralism, the fact that decisions are made and policies are set as close as possible to the source, and by a great many people, rather than by monolithic government from above. The system works as a coordinated whole through consensus and compromise, and through checks and balances. It derives its vitality from the encouragement of individual initiative. Moreover, there are things that the National Government can do best, things that State and local governments can do best, things that private industry can do best, and things that are done best by a cooperative effort of two or more segments.

History gives us an appreciation of the extent to which cooperation has propelled the rise of the American system. When the United States was primarily a maritime nation, the Government helped the private sector by providing navigational aids, coastal service, and rescue forces. Government dredged the channels, deepened ports, and developed port facilities. When the Nation spread across the continent, the Government helped by supporting the development of transportation systems, canals, pikes, railroads, shipping, highways, and, more recently, air transport. The more advanced and costly the systems, the larger the role the Government had to take. We can see this now in our effort to conquer space.

The Federal contribution to the extraordinary efficiency and productivity of our farms is well known to all of us. Less than 7 percent of our labor force now produces at low cost and in great abundance the variety of all the foods and agricultural products consumed by the rest of us.

Today, we live in a very complex society. Its needs are complex, and so are the patterns of interaction and cooperation among all the groups making up that society. The growing interdependency of these groups upon each other is greater than many realize and more crucial to our progress than many appreciate. Let us take some of the programs and activities of the U.S. Department of Commerce to illustrate the point.

Weights and measures are a good place to start. As the President indicated, unlike the centralized system in most other nations, enforcement of weights and measures statutes in our country resides in the several States, with the National Government providing the necessary technical support to assure uniformity and compatibility across the Nation, as well as a high degree of accuracy and dependability. This mutually beneficial cooperation, epitomized by this 50th National Conference, has helped provide the American people with the most advanced economy in all the world.

Transportation is another good example. The Department's Bureau of Public Roads works with the States in the development of a national network of roads, in highway research, and in the promotion of safety.

Significant also is the research and development work going on in the Office of the Under Secretary of Commerce for Transportation. This Office is the focal point for relating transportation to broad economic and social objectives. It advises me in all transportation matters and makes recommendations to other Government agencies. This office is stepping up its investigation of ways to improve highspeed rail transportation in heavily congested areas, such as, the Northeast Corridor that goes along the coast from Maine to Virginia.

We hope to conduct demonstration projects which will show new potentials in mass transit. Again, this will involve cooperation among the Federal and State governments, private industry, and many other groups.

Probably our best known cooperative endeavor in business matters at the local level is the work of the Department's 42 local offices, the so-called "Windows on Main Street." Each is a microcosm of the Department of Commerce that actively cooperates with industry and local governments in the solution of regional and local economic problems. More than six hundred Chambers of Commerce, Boards of Trade, and similar business groups join with these field offices in servicing and providing necessary information to businessmen.

The National Bureau of Standards, of course, has a very special interest for you. This again is an excellent example of the advantages to be gained through cooperative effort. You are already familiar with the benefits in the weights and measures field. The Bureau works closely with standards laboratories all over the United States, with industrial and other governmental laboratories, to make sure that the national measurement system is always adequate to the Nation's needs and that it is being used most effectively by science and industry.

There are literally tens of thousands of standards used in our vast mass production economy, in scientific laboratories, industry, and universities, and in space and defense projects. All these standards owe their validity to the few dozen ultra precise, national, agreed-upon standards developed and maintained by the Bureau of Standards. In turn, our industry, our commerce, our national programs, all of which are ever increasingly dependent on science and technology, depend upon an accurate measurement system.

A very important cooperative program at the National Bureau of Standards is the new Clearinghouse for Federal Scientific and Technical Information. The Clearinghouse is the central source for Federally supported and sponsored research and development reports. In cooperation with other Federal agencies, the Clearinghouse in the fiscal year 1966 will gather, index, and publicize some 70,000 technical reports. In a special effort to insure the most effective dissemination to industry, the Clearinghouse material is put into subject-matter packages—on metallurgy, for example—and distributed through State economic development agencies in States where the particular field is of economic importance. This program promotes full use in the private sector of technical work done with public funds. This is particularly valuable to small business, which is trying to make its way in an economic environment dominated more and more by increasingly complex and expensive science and technology.

There are two more programs I would like to discuss just briefly. The first is the proposed State Technical Services Act of 1965, which is sponsored by the Department of Commerce. The proposed legislation is being considered by the Congress now. This measure would enable the Federal Government to make grants to States in support of programs to make better commercial use of the latest findings of science and technology. These programs, planned and carried out locally, would place the findings in the hands of local business and industry.

The technical services would include such things as identifying new opportunities to apply technology to the advancement of regions and industries, and preparing and disseminating scientific or engineering information to facilitate its use.

To qualify for Federal matching funds, a State would designate an institution or agency responsible for that State's technical services program. When two or more States join in a cooperative program, they may designate a regional institution.

Free industrial competition is our main resource in this country. Our effort must be to raise the level of industrial technology overall. We especially need to locate and adapt and use existing technology, and to facilitate increased application of all technological advances.

The problem is a local one in two senses. First, in order to make it possible for groups of companies to apply new technology, one must know the special problems and needs of the particular location. What makes sense in New England may not necessarily be sensible for the Pacific Northwest, for example. Second, the best contributions will be made by those closest to the problems the program is designed to solve. The most effective transfer of technology will be made at the local level by people capable of working continuously on that local problem. It follows that the program should be mainly a local one, based on local institutions and local initiative.

As one last example of cooperation, I would like to mention my recent experience with the President's voluntary balance of payments program. This has been a most gratifying undertaking for me, because I have never seen a better example of business cooperation with government in a project of national importance.

As you know, the imbalances in our international payments have been a matter of serious concern for some years now. Our Government has taken several important steps to reduce the deficit—a drive to increase exports, a campaign promoting travel to the United States from abroad, rigid control of governmental overseas expenditures, etc. Business, of course, makes a major contribution to a solution of the problem through its vastly increased exports, but we needed additional help and many firms operating in the international economy, both large and small, are now cooperating in the President's voluntary program by stepping up exports and in various other ways increasing capital inflows to this country.

With the help of the business community, we are going to win the battle of the dollar, and it will be a victory for all Americans, because continued domestic economic growth, with increased job opportunities for our growing work force, depends on the sound dollar.

As an alumnus of the business community, I am mighty proud of my alma mater's performance in this vital national program.

One final word, and this is on the overriding issue of our time—a peaceful world in which all nations are free to develop according to their own desires without interference.

Every nation, large or small, powerful or weak, has a stake in this vital principle of self-determination. Every violation of this principle is a threat to the independence of all nations. It is a threat to their security individually and collectively, and it is a threat to world peace.

In Viet-Nam and the Dominican Republic, President Johnson seeks to preserve the principle of independence and to stay the threat of any world war. Peace is our aim. A settlement of differences around the conference table is our hope. Again and again, President Johnson has said that he will go anywhere, at any time, do anything, see anybody, if it will promote the cause of peace. He has repeated many times that the United States will negotiate with any government in order to try to resolve the issues of Viet-Nam. So far he has met many rebuffs but his hope has never flagged, because he is committed to peace, unconditionally and without reservation. And, in the meantime, if we do not uphold our treaty obligations in Southeast Asia, who will have confidence that we will uphold our treaty commitments in Berlin?

I hope all Americans will support our President as he bears these heavy burdens, not only for our country but for free nations and for free men everywhere in the world.

ADDRESS OF THE CONFERENCE PRESIDENT AND APPOINTMENTS TO STANDING COMMITTEES

by A. V. ASTIN, *Director, National Bureau of Standards*

Mr. Secretary, Ladies and Gentlemen, I am very pleased to have the opportunity to be here today and, as President of the National Conference on Weights and Measures, I am most gratified by the compliments and good wishes we have received here today from President Johnson and Secretary Connor. As Director of the National Bureau of Standards, which has been so closely associated with this Conference, I wish to add my personal congratulations for this milestone in your history, but also, and even more important, for your fine record of achievement in the service of the public and our Nation's economy.

I have also received some additional congratulations. Two Governors have seen fit to recognize this event. The Governor of Florida, Mr. Haydon Burns, writes as follows:

> Since I am unable to attend the National Conference on Weights and Measures, I am taking this means of extending to you and to your membership generally my most cordial greetings. I am thoroughly cognizant of the exceptional service rendered to the people of our various States and communities by the members of the Conference. Your fifty years of service merits the approval and appreciation of our citizens throughout these United States.
>
> It is my hope that this Golden Anniversary Conference will prove to be the most rewarding and pleasant meeting ever held.
>
> Sincerely,
>
> HAYDON BURNS.

Then from the Governor of South Carolina:

> On behalf of the people of South Carolina, we offer our congratulations to the National Conference on Weights and Measures on the occasion of your Golden Anniversary Conference. We are aware that South Carolina's long affiliation with the Conference has been reflected in the sound and progressive program of weights and measures in our State. Fifty years of service and equity to the agriculture, commerce, and industry is an outstanding accomplishment. Please accept our best wishes for continued progress in promoting the protection of the producer, the distributor, and the consumer.
>
> Sincerely,
>
> DONALD S. RUSSELL.

Then a final greeting comes from the Commissioner of Agriculture of the State of South Carolina. He says in part:

> On behalf of the South Carolina Department of Agriculture, I extend to the National Conference on Weights and Measures our gratitude for the constructive influence the continuing conferences have contributed to the uniformity of this department's administration of weights and measures laws and regulations. May this 50th Conference induce a rededication to the motto that equity may prevail. Congratulations and all best wishes to the Conference.
>
> Sincerely,
>
> WILLIAM L. HARRELSON.

As this year 1965 is a milestone in the history of the Conference, so it is also in the history of the National Bureau of Standards. It has been my custom each year to give you a brief report of what has been happening at NBS, and I would like for the remainder of my talk to continue that practice of reporting briefly of things of importance to NBS.

During the coming year, most of our staff in the Washington laboratories will move to our new Gaithersburg, Maryland, facilities. Although the schedule has been somewhat delayed, we do quite confidently expect to be about 90 percent moved a year from now. Coincident with this move, the NBS history will be published. In a sense, the history will sum up the first phase of the Bureau's life, that which ends with our vacating the Connecticut Avenue home we have occupied for more than 60 years.

But, in a far less concrete yet far more crucial sense, NBS has reached another sort of milestone at the time of this 50th Conference. It may be a while yet before any of us can appreciate its full importance. I refer to a major increase in central responsibilities assigned to the National Bureau of Standards.

Each year, it seems, I have had occasion to mention to you the growing responsibilities of NBS. The rapid growth of our country's scientific and technological activity alone has increased the Bureau's load manyfold. In addition, the Administration has assigned us many new responsibilities that are related to our special competence. Among these are:

First, to serve as the focal point within the Federal Government for stimulating the application of science and technology to the economy. In an age when science and technology have replaced natural resources as the fountainhead of national strength and economic growth, this is an important and all-embracing task.

Next, to set up and operate the National Standard Reference Data System. This is a long-needed attack on a very serious problem. The proliferation of scientific data in many fields of science has been a major roadblock to technological and industrial progress. NBS has been assigned the task of directing this centralized collection, evaluation, organization, and distribution of standard reference data. In addition to being an important task, it is an extremely formidable one.

Next, we are asked to establish and expand the Clearinghouse for Federal Scientific and Technical Information. Here, the product we handle is not data so much as research and development documents, the entire unclassified output of the considerable Federal scientific and technological complex. To do the job effectively and economically, this mass of information must be indexed and packaged for ready use by industry. Other related projects need to be done to keep industry abreast of current technological developments.

Next, we are asked to assume central responsibility for the Government's interests in engineering and commodity standards. Here we provide the technical base for performance criteria of the goods and services produced by industry. This activity is crucial to both domestic and international commerce.

We are asked next to set up and operate a central technical analysis service to conduct cost-benefit studies for our own and other Federal agencies. In this field we can make a real contribution to efficiency and economy in Government operations.

Another assignment is to establish a central and major Government resource in the automatic data processing field. Under this heading, we will be providing the technical base for standardization in automatic computers and in developing ways of using computers for new tasks and for using them more efficiently on old tasks. Here again we have an opportunity to return to the taxpayer, in the form of increased Government efficiency and effectiveness, many times the tax moneys invested.

Our Central Radio Propagation Laboratory in Boulder, Colorado, has also been given additional responsibilities. It has been asked to provide the Nation with space environment information and prediction services and to extend its support to the Nation's telecommunications industry to cover the infrared and optical portions of the electromagnetic spectrum. On the other hand, this important part of NBS is now scheduled to become a key component of a new agency, a proposed Environmental Science Services Administration. The proposed new agency was announced in the President's Reorganization Plan No. 2, consideration of which is now pending before the Congress. If the plan comes into effect, the National Bureau of Standards will once again have made a major contribution in the creation of a new scientific agency.

We have been asked to shoulder all these jobs in addition to our traditional measurement and measurement standards responsibilities. And all the while, measurement responsibilities have grown apace. We have demands for increased accuracy of measurements, increased range of measurements, and attendant increasing demands on our various measurement services—calibration, testing, and standard materials.

The Nation's scientific and technical capability depends in large part on the capability of the national measurement system. In a literal sense, measurement is the pacemaker of progress. In this age of science and technology, more and more of our activities depend upon the work of the scientist and the engineer. This applies to economic activities no less than to the glamorous advances in space and defense programs.

Other nations of the world are harnessing the power of science and technology, so much so that the lead we once enjoyed is being narrowed, more so in some instances than others. If we are to maintain our world position, we will have to expand our science and technology. And if we wish to expand our science and technology, we must have a national measurement system that is not just adequate to our needs but that unleashes our full potential for technological growth.

To maintain a proper balance between our resources and our responsibilities is particularly crucial this year, because of the coincidence of added responsibilities and added demands on the national measurement system.

We seek to maintain a proper balance in a number of ways. One means is to put ourselves out of some types of business, strange as that sounds. At every opportunity, we turn over to private industry or other laboratories, calibration functions, production of standard reference materials, any tasks which we feel others can handle and which, therefore, no longer need the unique capabilities of NBS.

One of the main purposes of our measurement research is to provide laboratories with the capability for self-calibration so that they are no longer directly dependent on us. We believe that the new standards which we hope the Congress will permit us to provide for the States will facilitate such decentralization. In addition, we are working toward a broader based measurement capability by seeking to make available independently reproducible standards—like the wavelength standard of length—through standard reference materials and through standard reference data.

These efforts to spread the measurement workload around help but do not solve the problem. Thus, it has become necessary for NBS management to take harder and harder looks at our programs to make certain that current efforts match current needs, rearranging both in order of priority, and then choosing the programs that survive and those that do not. The choice is becoming more and more painful.

Of encouraging interest with respect to the proposed new standards for the States, the House of Representatives has approved an appropriation of $400,000 to begin constructing the new sets of State standard weights and measures. I am sure all of you are familiar with this project, since it was urged upon us by this Conference. In any case, you will hear about it further in detail during the report of the National Bureau of Standards Office of Weights and Measures tomorrow morning. This appropriation, if sustained by the Senate, will enable us to prepare the first ten sets of standards, with the rest to be completed as funds permit in succeeding years.

Since I spoke to you last, in October to be more exact, I attended the Twelfth General Conference on Weights and Measures in Paris. Probably the most important action taken at that meeting was the adoption of a provisional redefinition of the second, the unit of time, in terms of an invariant transition of the cesium atom. The definition was made a temporary one, in anticipation of a more exact definition in the future.

In addition to revising the second's definition, the Conference adopted 12 new secondary standards of wavelength. Four wavelengths from each of the spectra of krypton 86, mercury 198, and cadmium 114 were affirmed.

The Conference also abrogated the old definition of the liter and designated it as being only a special name for the cubic decimeter. The resolution in which this action was taken, however, pointed out that the word "liter" should not be used to express the results of volume measurements of high precision.

The liter, when defined as the volume occupied by one kilogram of water, differed from a cubic decimeter by about 28 millionths, and this discrepancy—slightly out of line with other international measurements—frequently caused difficulty in precision work.

In another resolution, the Conference gave formal recognition to the curie, which has been used as the unit of activity of radioactive substances in a great many countries for a long time.

While at the meeting, I participated in the dedication of a new international radiation measurements laboratory on the outskirts of Paris. This new facility is a significant addition to the International Bureau of Weights and Measures, supported by the member nations. The laboratory will promote the standardization of measurement techniques for ionizing radiations for medical, industrial, and scientific purposes on a worldwide scale.

Now to return home. I would like to mention a few items of progress at NBS in several fields of measurement during the past year.

Our Metrology Division has developed a new weighing technique for very large weights which should save government and industry millions of dollars in the next few years. The new technique is called elastic weighing and makes use of a load cell as a comparator. It makes possible more rapid weighings of weights in the range of a few hundred pounds up to 10,000 pounds or greater with lower-cost, commercially available equipment.

Also, our metrology experts have performed the first practical length measurements using as a measurement tool the light emitted by a laser. The laser was incorporated into a device previously developed for automatically checking gage blocks against a wavelength of light, and it gave improved performance over other light sources which have been used.

We have developed a new method for measuring the power output of pulsed lasers. Development of the laser as a useful tool, particularly in very delicate applications like microwelding and surgery, is dependent on precise measurement and control of the power output.

Beginning on January 1, 1965, our radio station WWVB began broadcasting the new international standard atomic second. These WWVB broadcasts will enable us to study the problems of distributing atomic time and of maintaining the relationships between atomic time and other time scales.

We have initiated some new calibration services, for example, humidity measuring instruments and germanium resistance thermometers which measure in the range of 2 to 5 degrees above absolute zero. In addition, we have extended our vacuum calibrations down to about 1/760,000 of atmospheric pressure. Pressures in this range must be measured in such industrial processes as preparation of vacuum-melt steel and the freeze drying of food.

Time does not permit me to go very far in reviewing such accomplishments. I have chosen a few typical examples which I thought would be of specific interest to you.

Before closing my report, I would like to announce appointments to the Standing Committees of the Conference. At the present time, we have three standing committees, one on Education, one on Laws and Regulations, and one on Specifications and Tolerances.

To the Committee on Education, I am appointing John F. Madden, of the State of New York, to succeed Carl H. Stender, of the State of South Carolina, who has completed his term on that committee.

To the Committee on Laws and Regulations, I am appointing J. F. Lyles, of the State of Virginia, to succeed J. H. Lewis, of the State of Washington.

To the Committee on Specifications and Tolerances, I am taking advantage of Mr. Stender's release from one committee and appointing him to this committee to succeed R. E. Meek, of the State of Indiana.

I would like to express my sincere thanks to the members who are leaving these committees for their very valuable contributions to the work of the Conference. In addition, I would like to express my thanks to the members of all of the Conference committees, the annual committees as well as the standing committees, for their efforts to make this Conference a success and, in addition, to the members of our own staff, particularly to Mac Jensen, head of our Office of Weights and Measures and Secretary of the Conference, and his immediate associates for their valiant efforts on this 50th National Conference.

This closes my report to the Conference, and I express my thanks to you for letting me share in this Golden Anniversary celebration.

PRESENTATION OF HONOR AWARDS

Dr. Astin presented Honor Awards to members of the Conference who, by attending the 49th Conference in 1964, reached one of the four attendance categories for which recognition is made—attendance at 10, 15, 20, and 25 meetings.

AWARD RECIPIENTS

25 Years

R. Williams

20 Years

E. R. Fisher

15 Years

H. L. Badger
G. L. Johnson
B. D. Miller
J. I. Moore
M. Rapp
W. A. Scheurer
C. J. Wills, Jr.

10 Years

A. T. Anderson
H. N. Duff
J. W. D. Harvey
K. G. Hayden
J. M. Hudgins
C. L. Jackson
E. P. Nedrow
L. T. Reagan
W. H. Schneidewind
R. J. Silcock
R. N. Smith
N. P. Tilleman
H. F. Wollin

A NEW PROGRAM FOR TESTING POSTAL SCALES

by A. J. COFFMAN, *Deputy Assistant Postmaster General, Bureau of Facilities, U.S. Post Office Department*

As a representative of the Postal Service, I can begin by assuring you that we are very much interested, concerned, and affected by the deliberations of these Conferences.

For over 5,000 years, humans have weighed and measured articles in buying and selling. As civilization progressed and commerce expanded between people and nations, systems were developed and basic standards of weights and measures were determined and promulgated by laws. Governmental and quasi-governmental organizations have been brought into being in order to develop standards and to maintain and enforce the codes relating to these standards.

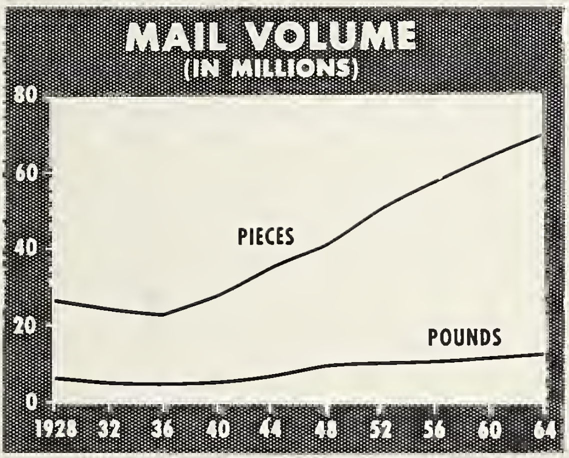
Conferences such as this have become invaluable in the solving of new problems concerning weights and measures caused by the advent of new procedures and technology, procedures that constantly develop as economic intercourse becomes more specialized and complicated.

The United States Post Office Department is the world's largest business receiving revenue based on the weight of materials handled. I can assure you that all of our employees are aware of the importance of accuracy and tolerances as related to weighing devices.

As you know, articles sent through the mail, from a post card to a seventy-pound package, are handled on the basis of postage rates established by law as to weight. There are only three rates charged in the postal services which are not based on weight. These services are: (1) Registered Mail—the rate is based on the value of the item being mailed; (2) Insurance—again the rate is based on the value of the mailed matter; (3) Postal Money Orders—based on the value of the money order.

Mail volume handled by your Post Office Department during fiscal year 1964 reached the unprecedented total of 69.7 billion pieces of mail. This represents 365 pieces of mail during the year for each man, woman, and child in the United States. One piece of mail each day of the year for each person in the country. The gross weight of this mail handled in fiscal year 1964 was 12.2 billion pounds. This volume, both by piece and by pound, is increasing annually.

Figure 1 portrays, in four-year increments, volume growth since 1928. Postage rates for mail are based either on weight or weight and distance. 89.96 percent of all postal revenues in fiscal year 1964 were based on weight alone. Another 8.5 percent was based on the combination of weight and distance. Therefore, 98.6 percent of all postal rates charged were based on the weight of the individual piece of mail being handled by the Post Office Department.



The weight of the item mailed is determined by weighing devices that are numerous and of varied construction. These numerous weighing devices have been developed by industry over the years to meet varied specialized requirements of the Postal Service. Scales have been manufactured of many types, styles, and in many price ranges. The smaller and less complex scales do not indicate all postage rates and must be used in conjunction with a postage rate chart to determine charges. The larger, more expensive scales are equipped with charts to automatically compute mail and parcel post rates.

Postal scales now in service used for the weighing of patron mail include automatic-indicating spring, beam, automatic-indicating fan, cylinder, and pendulum types. They may be computing or noncomputing. Capacities range from nine ounces to four pounds for letters and small parcels, and up to one hundred pounds for parcels.

Chart 1 is a very simplified organization chart depicting major responsibilities within the Post Office Department regarding weighing equipment.

The Bureau of Operations is charged with the responsibility of determining the need for types of equipment required in the postal services. The selection of a particular type of scale to meet postal requirements is based primarily on: (1) capacity needed; (2) accuracy required; (3) use; (4) installation; (5) speed of response; (6) operating environment; and (7) cost. These needs are developed as changes take place within the postal system. Examples of these changes are: changes in postal rates; types of mail being handled; changes in operating procedures; expansion or contraction of facilities; and obsolescence of equipment. In addition, our postal field employees estimate their requirements as to the number and type of operating equipment. These estimates include scales.

The Bureau of Operations, after determining budgetary limits, requests our Office of Research and Engineering to prepare detailed performance specifications for procurement purposes. The Office of Research and Engineering either updates or completely rewrites a specification for the particular type of scale to meet the requirements of the Bureau of Operations.

A performance specification is utilized in an attempt to take advantage of any technological changes and innovations made by the scale manufacturing industry. In addition, the technical advice of the Office of Weights and Measures, under the capable supervision of Mr. M. W. Jensen, is sought and used. Many production line pilot model scales are tested for the Department by the laboratory facilities of the National Bureau of Standards.

It must be pointed out that the Department has been quite conservative in making changes in the types of weighing equipment we use. We feel that we are not in a position to be an experimental leader, because the Post Office Department is a servant of the people who use its facilities and over the years the patrons have come to accept, without question, the charge for postage that is requested to mail the item submitted. We strive to use proven, low maintenance equipment with a long service life that will give us our required accuracy.

Upon finalizing a particular specification tailored to meet the requirements of the Bureau of Operations, the paper work flows to our Procurement Division, where competitive bids are sought for the manufacture of the required scales.

At this point I would like to direct a challenge to the representatives of the scale manufacturing industry. The Post Office Department cordially solicits your help and technical knowledge in meeting our needs for durable, low maintenance, and accurate weighing equipment. Within our Research and Engineering organization there is a group whose primary function is to coordinate the efforts of private industry as to application of their products in the Postal Service.

We firmly believe that competition is one of the strongest stimulants for quality and economy in the procurement of all postal equipment, including scales. Therefore, I would like you to accept my personal invitation for your company to strive to be the successful bidder on the procurement contracts we award for weighing equipment.

There are various other operations for which scales are used in the postal system other than the rating of mail. For instance, we are experimenting with scales in our work measurement system, and we are utilizing scales as part of our automated mail-flow system. Large capacity scales are used for the bulk weighing of third-class mail. Air mail and air lift first-class mail are weighed by the sack, so, as you can see, in the postal service we are utilizing scales as small as 9-ounce capacity to scales having capacities of 20 tons.

We now come to the problem of maintaining all scales, so that they are within specified tolerances, and we can be sure that neither the patron nor the Post Office is being over- or undercharged. Over the years, our postal employees have made a conscientious effort to keep our scales within tolerances. However, due to the magnitude of our operations and the constantly growing volume of mail, scale testing is the kind of a detail that may be overlooked or postponed. Many times, our employees' efforts have been diverted to seemingly more urgent matters. In many instances, the necessary tools and manpower were not available to accomplish the job. As you may know, there is at least one scale in every postal facility. There are now over 45,000 individual postal facilities handling patron mail transactions, utilizing over a quarter of a million scales.

Have you ever been in any community in this great Country of ours, where you have not found facilities available to post a letter? I seriously doubt it. On the other hand, our equipment maintenance forces are employed only at 544 of our larger postal facilities.

Our current regulations state that each scale must be tested every year where testing equipment is available. Unfortunately, testing equipment has not been available at many facilities. Therefore, I am sorry to report to you that there are many scales in use today that have not been adequately maintained. However, I am happy to report that a nationwide scale testing program has been inaugurated in the Postal Service. We also have regulations in the Postal Service that every postal facility be annually inspected administratively and financially by a representative of our Postal Inspection Service.

In line with the economy program of President Johnson, we have requested and received the wholehearted support of the Postal Inspection Service so that, while at a facility for an inspection, the Postal Inspector will also test the scales. This cooperation will save the Post Office Department a very substantial sum of money, because our maintenance employees will not have to travel for the sole purpose of scale testing.

After learning of the cooperative spirit of the Postal Inspection Service, it was decided that it would be a physical impossibility to request the Postal Inspector to carry test weights totaling 70 pounds. Therefore, the Maintenance Division of the Bureau of Facilities devised a maintenance scale testing procedure. The purpose of this procedure is to ascertain whether or not a scale is in need of maintenance attention. In addition, a test weight kit of 21 pounds and 53 grains was developed and procured. Both the testing procedures and the development of the test weights were accomplished through the cooperation of the staff of the Office of Weights and Measures.

The procedure was field tested in February and March of this year at 150 of our large metropolitan Post Offices, and was revised and republished in April of this year. The procedure, which is included as Appendix A, deviates from the test procedure recommended by the Office of Weights and Measures in certain details. Our procedure obviously is designed specifically for postal scales.

Representatives of the Inspection Service and our own maintenance people are now in the process of testing each and every scale now in service. Some of the folks doing the scale testing have been given training in maintenance testing of scales. Each scale tested in accordance with the maintenance scale testing procedure is labeled as to whether or not it meets the tolerance requirements. The labels are pictured on Chart 2.

The form used to identify those scales not meeting the specified tolerances has a tear-away post card attached. This post card, after being posted as to the location, type, and probable malfunction, is forwarded to the appropriate regional office. Our current instructions are: The scale must be repaired or replaced within 30 days.

In conjunction with this particular program, we are establishing, throughout the country, Area Maintenance Offices. These offices are geographically located not more than 175 miles from any office for which they will have a maintenance responsibility for postal equipment. With the establishment of the Area Maintenance Offices, we now have the maintenance capability to give every scale the attention it requires. In addition, criteria is now being developed for the disposal of those scales which are uneconomical to repair.

Weights and measures officials in a number of locations throughout the United States have voluntarily contributed the services of their inspectors to check Post Office scales in their respective jurisdictions and have called attention of the local Postmasters to defective or inaccurate scales in use. To these officials and inspectors, the Post Office Department is deeply grateful.

We would be delighted to receive additional assistance from weights and measures officials and inspectors throughout the United States where, in the course of conducting your operations, you may find the time to test the scales in the Post Offices in your respective jurisdictions. All local Postmasters have received instructions regarding your employees conducting tests on Post Office scales. The local Postmaster is our coordinator in your area.

Your testing of Post Office scales is of immeasurable assistance to us and is a public service rendered.

I was requested to speak before this gathering in order to tell you what is new in the Postal Service regarding our weighing equipment. We feel that perhaps the postal establishment stood still for a long period of time regarding the testing and maintenance of our scales. In 1962, the Maintenance Division was established in the Bureau of Facilities. Under the able and aggressive direction of Mr. C. A. Dieman, much has been accomplished in the scheduling of efficient and low cost maintenance. This program is one example of how the Postal Service is attempting to adequately maintain its equipment at the lowest possible cost.

You may not wholeheartedly agree with our methods, because we have deviated from the recognized and published procedures of the organizations which you represent. However, please bear in mind that the primary purpose of our maintenance scale testing program, performed to a large extent by employees who have had no scale experience and are not scale mechanics, is to ascertain whether or not a particular scale needs maintenance attention. You can also rest assured that upon completion of any repair operation to a scale, the procedures you follow, as specified by Handbook 44, will be followed by our trained postal mechanics who will perform the necessary corrective maintenance and repair.

POST OFFICE DEPARTMENT

CHART 1. ORGANIZATION CONCERNED WITH SCALES

Bureau of Operations	*Office of Research and Engineering*	*Bureau of Facilities*
Space and Mechanization Requirements Division (Determines Scale Needs)	Construction Engineering Division (Develops Scale Specifications)	Procurement Division (Purchase and Contract Administrator)
	Industry Coordinator (Liaison with Scale Manufacturers)	Maintenance Division (Installs and Maintains Scales)

CHART 2. REVISED INTERIM TESTING PROCEDURE

9-OUNCE BEAM SCALE

Section I—Zero Balance Test

Step 1: Place beam poise at zero graduation. Scale is in balance if the red indicator at the tip of the beam is in alignment with the zero balance line in the center of the trig loop.

Step 2: If the scale is out of balance, turn the adjustment screw at the end of the beam.

(1) Counter-clockwise if the beam is in the downward position;
(2) Clockwise if the beam is in the upward position.

Step 3: If the scale cannot be balanced by turning the adjustment screw, the scale must be rejected.

Section II—Sensitivity (SR) Test

Step 1: Place a 10-grain test weight on the platform with the poise set at zero. The beam must rise so that the balance indicator touches the top of the trig loop. (If the indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 2: With the 10-grain weight on the platform rebalance the scale to zero. Remove the 10-grain weight. The beam must fall so that the balance indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.) Replace the 10-grain weight on the scale platform and recheck zero balance.

Step 3: With the 10-grain weight on the platform, move the poise to the 9-ounce notch on the beam and balance by placing an 8-ounce and a 1-ounce weight on the platform. Remove the 10-grain weight. The beam must fall so that the indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.) Replace the 10-grain weight on the platform.

Step 4: Place an additional 10-grain weight on the platform. The beam must rise so that the balance indicator touches the top of the trig loop. (If the balance indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 5: Remove all weights from the platform and set the poise at zero. Balance the scale at zero.

Section III—Accuracy Test

NOTE: During the test, it is advisable to keep the test weight load centered or evenly distributed on the scale platform so as to avoid introducing errors resulting solely from an off-center position of the load.

Step 1: Move the poise to the 1-ounce beam notch.

Step 2: Place the 1-ounce test weight on the platform.

Step 3: Observe the balance indication. The balance indicator must come to rest somewhere between the top and bottom of the trig loop. (If the indicator rests either at the top or at the bottom of the trig loop, the scale must be rejected.)

Step 4: Repeat the same procedure (Steps 1 through 3) with test loads of 3, 5, 7, and 9 ounces.

Step 5: Upon completion of the test, remove all weights, return the poise to the zero notch on the beam, and recheck zero balance.

16-OUNCE BEAM SCALE

Section I—Zero Balance Test

Step 1: Place beam poise at zero graduation. Scale is in balance if the red indicator at the tip of the beam is in alignment with the zero balance line in the center of the trig loop.

Step 2: If the scale is out of balance, turn the adjustment screw at the end of the beam:

(1) Counter-clockwise if the beam is in the downward position;

(2) Clockwise if the beam is in the upward position.

Step 3: If the scale cannot be balanced by turning the adjustment screw, the scale must be rejected.

Section II—Sensitivity (SR) Test

Step 1: Place a 10-grain test weight on the platform with the poise set at zero. The beam must rise so that the balance indicator touches the top of the trig loop. (If the indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 2: With the 10-grain weight on the platform rebalance the scale to zero. Remove the 10-grain weight. The beam must fall so that the balance indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.) Replace the 10-grain weight on the scale platform and recheck zero balance.

Step 3: With the 10-grain weight on the platform, move the poise to the 16-ounce notch on the beam and balance by placing a 1-pound weight on the platform. Remove the 10-grain weight. The beam must fall so that the indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.) Replace the 10-grain weight on the platform.

Step 4: Place an additional 10-grain weight on the platform. The beam must rise so that the balance indicator touches the top of the trig loop. (If the balance indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 5: Remove all weights from the platform and set the poise at zero. Balance the scale at zero.

Section III—Accuracy Test

NOTE: During the test, it is advisable to keep the test weight load centered or evenly distributed on the scale platform so as to avoid introducing errors resulting solely from an off-center position of the load.

Step 1: Move the poise to the 1-ounce beam notch.

Step 2: Place the 1-ounce test weight on the platform.

Step 3: Observe the balance indication. The balance indicator must come to rest somewhere between the top and bottom of the trig loop. (If the indicator rests either at the top or at the bottom of the trig loop, the scale must be rejected.)

Step 4: Repeat the same procedure (Steps 1 through 3) with test loads of 4, 8, 12, and 16 ounces.

Step 5: Upon completion of the test, remove all weights, return the poise to the zero notch on the beam, and recheck zero balance.

4-POUND BEAM SCALE

Section I—Zero Balance Test

Step 1: Place beam poise at zero graduation. Scale is in balance if the red indicator at the tip of the beam is in alignment with the zero balance line in the center of the trig loop.

Step 2: If the scale is out of balance, turn the adjustment screw at the end of the beam:

(1) Counter-clockwise if the beam is in the downward position;

(2) Clockwise if the beam is in the upward position.

Step 3: If the scale cannot be balanced by turning the adjustment screw, the scale must be rejected.

Section II—Sensitivity (SR) Test

Step 1: Place a ⅛-ounce test weight on the platform with the poise set at zero. The beam must rise so that the balance indicator touches the top of the trig loop. (If the indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 2: With the ⅛-ounce weight on the platform, rebalance the scale to zero. Remove the ⅛-ounce weight. The beam must fall so that the balance indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.) Replace the ⅛-ounce weight on the platform and recheck zero balance.

Step 3: With the ⅛-ounce weight on the platform, move the poise to the 4-pound notch on the beam and balance by placing four 1-pound weights on the platform. Remove the ⅛-ounce weight. The beam must fall so that the indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.) Replace the ⅛-ounce weight on the platform.

Step 4: Place an additional ⅛-ounce weight on the platform. The beam must rise so that the balance indicator touches the top of the trig loop. (If the balance indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 5: Remove all weights from the platform and set the poise at zero. Balance the scale at zero.

Section III—Accuracy Test

NOTE No. 1: During the test, it is advisable to keep the test weight load centered or evenly distributed on the scale platform so as to avoid introducing errors resulting solely from an off-center position of the load.

NOTE No. 2: There are some 4-pound beam scales in service which do not have the ounce graduations for the first pound. For these scales, perform an Accuracy Test at the 1-pound, 2-pound, 3-pound, and 4-pound notches on the beam scale.

Step 1: Move the poise to the 1-ounce beam notch.

Step 2: Place a 1-ounce test weight on the platform.

Step 3: Observe the balance indication. The balance indicator must come to rest somewhere between the top and bottom of the trig loop. (If the indicator rests either at the top or at the bottom of the trig loop, the scale must be rejected.)

Step 4: Repeat the same procedure (Steps 1 through 3) with test loads of 4, 8, 12 ounces, 1 pound, 2 pounds, 3 pounds, and 4 pounds.

Step 5: Upon the completion of the test, remove all weights, return the poise to the zero notch on the beam, and recheck zero balance.

NOTE: Before conducting any maintenance tests on the 100-pound beam scale it must be ascertained that there are no slot weights on the hook weight assembly.

Section I—Zero Balance Test

Step 1: Place the ounce poise and the main poise at zero graduation. Scale is in balance if indicator at the tip of the beam is in alignment with the zero scribe line in the center of the trig loop.

Step 2: If the scale is out of balance, turn the adjustment screw at the end of the beam:

(1) Counter-clockwise if the beam is in the downward position;

(2) Clockwise if the beam is in the upward position.

Step 3: If the scale cannot be balanced by turning the adjustment screw, the scale must be rejected.

Section II—Sensitivity (SR) Test

NOTE: During the test, it is advisable to keep the test weight load centered or evenly distributed on the scale platform so as to avoid introducing errors resulting from an off-center position of the load.

Part A—Short Beam (0 to 16 Ounces)

NOTE: The main beam poise must be in the zero notch.

Step 1: Place a 1-ounce test weight on the platform with the poise set at zero. The beam must rise so that the balance indicator touches the top of the trig loop. (If the indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 2: With the 1-ounce weight on the platform, rebalance the scale to zero. Remove the 1-ounce weight. The beam must fall so that the balance indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.) Replace the 1-ounce weight on the scale platform. Recheck zero balance.

Step 3: With the 1-ounce weight on the platform, move the ounce poise to the 16-ounce notch on the short beam and balance by placing a 1-pound weight on the platform. Remove the 1-ounce weight. The beam must fall so that the indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.)

Step 4: Place a 2-ounce test weight on the platform. The beam must rise so that the balance indicator touches the top of the trig loop. (If the balance indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 5: Remove all weights from the platform and set the poise at zero. Rebalance the scale at zero.

Part B—Main Beam (0 to 100 Pounds)

NOTE: The ounce poise must be in the zero notch at the short beam.

Step 1: Place a 1(ounce test weight on the platform with the poise set at zero. The beam must rise so that the balance indicator touches the top of the trig loop. (If the indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 2: With the 1-ounce weight on the platform, rebalance the scale at zero. Remove the 1-ounce weight. The beam must fall so that the balance indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.) Replace the ounce weight on the scale platform.

Step 3: With the 1-ounce weight on the platform, move the poise to the 20-pound notch and balance by placing five 1-pound and three 5-pound weights on the platform. Remove the 1-ounce weight. The beam must fall so that the indicator touches the bottom of the trig loop. (If the indicator fails to touch the bottom of the trig loop, the scale must be rejected.)

Step 4: Place a 2-ounce weight on the platform. The beam must rise so that the balance indicator touches the top of the trig loop. (If the balance indicator fails to touch the top of the trig loop, the scale must be rejected.)

Step 5: Remove all weights from the platform, set the poise at zero, and rebalance the scale at zero.

Section III—Accuracy Test

NOTE

No. 1: During the test, it is advisable to keep the test weight load centered or evenly distributed on the scale platform except while conducting the shift test (Steps 10–12) so as to avoid introducing errors resulting solely from an off-center position of the load.

NOTE

Note 2: During the conduct of this test, when testing on the short beam, the poise on the main beam must be in the zero notch; when testing on the main beam, the poise on the short beam must be in the zero notch.

Step 1: Move the poise on the short beam to the 1-ounce notch.

Step 2: Place a 1-ounce test weight on the platform.

Step 3: Observe the balance indication. The balance indicator must come to rest somewhere between the top and bottom of the trig loop. (If the indicator rests either at the top or at the bottom of the trig loop, the scale must be rejected.)

Step 4: Repeat the same procedure (Steps 1 through 3) on the short beam, with test loads of 4, 8, 12, and 16 ounces.

Step 5: Remove all weights from the platform, return the poise to the zero notch, and recheck zero balance.

Step 6: Move the poise on the main beam to the 1-pound notch.

Step 7: Place a 1-pound test weight on the platform.

Step 8: Observe the balance indication. The balance indicator must come to rest somewhere between the top and bottom of the trig loop. (If the indicator rests either at the top or at the bottom of the trig loop, the scale must be rejected.)

Step 9: Repeat the same procedure (Steps 6 through 8) with test loads of 3, 5, 10, 15, and 20 pounds.

Step 10: With the 20 pounds of weights on the platform, remove and replace (do not slide) the three 5-pound weights to the right front corner of the scale platform grouped over the main load support element.

Step 11: Observe the balance indication. The balance indicator must come to rest somewhere between the top and bottom of the trig loop. (If the indicator rests either at the top or at the bottom of the trig loop, the scale must be rejected.)

Step 12: Repeat the same procedure (Steps 10 and 11) at the remaining three corners of the scale platform.

Step 13: Upon completion of the test, remove all weights, return the poise to the zero notch, and recheck zero balance.

70-POUND PARCEL POST SCALE—AUTOMATIC AND DRUM

Section I—Zero Adjustment

Step 1: Check the scale indicator to ascertain that it is in precise alignment with the zero graduation.

Step 2: If an adjustment is necessary to bring the indicator in precise alignment, turn the adjustment screw either to the left or to the right as appropriate.

Step 3: With the indicator in precise alignment, manually depress the scale platform twice. The indicator must return to the precise alignment with the zero graduation. If the indicator fails to return to the precise alignment with the zero graduation, the scale must be rejected.

Section II—Accuracy Test

NOTE: During the test, it is advisable to keep the load well centered or evenly distributed on the scale platform at all times except during the shift test (Steps 4 through 6) so as to avoid introducing errors resulting solely from an off-center position of the load.

Step 1: Place a 4-ounce test weight on the platform.

Step 2: Observe the indicator; it must come to rest within $\frac{1}{4}$ of the graduation space above or below the 4-ounce graduation line. (If the scale indication is in error by more than $\frac{1}{4}$ of the graduated interval, above or below the test load graduation, the scale must be rejected.)

Step 3: Repeat the same procedure (Steps 1 and 2) with test loads of 8 ounces, 12 ounces, 1 pound, 2 pounds, 3 pounds, 4 pounds, 5 pounds, 10 pounds, 15 pounds, and 20 pounds.

Step 4: With the 20 pounds of weights on the platform, remove and replace (do not slide) the three 5-pound weights to the right front corner of the scale platform grouped over the main load support element.

Step 5: Observe the indicator; it must come to rest within $\frac{1}{4}$ of the graduation space above or below the 20-pound graduation line. (If the scale indication is in error by more than $\frac{1}{4}$ of an interval above or below the 20-pound graduation, the scale must be rejected.)

Step 6: Repeat the same procedure (Steps 4 and 5) at the remaining three corners of the scale platform.

Step 7: Upon completion of the test, remove all weights from the platform and recheck zero alignment.

THE NATIONAL CONFERENCE ON WEIGHTS AND MEASURES—A PROGRAM FOR THE FUTURE

by V. D. CAMPBELL, *Chief, Division of Weights and Measures, Ohio Department of Agriculture, Reynoldsburg, Ohio, and Chairman, National Conference on Weights and Measures.*

This Conference marks a milestone in the weights and measures program for our country. As you well know, we are celebrating our Golden Anniversary. The future of our Conference depends to a great extent upon what has been done in the past. It seems appropriate then, to examine the heritage we are leaving for the future—the background upon which future Conferences will build.

Is it a good heritage or a bad one? One of which we can be proud or be ashamed? Let us take a quick look for the answer.

In 1905, Director S. W. Stratton, of the National Bureau of Standards, called a meeting of representatives of the several States. The purpose of the meeting was "to bring about uniformity in the State laws referring to weights and measures, and also to effect a closer cooperation between the State inspection services and the National Bureau of Standards." Eleven persons attended that first Conference. Today, sixty years later, attendance will probably exceed 650.

Such a Conference, sponsored by the National Bureau of Standards, has been held regularly—except in time of war or other national emergency—to the present time.

Over the years there has been consistent growth in all aspects of weights and measures work. There is no denying that mistakes have been made at times but the objective has always been a constructive one, and that objective has been attained time and time again. We, in the several States, have looked to the National Conference for guidance and have found it.

The third National Conference, upon recommendation of the Executive Committee, adopted suggestions for State laws. This was the beginning of the Model Law. Since then, this Model Law has been enlarged and amended, as need arose, but always with improvement. The weights and measures laws of every State, since the adoption of the Model Law, have been based, in whole or in part, upon it. This is a part of the heritage of the last fifty years.

Participation in the Conference has grown and become more inclusive and rightly so. At first, only State officials attended. Soon municipal and county officials became active members.

Quite properly, then, representatives of manufacturers and business groups became participants as associate members. In addition, we have brought to our Conferences representatives of other Federal agencies that have common problems with weights and measures officials: These include the U.S. Department of Agriculture and the Federal Food and Drug Administration. All these groups provided a broad educational base, enlarging the services and values of the Conference to State and local officials, to industry, and to the general public. All this is a part of our heritage.

If each of you were to write down on a piece of paper the number of subjects you thought might have been brought before our Conference and tabulate the items, there would be a wide variety of answers, and most lists would probably be "underregistrations." To fully appreciate the vast scope of subjects which our Conference has had before it, hear this. The *Index to the Reports of National Conferences from the First through the Forty-fifth* lists 688 *major* subjects, which were presented by 496 different individuals. But the 688 major items are only part of the story. A number of these items are subdivided into separate subjects. For example, the title "Bottles" has under it discussions on the characteristics, the testing, specifications and tolerances of bottles for alcoholic beverages, oil, milk and cream. Bottles, in one aspect or another, were discussed in 22 different Conferences. This will give us an idea of the vast range of subject matter that has been presented.

The value of our heritage depends largely upon what leadership is provided. The leadership of the National Conference on Weights and Measures has been outstanding. The Conference index lists 496 speakers. I attempted to go through the list and select a few of those to whom we owed so much.But this was a task far beyond my ability. I will name just a few from the National Bureau of Standards who have contributed a great deal. These names, as you will recall them, will give you an idea of the splendid leadership we have had. S. W. Stratton, the first Director of the Bureau, L. A. Fischer, F. S. Holbrook, L. V. Judson, L. J. Briggs, E. U. Condon, H. W. Bearce, Wilmer Souder, R. W. Smith, A. V. Astin, H. H. Russell, W. S. Bussey, and M. W. Jensen.

The leadership from State and local officials and industry has been consistently excellent through Conference after Conference.

This rich heritage of leadership has constantly led toward the objective of that first Conference, i.e., nationwide uniformity of laws, along with uniformity of regulations, interpretations and enforcement procedures.

NBS, striving to constantly bring about greater uniformity and precision of measurement, has worked with the various Conference Committees in establishing reference material such as handbooks, technical papers and educational aids. These include films, audiovisual aides, handbooks on procedures and administration, and specifications and tolerances for weighing and measuring devices.

All this is a part of the heritage of past National Conferences. This Conference, as you know, will be considering a complete revision of H–44. This revision marks a decided advance in this publication—but more about this later.

The cooperation between regulatory officials, representatives of manufacturers, and business groups has been made possible by the National Conference. Without it there could not help but be wide gaps of misunderstanding between these groups. This past year, for example, has witnessed excellent cooperation between industry, business groups, and members of the Committee on Specifications and Tolerances in the proposed revision of H–44.

Out of the National Conferences, where folks with like problems can communicate, have come State and regional conferences, newsletters, weights and measures schools, a correspondence course, the observance of National Weights and Measures Week, and much more. In all of this, the National Bureau of Standards has played *the* important role. We owe much to the present staff of the Office of Weights and Measures.

This is a brief look at the heritage left to the future by 50 National Conferences. It is a good heritage, one of which to be proud.

What does the future hold? Even greater achievements than in the past. More and more, the results of future Conferences will tend to influence Federal, State, and local weights and measures programs.

The primary objective of National Conferences will probably not change a great deal, unless the Federal Government should enter into the field of enforcement. To my knowledge, there is no thought of this so far as the NBS Office of Weights and Measures is concerned. Yet this possibility must be recognized, which should keep all States alert to doing a better and better job. Assuming that the objective shall continue to be for greater uniformity of laws and regulations and uniformity in the field of procedures, we might look for future Conferences to follow the guidelines provided by our past, but to expand, enlarge, and intensify these items.

This history of measurement has been one of a constant search for accuracy from the time that the cubit was standardized by Menes of Egypt to the recently changed definition of the meter. This search for greater accuracy will be based upon advancement in scientific and technical knowledge. Needless to say, the whole world has gone forward in this direction at a most rapid rate. Weights and measures cannot help but be affected. We, in this profession, will be given a tremendous challenge to keep up with the world. We cannot do otherwise.

State and local jurisdictions will be demanding more scientifically trained personnel. The National Conference, recognizing this, can determine what might be desirable qualifications; committees could well be working on courses of study. A good job has been done, but there is still a long way to go in this field, and local officials will continue to look to the National Conference for guidance.

In the search for greater accuracy, more State laboratories of weights and measures will be established; and those in existence today will be improved. How will this affect the National Conference? In the past, there have been a few dissertations on laboratory procedures, but most have been suggestions on field work. Suggestions on field work will continue, as new devices, etc., are developed, but look for the National Conference to gradually allocate more time to laboratory needs—which will include suitable equipment as well as procedures.

Since we live in an ever more rapidly changing world, many of the subjects presented to National Conferences will have a new look. Instead of debating the tolerances on glass bottles, it may well be that the emphasis will be upon plastic containers, and this may be not too far in the future either.

While the objective of the National Conference cannot help but be uniformity for the benefit of the entire Nation, *complete* uniformity will never be achieved. You may or may not agree with me, but I believe that complete uniformity would be a tragedy. Individual incentive and creative thinking will bring variations. Some noncompliance will probably always be present. But progress will be made *provided* that such nonuniformity is directed toward accuracy. Every National Conference cannot help but recognize that opportunity must be given for full evaluation of differences. The National Conference of the future will be the medium of exchange of even more information than in the past. I mention this for this reason: Regularity of attendance to National Conferences, in the future, will be more important and significant than in the past. You cannot afford to miss, and this applies not only to officials but industry as well.

The ease of communication, travel, and transportation brings States closer and closer together. The need for understanding, for cooperation and uniformity, will likewise become greater. I must be familiar not only with Ohio's requirements, but also with those of my sister States, so that I can better serve my own State. The officials who are in State work know how this need is developing.

In the changing scene, the organization of the National Conference will likely change somewhat, too. There is nothing sacred in any given setup. It has changed in the past and probably will in the future. This is good. This is not to criticize the present organization because as we are all aware, it does serve well; but any organization should change to meet changing situations. Not many years ago there were five standing committees; now there are three. And all is well! But be prepared for changes. However, regardless of organization, it should have its roots in the National Bureau of Standards—that I do not expect to change.

As in the past, the National Conference programs will bring challenges to people engaged in weights and measures. For example, let us look at the Tentative Report of the Committee on Education as printed on page 20 of the Announcement.

> In addition to the above items the Committee would like to explore the possibility of developing outlines and other material which would provide the basis for presentations of weights and measures information for school classes at the elementary and secondary levels. This is an item that has been considered by some weights and measures officials for many years. A few officials have, in fact, developed and presented educational material to the students in their jurisdictions.

This Committee is saying to us that in the field of education there is much to be done. This Committee, like the others, has done a fine job. For example, the observation of Weights and Measures Week, is constantly growing. Yet, the Committee feels the need of a much more basic and fundamental educational program. And, you know, I think they are correct. Along this same line, look for the Office of Weights and Measures to develop more educational material, for both the men in service as well as for the public.

We are all very happy that the Office of Weights and Measures has advanced recently in two directions: (1) The securing of a larger and well-trained staff, and (2) securing excellent laboratory facilities. These two achievements will work hand in hand to carry on precise scientific investigations into the many problems which are encountered in the field of weights and measures, as well as providing more help to State and local officials. The present staff and the new facilities will provide a foundation for future growth and service. The National Conference of the future will be the beneficiary of much that is accomplished by the Office of Weights and Measures. That is why, I feel that the National Conference must continue to be rooted in the National Bureau of Standards.

We, as a Nation, have entered the Space Age but, as individual units, we have not been touched by this era. Oh, yes, we may have had to check some standards for industry engaged in Space Age work but that is about all. In the future, we are certainly going to come in contact with its problems more and more. For example, in the package labeling field. A statement of weight on a package in the "weightless" portion of the stratosphere would be meaningless. Astronauts, we are told, carried food in squeeze tubes. When space travel becomes a fact on a large scale, future National Conferences might well consider what is proper labeling for such. In any case, it will not be too long before these Conferences will be dealing with problems brought about by space travel.

The future will provide many problems and challenges which we cannot now see. But I have great faith that future Conferences will meet the problems efficiently and effectively.

The spirit of the National Conference is so well illustrated in a poem written many years ago by Edgar Guest entitled, "It Couldn't Be Done." I will read it and, in your thinking, substitute the words "National Conference" for the word "He."

Somebody said it couldn't be done,
But he with a chuckle replied
That "maybe it couldn't," but he would be one
Who wouldn't say so till he'd tried.
So he buckled right in with the trace of a grin
On his face. If he worried, he hid it.
He started to sing as he tackled the thing
That couldn't be done, and he did it.

Somebody scoffed: "Oh, you'll never do that;
At least no one ever has done it,"
But he took off his coat and he took off his hat

And the first thing we knew he'd begun it.
With a lift of his chin and a bit of a grin,
Without any doubting or quiddit,
He started to sing as he tackled the thing
That couldn't be done, and he did it.

There are thousands to tell you it cannot be done.
There are thousands to prophesy failure;
There are thousands to point out to you one by one,
The dangers that wait to assail you.
But just buckle in with a bit of a grin.
Just take off your coat and go to it,
Just start in to sing as you tackle the thing
That "cannot be done," and you'll do it.

I know they will come through!

MORNING SESSION—WEDNESDAY, JUNE 23, 1965

(L. BARKER, *Vice Chairman*, Presiding)

ACTIVITIES OF THE OFFICE OF WEIGHTS AND MEASURES, NATIONAL BUREAU OF STANDARDS

by M. W. JENSEN, *Chief, Office of Weights and Measures, and Staff*

This has been another busy and productive year in the Office of Weights and Measures. It has been a year of sound progress.

We have a new staff member, Tom Stabler, from whom you will hear a little later. Tom came to us from the University of Maryland and the Maryland Weights and Measures Department. He is our Laboratory Metrologist, and will have responsibilities in the weights and measures laboratory field. He will assist in the design, test, installation, training, and facilities selection of weights and measures laboratories and laboratory technicians of the States, and similarily for local jurisdictions and industry, as our help is called for.

We are quite delighted to have as a Student Trainee for the summer a young man from the Alfred Tech Measurement Science Course, Mike Tartaglia.

Don Mackay, who, of course, is an Engineer on the staff of the Office of Weights and Measures and from whom you have heard each of the past two years, has largely been on another assignment during this past year, as Acting Chief of the Office of Commodity Standards.

We have had many activities since the Conference last met. Probably the largest single two were planning for this Golden Anniversary and working with the Committee on Specifications and Tolerances and with industry in the complete revision of NBS Handbook 44.

Our family has grown. OWM now includes, in addition to our traditional weights and measures responsibilities, responsibilities in the area of Federal-State technical services. Also, the Chief of the office of Weights and Measures now acts as Manager, Engineering Standards, which includes responsibilities in the areas of commodity standards, standards fixed by statute, and a new Standards Communications Center.

Plans for the program of new standards for the States are well under way, and you will hear more about this later. You heard Dr. Astin report yesterday that the House has agreed to a $400,000 appropriation to start this program.

Now to report on the specific activities, I am quite pleased to present to you some of the members of our senior staff.

H. F. WOLLIN, *Engineer*

Indeed, it has been a busy year for the Office of Weights and Measures, and especially so when one considers the large number of conferences and meetings that we have prepared for and participated in since last year's National Conference.

Most important, of course, was our preparation for this, the 50th National Conference on Weights and Measures. We certainly hope that by now you have seen and enjoyed some of the things on which we put in extra effort. Naturally, we will be pleased if you find the remaining business sessions and the Exposition and our social events to your liking, for I might say that we have tried very hard to make this a really commemorative affair in celebration of this golden occasion. Certainly we hope you will long remember it.

Members of the OWM staff have covered the country attending conferences and meetings—a total of 18 State and regional conferences in all. This is a record that we are very proud of. We feel this is a vital part of our responsibility to the States, and we know also it is equally important to us, for it helps to maintain that network of cooperation and communication which we feel is so necessary in the field of weights and measures.

Our travels do not stop here, however. There were many industry and business conferences and meetings that we participated in during the past year which we consider also of prime importance.

Last year we accepted invitations to attend 13 major conferences that were held by business and industry associations, agencies of the Federal Government, and private organizations, all of which have an interest in weights and measures activities. Just to name a few, there was the Produce Packaging Association meeting, the American Ladder Institute meeting, the National Scale Men's Association, the Chemical Specialties Manufacturers Association, the Post Office Department, and the Milk Market Administrators of the U.S. Department of Agriculture meeting.

So far I have accounted for only about one-half of our travel and activities away from Washington. Over the course of a year, we make many other visits and hold meetings and training sessions—you will hear more about the training sessions from Dick Smith a little later—meetings with representatives of industry, business, governments, and private organizations.

Thus, I think you can see that our outside activities, activities away from Washington, keep us on the move and very busy. However, as you know, our base of operations is located in our offices and laboratories near Gaithersburg, Maryland, the site of the new facilities for the National Bureau of Standards.

Many of you will remember that, in 1962, Mr. Jensen and Mr. Mackay visited several Latin American nations under the auspices of the Agency for International Development of the U.S. Department of State. The main purpose of this trip was to survey the several nations as to their interest in, willingness to undertake, and probable abilities to proceed with a program of weights and measures standardization and control. The success of this trip in South America was evident from the very beginning, for it created considerable interest among our neighbors in Central and South America for a weights and measures program.

Since that time, considerable effort has been made by representatives of our country, and of the countries of Latin America, to complete the necessary arrangements for the establishment of weights and measures programs.

I am pleased to report now that we in the Office of Weights and Measures have been privileged to have had the opportunity to play a major role in this program and in the establishment of it.

Very briefly, developments to date are these:

1. The Agency for International Development, U.S. Department of State, provided us with funds for the design and construction of a set of weights and measures standards and laboratory instruments and accessories for a developing nation in Latin America. This task was completed some time ago, the standards being very similar in design to the new State standards, except that the Latin American standards were, of course, in the metric system.
2. About two months ago, we received authorization from the State Department to pack and ship the standards to Bogota, Columbia, where a model weights and measures laboratory was to be created at the National University of Colombia. This phase of the program was completed just last week.
3. Next Wednesday, June 30, Mr. Thomas Stabler and I will fly to Bogota, Colombia, for approximately one month, for the purpose of setting up the model weights and measures laboratory and conducting laboratory training of officials from Colombia and other nations in South America. The laboratory will serve as a training base for all Latin American countries that expect to establish weights and measures programs in the near future. While we are in Colombia, we will also survey weighing and measuring practices in commerce and conduct training of the University personnel on administrative and technical procedures associated in the administration of a weights and measures program.

T. M. Stabler, *Laboratory Metrologist*

One of the most important and most significant developments in weights and measures in the past hundred years has been announced at this Conference a couple of times now, and that is the new State Standards Program. This program will not only include new standards of mass, length, and volume, but also the precision instruments of measurement to complement a weights and measures laboratory.

Included in the standards of mass are two 500-pound nesting mass standards, a set of 32 mass standards in the range of 50 pounds to 1-millionth of a pound. Also, a 2500-pound precision balance and 3 semiautomatic, single-pan balances. These are of 50-pound, 5-pound, and 1-pound capacities.

The volume standards include a 5-gallon stainless steel capacity standard and a pipette and burette assembly, consisting of 6 pipettes—1 gallon, ½ gallon, 1 quart, 1 pint, ½ pint, 1 gill—and two burettes, a 1-fluid ounce burette and a 20-minim burette.

The primary length standards are a 25-foot steel tape with engraved graduations in metric and U.S. customary units; a 100-foot steel tape; and a standard length bench. The length bench is 17 feet long, mounted on wall brackets, and has a stainless steel bar graduated in metric and U.S. units.

Many accessories accompany these standards—for example, microscopes, precision rules, tension weights, illuminators, and thermometers.

I will be visiting the States, as will other members of the staff, to review existing conditions, in an effort to determine the States' qualifications as recipients in this program.

An adequate physical plant and full-time personnel are essential for effective conduct of a calibration center. To fill the need for calibration services until the State laboratories can perform their own calibrations, the Office of Weights and Measures has assumed this responsibility at the National Bureau of Standards.

The Metrology Division at the Bureau will no longer calibrate field standards for the States. These tests are to be conducted at the Office of Weights and Measures laboratory.

We in the Office of Weights and Measures eagerly anticipate the establishment of weights and measures laboratories in all States of the United States and the training of qualified personnel to perform a most essential service, necessary not only for weights and measures activities of the States, but also for educational institutions, industry, business, and for research and development effort.

R. N. SMITH, *Technical Coordinator*

Technical training is a major activity of the Office of Weights and Measures, and it is one activity to which we devote a tremendous amount of time and effort. I am certainly happy to be a part of this important activity and am thoroughly enjoying it.

As weights and measures work becomes more technical, the need for careful selection and training of qualified personnel increases proportionately. Technical training always plays a vital role in the promotion of nationwide uniformity in weights and measures control.

With our limited staff, we cannot begin to handle the total training effort that is required, but, by working in many different ways, and by using many different methods, we think we can assist the jurisdictions in setting up and maintaining adequate training programs.

During the past year, what we term special field training was conducted in five States. In each case the State had purchased new and specialized equipment to enable them to add some new phase of activity to their existing program.

Two examples come to mind. First, in Arkansas, where a new large-capacity scale testing unit was purchased; second, in Virginia, where the testing of slow-flow meters and automobile odometers was initiated.

Upon the request of three States that had encountered short length ladders being offered for sale, a study was made of ladder marking and merchandising practices. This study was made with the complete cooperation of the ladder industry. We reviewed all the existing American Standards Association codes and Federal specifications in this area and worked through the American Ladder Institute in the development of what we feel now is a comprehensive guide to ladder measurement, tolerances, and marking requirements. This recommendation for ladder measurement standardization will be distributed to each State office soon.

In an effort to promote greater uniformity in laws, regulations, and testing equipment, State office technical visits were conducted in 12 States. We hope to contact each State office at least every other year in the future.

The second audio-visual technical training aid was produced. At the Conference last year it was our privilege to show you our first training aid—The Examination of a Computing Scale. We now have completed and have available for loan or purchase the second training aid, The Examination of a Single Product Motor Fuel Dispenser.

We presently are working with the Packers and Stockyards Division of the U.S. Department of Agriculture on the examination of a livestock scale, and we hope to continue the production of these training aids to cover all basic commercial weighing and measuring devices.

We have, of course, continued to assist the States in the conduct of classroom type training courses. These normally are of two- or three-day duration, are directed to all inspectors, and cover a broad range of weights and measures subjects.

As you have heard, our laboratory training program is being greatly increased. We have a supervisors school, which will be the third supervisors school, scheduled for Boulder, Colorado, August 9 through August 11. We are planning more industry seminars for the coming year.

S. HASKO, *Engineer*

Last year, the 49th National Conference on Weights and Measures amended Section 3.1. on Net Quantity of the Model State Package Regulation to read, in part., as follows:

> The declaration of quantity on an aerosol package shall disclose the net quantity of the commodity (including propellant) that will be expelled when the instructions for use as shown on the container are followed.

In January of last year, an extensive study of methods for checking aerosol packaged products was initiated. The specific aim of this study, conducted jointly by the Office of Weights and Measures and the Chemical Specialties Manufacturers Association, Aerosol Division, was to find an acceptable method whereby the average net delivered weight of a sample of an aerosol package could be accurately and simply determined by weights and measures inspectors.

At the last Conference, possible procedures for checking nonfood foam-type products were discussed and demonstrated. The net results of this study have been the development and dissemination of four simple package-checking procedures covering the major portion of the spectrum of aerosol products.

The methods were prepared as supplements to the package-checking procedures presented in NBS Handbook 67, *Checking Prepackaged Commodities.* They were developed in four broad categories of aerosol products, selected according to product characteristics and applications. The categories are as follows:

1. Non-food foam products, such as, shaving creams, shampoos, hand creams, and cosmetic foams;
2. Low viscosity products, such as, hair sprays, starches, personal and room deodorants, window cleaners, insecticides, and furniture polishes;
3. High viscosity products, such as, paints, lacquers, varnishes, plastic finishes, and undercoatings;
4. Food products, such as, whipped toppings, frostings, syrups, frosted whips, and spreads.

In addition, a special report form to be used in conjunction with these procedures was prepared.

Since the high viscosity and food product procedures were just recently issued, some of the products on the shelves now may be short when checked using the new procedure. It is recommended that sufficient time be allowed for the old stock to be depleted. Initially, it may be advisable for weights and measures officials to issue warnings to the company when short-weight products in these categories are found.

What is next in the field of aerosol products? That depends on you. While we strive to develop sound procedures, we are constantly on the lookout for possible inconsistencies in these methods, and only the use of these procedures by weights and measures officials will reveal any deficiencies or exceptions.

One exception was recently noted in the checking of aerosol packaged toothpaste. Work on this type of product will be needed.

In the area of measuring equipment, improvement must be a continuous process. While the present fabric-measuring tapes have been a marked improvement over the cloth tapes, they still leave much to be desired. Studies are being initiated on methods of improving the present tapes and on other possible tape material.

L. J. CHISHOLM, *Technical Writer*

I am going to touch lightly on three subjects—the Weights and Measures Tech Memo, the OWM Library, and the metric system. Within the last few weeks, the library and the metric system have been somewhat synonymous, but more about that in a minute.

The Tech Memo was originated with the idea in mind that it should be issued as often as was dictated by necessity. As material has been accumulated that was of interest to State and local jurisdictions, the Tech Memo has been distributed. When the Tech Memo was originated, it was thought that it would have not one but two purposes. The basic and obvious purpose was to disseminate information of national and professional interest to the various weights and measures jurisdictions throughout the United States. The second reason for the Tech Memo has been perhaps less obvious and less emphasized.

There are many weights and measures jurisdictions that either for budgetary or time considerations have no newsletter and have no ready communication with sister jurisdictions. It is this deficiency that also gave rise to the Tech Memo.

There are some States that are fortunate enough—and we welcome them—to have the facilities to issue a newsletter. But the newsletters, filling an important and often uninterpreted role, are few enough when one considers the need for communication in this field that is so basic to the everyday lives of the people in our country.

Throughout the past years, one of the most important parts of the OWM program has been the State visit, the head-to-head consultation between local officials and the OWM staff. But the workload of State officials, as you know more personally than I, is increasing, and the responsibilities of OWM are growing much faster than its staff. So lines of communication, as time and work squeeze all of us, inevitably become more crucial.

In a State visit the value is inherent—the two-way communication between local and national officials. In the Tech Memo so far, in its infancy, communication has been from national to local. But this is not enough. We would like all weights and measures officials, and especially those without ready organs of communication, to consider the Tech Memo as their own personal newsletter. When you are out on a job and something occurs to you that might be a problem shared by all officials or, better yet, a solution to a problem that might be of benefit to other officials, let us hear about it. The Tech Memo is there for that purpose.

We would like all officials throughout the United States to feel that they have a voice available, the Tech Memo, to air the problems of the day.

We can issue the Tech Memo as often as is needed. There is no time limit or restriction. So let us hear from you. As we in OWM conceive it, the Tech Memo should not be talking at you; it should be talking with you.

In recent weeks, the National Archival Weights and Measures Library, besides fulfilling its normal role as a good source of weights and measures information for our staff, has received a great deal of use by outside researchers, mostly reporters. This has been prompted, of course, by the recent British announcement of their intention to switch to the metric system over the next ten years. The reason for the great interest here is perhaps obvious. Our American customary inch-pound-gallon system was inherited from the British inch-pound-gallon system, and the announcement that they are going to do away with that system must cause us to pause and reexamine our position. We inherited our weights and measures system from them, and they are throwing it out. But such thoughts have more to do with psychology than fact, more to do with romance than economics, and the basic contentions of whether to switch or not to switch remain the same for us.

When you consider the pros and cons of metric adoption for any particular country, you have to argue it in relation to the economy of that country. A country like Albania, for instance, could switch to the metric system in one year, or we might as well say even one day. All they have had to do is announce it, because they had very little industry to speak of.

But the United States today is unique in the history of the world. There has never been an economy this large or this complex or this rich.

So we are right back to the issue that has been before Congress for the last several years. There have been bills calling for a study to determine the feasibility and practicability of metric adoption in this country. This question must still be answered. Just how feasible and practical, how wise is it, for us to consider changing the base of this uniquely complicated economy. As the people attending this Conference well know, when you tamper with the weights and measures of an economy, you are dealing with the very basis of commerce. Without weights and measures there would be no commerce, and with the unique economy existing in the United States, any considerations as broad as the changing of the entire system must be carefully weighed before any action is taken.

In Congress, one of the most persistent and dedicated proponents of a metric study has been Congressman Miller of California. According to his committee, the Committee on Science and Astronautics, hearings on H.R. 2626, a metric study bill, are to be held in August of this year.

Congressman Miller has been quoted as saying he feels that the British action will spur activity on this bill. We will be observing these hearings closely and report our observations to you in coming Tech Memos.

Mr. Jensen: During the past year we have issued a number of publications. As you know, we feel definitely that the results of investigations have very little meaning unless they get out to you in a form that is useful to you. Included among these are Handbook 94, *The Examination of Weighing Equipment*, Handbook 98, *Examination of Farm Milk Tanks*, and Handbook 99, *Examination of Liquefied Petroleum Gas Liquid-Measuring Devices*.

During the coming year we have definite plans to revise Miscellaneous Publication 233, which contains the basic tables of equivalents between the metric and customary systems. We hope to revise Handbook 67, *Checking Prepackaged Commodities* and, of course, to prepare others as these are needed and as time permits.

We have seen a lot of interest in how the new State standards program might be handled, and let me give you briefly our thoughts up to this point, with your understanding that these are by no means final or firm.

We hope, as soon as the dollars definitely are available to get out the bid specificatio' ,.

At that time, we will issue general information to the States as to what we consider to be reasonable readiness to receive and put into service the new standards. To those States that indicate readiness, we will send somebody from the staff to look and discuss the whole program and to fill out a rather extensive report form.

I hope also to establish an informal advisory group made up of State officials, distributed somewhat geographically and with particular knowledge in this field. We will take our reports to this advisory group, ask them to study the reports, and come back to us with their views as to the order of issuance of the standards as they become ready. Final decision, of course, rests with the National Bureau of Standards.

Coincident with the issuance of the standards will be the supervision of the installation and the training of the laboratory metrologists by a member of our staff.

I am particularly proud that, during the past year, seven of our relatively small staff were singled out by the Bureau for special awards.

I think, all in all, we can say it has been a year of solid progress, and perhaps a preface for years of greater progress to come.

I should like to express to you our gratitude for the opportunity to work with you, the weights and measures officials, people in business and industry, toward sound progress in what we believe to be a very vital field.

THE MEASUREMENT OF LIQUIDS—YESTERDAY

by PAUL RENFREW, *Consultant, Liquid Controls Corporation, Chicago, Illinois*

Introduction

A study of the measuring practices of a nation or race must take into account their geographic location, the ability and integrity of their ruler, their commercial activities, extent of their technological knowledge, and the character of the people themselves. Conversely, a system of weights and measures has a very direct effect upon the people of a country. It is, like their language, often used without conscious thought.

Most of the information concerning the measuring standards and practices of the ancient civilizations has come to light within the last 200 years. Many contradictory theories have been proposed that make it difficult for a layman to trace any positive course of logical development.

The systems and practices of most interest to Western Europe and America were developed and used by the empires which arose in Egypt, Mesopotamia, and other areas surrounding the Mediterranean beginning from about 7000 or 8000 B. C.

Origins of Weights and Measures

It can safely be assumed that the cave man's principal problems were obtaining food and protecting himself from the elements and his enemies. Therefore, he had no need for any objective measuring devices or standards. As man evolved away from cave dwelling and began building his own shelters, he felt the need for something with which to make linear measurements. Such a demand probably was satisfied by choosing a straight young sapling and cutting notches along its length.

The development of all weights and measures systems and standards followed a demand. First, linear measurement was required in the building of houses, temples, pyramids, boats, etc., and for land identification. Weighing methods were developed after gold and silver became important mediums of exchange. Olive oil and wine became important items of commerce, and liquid measuring systems and standards followed. A liquid measure standard was often a container that would hold a specified weight or count of seeds.

The Babylonian liquid measure Ka was the volume of a cube of one handbreath (3.9 to 4 in.^{3}). Dimensioning the volume is a scientific approach, if we ignore the variation in the width of the human hand. However, the cube had to contain a weight of one Great Mina of water. The weight of one Great Mina agrees somewhat with that of the modern kilogram.

Available literature does not make clear the subdivisions of the Ka and, to further complicate matters, two sets of standards were employed using multiples of this unit. Each probably served its purpose in commerce, religion, or customs of that day. It is believed that the Babylonian Gin (1.25 to 1.3 U.S. gallons) formed the basis for the Hebrew liquid measure Hin. The Ka and its multiples were 300 Ka = 60 Gin = 1 Gur.

The Gur represented a volume approaching 80 U.S. gallons. Considering the means then available for handling and transporting objects, it seems doubtful that there was a standard legal measure of such volume. It is easier to believe that the Gur was a stationary vessel the contents of which were transported in smaller volumes.

In a French Museum there is a vase believed made about 2400 B. C. It holds a quantity which the Babylonians called a Niggin. The volume of this vase was checked and found to be 4.71 liters or approximately 1¼ U.S. gallons. It is quite highly decorated and was probably used for ceremonial functions.

Ancient Egypt had a highly developed system of linear measurements required for the building of the pyramids (3000 to 2500 B. C.). Available evidence indicates that their early commerce was by barter only. Apparently they did not use the equal-arm balance in commercial trade until about 1350 B. C., although there are some records indicating weighing was done by goldsmiths and jewelers as early as 2500 B. C.

Ancient Egyptian liquid measures were arranged on a systematic basis—

Ro		Hin		Kekat		Khar		Cubit ^{3}
9600	=	300	=	30	=	3/2	=	1

The Hin is a measure of about 30 in.^{3} and the Khar is a volume approximating 25 gallons. Three Egyptian vessels used as liquid measure standards, now in a British Museum, have been checked and show the Hin measures may have varied considerably, from 27 to 35 in.^{3}.

In a Cairo Museum are two Egyptian conical capacity standards, one silver and one bronze. These cups have calibrated rings marked Hin, ½ Hin, etc.

The University College of London has an early Egyptian bronze measure. It contains a volume equal to $\frac{1}{16}$ of a Khar or something over $1\frac{1}{2}$ U.S. gallons.

The early Hebrews were not a scientific people. They derived their systems of weights and measures from their neighbors, principally Egypt and Babylon. Neither did they have any uniformity among their standards; they may have had three or more different standards at one time, although they did attempt to develop some order to their system. It will be noted from the following that the Hebrews, like the Egyptians, had several different standard volumes of liquid measure with a nondecimal relationship.

Log		Kab		Hin		Bath		Kor
720	=	180	=	60	=	10	=	1

The volumes of these standards are not definitely known, but it is believed that the Bath was a volume of 36.92 liters or approximately $9\frac{1}{2}$ U.S. gallons. On this basis the Log would be something over a U.S. pint and the Hin about $1\frac{5}{8}$ U.S. gallons. The Hebrews apparently also had a special unit of measure connected with their religion—a sacred Bath which was a smaller unit equivalent to about $7\frac{3}{4}$ U. S. gallons.

Early Hebrews also maintained a close relationship between dry and liquid measures. For the most part they were the same volume but with different names. For instance, Kor for liquid and Homer for dry measure were of the same respective size as were the Bath for liquids and Ephah for dry products.

The Syrians and Phoenicians also legalized standards. The Phoenicians, being the sailors and traders of the times, exerted a powerful influence on Eastern Mediterranean weights and measures and measuring practices. Syrian conquest and control of Egypt made the Syrian-Phoenician capacity unit the most common in Egypt from about 1500 to 1400 B. C.

In formulating their measuring standards, they adopted those of their neighbors, making such changes as suited their convenience. Among their standards was a small measure called a Log with a capacity of 33 in.^{3} (somewhat larger than a U.S. pint), and a large unit, Saton, somewhat larger than the Hebrew Bath. However, they made no progress in either uniformity or order in establishing their system.

There is reliable evidence that the Persian trade with the eastern Mediterranean empires was rather extensive. They apparently developed their own weights and measures from past custom and practice, because they were radically different. As evidence of the association of Persia with the Mediterranean empires, Herodotus felt it necessary to develop the relationship between the Syrian-Babylonian Log and the Persian Karpetis as 4:9. The Log contained 33 in.^{3} and the Karpetis about 74 in.^{3} which agrees closely with the ratio developed by Herodotus.

Here were five or six Kingdoms that were almost within walking distance of one another and yet each had a different liquid-measuring system. But there is a general pattern to their standards. First, it would appear that they intended to have a standard volume for every phase of their commercial and domestic life. Second, they all established a standard volume that approximates the present U.S. pint, another between five and seven quarts ($1\frac{1}{4}$ to $1\frac{3}{4}$ U.S. gallons), and a large unit which varied from eight or ten gallons up to about eighty.

Unfortunately, these early civilizations did not leave posterity the equivalent of the National Bureau of Standards Handbook 44 or 45. Consequently, nothing is known about their procedure for developing standards smaller or larger than the primary unit. It is not known if they had even considered using a particular size of standard measure as a primary unit. It would, however, be natural to assume that their primary measuring standard was, knowingly or not, a measure developed originally on the basis of the weight of a certain quantity of seeds.

There is no evidence that they gave consideration to the many variables, such as moisture content, size, or density of the seeds in establishing a unit of weight on the basis of a certain quantity of seeds. It follows that they would pay little attention, to such factors as liquid clinging to surfaces, liquid characteristics, or perhaps small amounts of spillage. They had no means for ascertaining specific gravity or temperature.

The discussion up to this point is not intended to represent a complete, exact, and detailed history of weights and measures as practiced by these ancient people. It does, however, illustrate in a general way the methods and bases used in developing their standards of liquid measure, and also shows the lack of uniformity and order in these early systems. Systems were constantly changing due to economic pressure from neighboring states, conquests, daily practices of the merchants of commerce, whims of rulers, and changes in the people themselves.

The First Water Meter

There was a water meter in existence over 3000 years ago in North Africa. It was necessary to divide the water from a well or spring so that each land owner received his fair and proportionate share. The procedure was very simple: "A man pulls a pot of water on a cord from the well which is turned into an irrigation ditch. Each land proprietor gets water until the number of full pots allotted to him by the water commission is reached. The man at the spring knows the irrigation program and when the turn for the next landowner comes, he throws a piece of straw in the water. When the length of straw arrives at the land to be irrigated next, the necessary sluice gates are changed."

Another story on the ancients dividing water tells of a bowl with a hole in its bottom. A local official sits at the public fountain, blows a horn, floats the bowl on the water, waits patiently for the bowl to sink, and then blows the horn again. At the sound of the horn an irrigation ditch is turned "on" or "off."

These operations did not attempt measurement in standard units. The size of a pot was probably determined on the basis of how much a man could readily lift from the well.

Commercial Practices of the Ancient Civilizations

Converting volume from one standard to another when exporting or importing no doubt involved much bartering and haggling. It is obvious that the lack of uniformity and the constant change would create confusion, disagreement, and fraud. In some areas merchants, traveling on business, carried two or three sets of measures, each meeting the legal standard of a city to be visited. Some merchants had one measure for purchasing and another for selling—it helped their profits. Others would change the capacity of their measures to their advantage. There are many Biblical references to the lack of integrity in measurement.

By the 7th or 8th century B.C., the great eastern civilizations had declined to a level of practically no influence in the Mediterranean and Middle Eastern commerce. The Greeks and Romans dominated trade in the area until the 6th or 7th century A.D. Their systems of weights and measures formed the basis of practically all exchange.

Liquid Measuring in Greece and Rome

The rise of Ancient Greek civilization had the advantage of many previous centuries of metrological history and the Greeks developed their system from it. They apparently used linear measurements for establishing their primary liquid measure, the volume being $\frac{9}{10}$ of a Babylonian cubic foot. This measure, known as a Metretes, was equivalent to 39.39 liters or approximately 10.4 U.S. gallons. They subdivided the Metretes on a duodecimal basis. The Amphora, $\frac{1}{12}$ of a Metretes, was a measure approximating 7 U.S. pints and was further subdivided duodecimally.

The Ancient Romans inherited the experience of the Greeks and their weights and measures standards harmonized to a considerable degree with those of Greece. They even used some of the same terminology, but had different volumes for their standards. The Romans also developed their primary liquid measure on the basis of linear measurements. They established the Amphora as their primary unit with a volume of 1 cubic Roman foot.

Neither did they elect to subdivide duodecimally. The Roman Congius was one-eighth of an Amphora. In the British Museum is a copy of a bronze Congius made in 75 A.D. This has been found to contain 198.359 in.^{3} which is slightly less than 7 U.S. pints.

Several Roman rulers made attempts to obtain honest measure for the people. In Pompeii, for example, the Magistrates established a set of standard measures adjacent to the market place. There were large bowls for dry measures. The smaller ones for wines, oils, and other liquids were emptied by removing a plug in the bottom.

Neither the Greeks or the Romans made any significant progress in either establishing their weights and measures on a more scientific foundation or in the use and honest application of their standards in commerce. Their trade in liquids was probably not any more extensive than that of the Mediterranean empires, so they were under no great pressure. The standards as developed met the requirements of the period.

At the height of its power, Rome controlled most of Europe and Western Asia, and its weights and measures system predominated.

With the decline of the Roman Empire, there was a general decline and loss of interest in science. Weights and measures systems were not maintained with any uniformity or order.

Medieval France

Weights and measures in medieval France reflected conditions following the fall of the Roman Empire. Charlemagne (768–814 A.D.) made quite a determined effort to obtain uniformity and order. To accomplish it he had reproductions of the royal standards distributed over the entire realm. Charlemagne inherited and adopted the weight unit of the Arabs which remained standard in France for many years. During this period, France developed a system of liquid measures.

Quart		Pot		Minot		Velte		Setier		Quartreau		Muid
576	=	144	=	48	=	36	=	12	=	4	=	1
.125	=	.500	=	1.5	=	2	=	6	=	18	=	72 U.S. gallons (approx.)

It would appear that they followed the practice of the ancients in developing their liquid measure system to provide standards for all of their commercial activities. The small measures, Quart through Velte, would serve for retailing wine, beer, oils, etc., while the Quartreau and Muid seem practical for the wholesale trade. Cooperage was an expanding industry, so perhaps the Muid represented the contents of the standard wine cask of the times. The wheel had been used for a number of years, so they could have transported a Muid by horse and cart.

Throughout all of Europe there was great diversity in weights and measures until well into the 19th century. There were dozens of cities, principalities, and kingdoms, each with their separate system.

Anglo-Saxons

Around 1266 A.D., King Henry III issued an edict, "By Consent of the Whole Realm, the Kings measure was made so that an English penny, which is called sterling, round without clipping, shall weight 32 grains of wheat dry in the midst of the ear; twenty pence make an ounce and 12 ounces make a pound and eight pounds make a gallon of wine and eight gallons make a bushel of London."

The Anglo-Saxon standards are of historical interest to America, because they originated the U.S. gallon. The original volume of the gallon was 230.4 in.^{3} which was later changed to 231 in.^{3}.

The wine gallon continued to be a standard measure in England for many years. To help his subjects, Henry VII (1485–1509) legalized a gallon of 272 in.^{3} known as the corn gallon. In 1601, Queen Elizabeth recognized an ale gallon of 282 in.^{3}. For a period England had three different standard gallons containing 230.4, 272, and 282 in.^{3}.

In 1688, someone informed the English King that the true standard wine gallon contained only 224 in.^{3} instead of 230.4 in^3. Such a difference was close to the King's heart as it would materially affect his income from taxes on wine. The excise tax commissioners were in an embarrassing position. They first inspected the standard measures at the exchequer and found the gallon to be much larger than their own. Next, they checked with the Guildhall of the City of London and found the measure there to contain 224 in.^{3} as the King had been informed.

The Commissioners then referred the matter to the Attorney General who advised that they "could not resort to the Guildhall for a standard as there was no law nor could a law be imposed that would permit legalizing a Guildhall measure. Neither could they resort to the Exchequer standards as there was no law making them legal and besides the King would be the loser if they did so." After further consideration the Attorney General rendered the opinion "Tho I do not know or see how 231 cu. in. came to be taken up and settled as the contents of a wine gallon, yet I do not think it safe to depart from it now that its usage has settled it."

This action apparently settled the matter until 1700 A.D. when the wine gallon's validity was challenged by an importer who was using the larger beer and ale gallon. The authorities did not prosecute, because of their weak legal position—Attorney General's opinion was not law. Parliament then acted quickly to strengthen the law, "be it further enacted that any round vessel (commonly called a cylinder) having an even bottom and being seven inches in diameter throughout and six inches deep from top to bottom or any vessel containing 231 cu. in. and no more shall be deemed and taken to be a lawful wine gallon." England now had a legal wine gallon of 231 $in.^3$ which was founded on an unchangeable basis.

In 1688, the Commissioner of Excise advised the Treasury that they were gaging ale and beer by a quart of 70.5 $in.^3$ citing a law, "be it enacted, that every six and thirty gallons of beer taken by gauge according to the standard ale quart, four of which make a gallon, remaining in the custody of the Chamberlain of his Majesty's Exchequer, shall be reckoned, accounted, and returned by the gauger for a barrell of beer; and every two and thirty gallons of ale taken by the gauge according to the same standard shall be returned for a barrell of ale; and all other liquors according to the wine gallon." From this it would appear that the most important duties of the weights and measures inspector was to check containers of ale, beer, wine, etc. Weights and measures enforcement was part of the tax collecting division of the government.

The wine, corn, and ale gallons existed until 1824 when a change was made on recommendation of a study commission appointed in 1818. This commission developed the 10-pound gallon, as they found it to be in agreement with the Exchequer standard pint which contained exactly 20 avoirdupois ounces of water. This Exchequer pint was an Elizabethian standard dating back to 1602. Apparently, the commission attempted to perpetuate tradition and at the same time develop a scientific and unchanging base. However, it was 1878 before the Imperial gallon was legally defined as ten pounds of distilled water at 62°F., which is the standard today. Thus ended the wine, ale, and corn gallons in England.

United States Legalizes the Wine Gallon

One of George Washington's first official statements, upon taking the Presidency, was to urge Congress to provide the people with a uniform weights and measures system. Dry measures varied from State to State. The English wine gallon was the most popular, but the ale and corn gallons were also in use.

Complaints from abroad stated that trade with the United States was a gamble. Collectors of Customs had very personal ideas about the size of a gallon or a bushel. A shipper might pay ten percent more duty on the same commodity in New York than in Philadelphia.

It took a Swiss immigrant by the name of Ferdinand Rudolph Hassler to get action. Hassler was a mathematics instructor at West Point who was making a survey of the coast. In 1830, Congress asked the Treasury to investigate the standards in use at the Customs House. Hassler was clearly the best qualified for the job and so was given the assignment.

To Hassler it was a simple problem. If a gallon in New York was to be the same volume as a gallon in Philadelphia, there had to be a standard for comparison. After some investigation, he adopted the wine gallon of 231 in.^{3} as the standard. It was the most widely used in the States. The Imperial gallon was unknown and there was no public knowledge of the Metric System.

In 1836, Congress instructed the Secretary of the Treasury to supply each State with a set of standards and thus, in effect, legalized the 231 in.^{3} gallon in the United States.

It has required several thousand years for man to create a system of weights and measures, based on a solid technological foundation, that could be equitably enforced.

Past rulers, upon coming into power, found their countries employing corrupt and debased standards. This reflected upon their ability, impeded commerce, and influenced their income from taxes. To each it was a challenge; it seemed so simple and easy to correct. Each one made laws and passed decrees, but seldom did more than ultimately increase the confusion.

A Chinese ruler was successful in building the Great Wall of China, but could not enforce his design for one weight and one measure in place of the discord and confusion. Charlemagne, William the Conqueror, Henry VIII, and others tried to correct the condition. All failed and, unfortunately, the condition prevailed until rather recent times. In fact, the industrial revolution had already started when the steps were taken. France enforced the Metric System beginning in 1840, the British Imperial gallon was finally legalized in 1878, and the U.S. gallon of 231 in.^{3} was adopted in 1836.

From the standpoint of liquid measuring, the peoples of the world were now ready for such great events as Drake's oil well in 1859, the automobile and high speed transportation, beginning at the turn of the last century, and our present great petroleum, petro-chemical, and food industries.

The liquid measure requirements of the ancient, medieval, and even pre-modern peoples were limited to food items, such as wine, beer, ale, cooking oils, etc., which were handled in relatively small volumes.

Measuring Water by Mechanical Means

As population and commerce increased, water became more and more important. As cities grew larger, water distribution systems were required. The increasing number of these systems developed the need of a means for measuring consumption. An individual home or factory should pay for the water transported through the system. For this purpose, something more elaborate than a calibrated container was required.

Man had already seen considerable technological progress when this requirement became evident; considerable research had already been done. In 1730, Henri Pitot developed a means for measuring water flow in a pipe. It bears his name and is still used today in a modified and improved form. In 1790, Reinhard Woltman invented a current meter. It was originally designed to measure water in an open ditch, but was later revised for measuring liquid flowing in a pipe. The Woltman meter was a turbine type and, in appearance at least, very similar to present turbine meters. A Mr. Siemens working in England designed a reaction type turbine meter about 1850. This was used for several years.

The accurate and practical measurement of water attracted more attention from engineers and scientists during the last half of the 19th century than any other problem. There were more patent applications for water-measuring devices than for any other single item from 1850 to 1900. Most of these ideas died a natural death. Two survived and are in use today—the nutating disc meter and the oscillating piston meter. Many home owners and industries pay for water used on the basis of the register of a nutating disc meter, which, of course, has been improved by better materials, design, and workmanship, but the basic principle remains unchanged.

During this period, there were other important developments for measuring flow of water in pipes which included:

1. The venturi tube by Herschel in 1887. This type of meter is still used and has been made for measuring flow in pipes of ¼ inch to 8 feet or more in diameter.
2. William Sewell developed a piston meter in 1850 which was built by Worthington of New York. It had a high pressure drop and developed objectionable pulsations, and so fell by the wayside.
3. A rotary piston meter was designed and patented in the 1880's. It is not used today.

Water was the first liquid handled and consumed in sufficient quantity to justify a mechanical means for measuring it.

Drake's Oil Well

In 1859, Col. E. L. Drake completed the first successful oil well in Titusville, Pennsylvania. This well only went to a depth of 69 or 70 feet, but it is still considered as the beginning of the American petroleum industry and, in fact, the petroleum industry of the world. Drake's well started a stampede. Within ten years, more than 2,000 wells had been drilled with production of crude oil exceeding a rate of 4,000,000 barrels a year.

At the time of Drake's success, the people of North America and Western Europe were ready for the benefits of oil. In the heavily populated cities they had passed from candles through sperm oil lamps and were enjoying the convenience of both coal oil and gas. The less populated areas were using mostly coal oil.

Only the very remote sections used sperm oil or candles. The era of improved illumination had started.

By 1859, there were many small refineries producing coal oil as a by-product of coal distillation for gas manufacture. They were producing over 20,000 gallons of coal oil per day and this continued to increase for some time. The name coal oil carried over into the production and use of kerosene.

Petroleum as a potential source of illumination was very quickly recognized. It was natural for the crude producers to consider the coal oil refiners as the logical people to process their production. They were already in the illuminating oil manufacturing and marketing business. Here was the beginning of petroleum refining.

The crude oil was transported from the producer to the refiner by horse drawn wagons, river barge, and rail in wooden barrels. The barrel was the unit of measurement. Records indicate that the barrel originally used for this purpose usually held a volume of 40 U.S. gallons. However, the capacity of barrels often varied.

These barrels were very poorly made. The lumber used was not proper for the purpose, not properly treated, and workmanship was poor. The producers had to have barrels in order to move their crude oil and no doubt had to accept what they could get. Many barrels could not withstand the rough usage and, as

FIGURE 1. *Oil delivery, ca. 1860.*

a result, leaked badly. It would seem entirely probable that the cooper, after completing a barrel, would cut or stamp the capacity in a conspicuous place. However, available literature does not indicate what procedure was followed in verifying the volume of a barrel.

Considering the commercial practices of the period and the economic expansion that was occurring, it would seem extremely doubtful that these barrels were very carefully calibrated for volume. Perhaps checking for size with a wooden yardstick was sufficient for both buyer and seller. It is safe to assume that this condition and the leakage being experienced resulted in negotiation and adjustment of the volume of each shipment before the transaction was completed. It would be necessary for the refiner to check the contents of each barrel received.

It is evident that transportation of crude oil in wooden barrels would be very unsatisfactory and was so considered by both the producer and refiner. The first attempt at improving it was made about 1865 when two wooden tanks holding 40 or 50 barrels each were mounted on a railroad flat car.

Production in 1865 had reached proportions requiring larger tanks. Wooden tanks containing from 200 or 300 up to 1,000 or 1,200 barrels were becoming common. Experimental iron tanks of even larger capacity were built.

With the advent of tanks of such capacities, it was, undoubtedly, necessary to attempt a careful calibration. It would be natural to assume that such calibration would be accomplished by carefully measuring the size of the tank and computing its volume mathematically. This would then represent the beginning of tank strapping, a practice that has been followed for years by the oil industry.

Sometime between 1865 and 1870, the recognized and accepted standard volume for a barrel of crude oil was changed to 42 U.S. gallons.

Coal Oil and Kerosene

The liquids of commerce in Colonial America during the first half of the 19th century were foods, such as vinegar, wine, liquors, etc., and whale (sperm) oil for lighting. All of these were handled in small volume and sold in small containers. Neither the Federal or State governments had any regulations covering such containers. They simply were accepted by the people.

During this same period, there was a public clamor for better lighting. Sperm oil was very expensive and available only to the wealthy. In the mid 1850's coal oil, a by-product of the then expanding gas industry, was introduced and quickly accepted. Its popularity continued for some 10 or 12 years. Kerosene, a product of petroleum, was automatically and enthusiastically accepted (being used as early as 1860) and marketed through the same channels that had been handling coal oil.

Both coal oil and kerosene were packaged and delivered to the retailer in wooden barrels. Illuminating oil was retailed by the general store, the blacksmith shop, hardware merchants, harness and saddle makers, etc. After forcing a spigot into the bung hole tightly, the retailer mounted the barrel on a wooden rack.

The oil was then drawn from the barrel directly into the customer's container. It is very doubtful that much attention was given to exactness of measurement.

For some reason, it became the practice for the refiner to deliver illuminating oil to the retailer on the basis of weight. Perhaps the leaky barrels promoted it. But the retailer sold the oil by the gallon. Therefore, either the refiner or retailer had to convert weight to gallons. Instruments for measuring specific gravity were not yet available; so it probably was the retailer who determined the number of gallons in a barrel. He purchased his oil on a weight basis and had to sell enough gallons to make a profit. In view of the leaky barrel problem, it was up to the merchant to check very carefully the contents of each new barrel received.

Kerosene delivery to the retailer in barrels started to diminish in about 1875 when the first tank wagon was put into service in the St. Louis area. Among the advantages claimed for this new development was that of being able to deliver to the retailer any volume, 10, 20, 25 gallons, etc., in units of gallons. Transferring the oil from the tank wagon to the retailer's barrels or drums was a manual operation. The driver would hang a bucket on the spigot of the wagon tank, draw it full, and then by the aid of a funnel, pour it into the retailer's container. The bucket was the measure.

Consumption of kerosene was to increase from less than 90,000 in 1865 to over 500,000 gallons per day in 1885. Better means of measurement were required and improved methods of handling needed. The leaky barrels were not only messy and costly, but dangerous. Improvements came often in all phases of the rapidly developing petroleum industry except for the retailer, and nothing was accomplished for him until the mid 1880's.

Liquid-Measuring Devices

In 1885, S. F. Bowser of Ft. Wayne, Indiana, designed, built, and sold to a grocer the first self-measuring pump for dispensing coal oil or kerosene to the domestic trade.

The first unit comprised a 40- to 50-gallon metal tank on which was mounted a hand-operated piston-type pump. As compared to present-day standards, it was very crude, having a wooden piston and marbles for valves, and having to be installed inside, because it was not weatherproof. The tank had to be filled using a bucket, but the kerosene could be delivered and measured directly into the customer's container. It was, at least, a great improvement over the barrel and spigot; and was instantly accepted.

By 1900, there were about 8,000 motor driven vehicles in the United States that burned gasoline. In 1898, the Bowser Company designed a new type of gasoline-dispensing unit for outdoor installation. It consisted of a tank and pump mounted in a wooden cabinet, but the tank still had to be filled by bucket. Locating this new dispensing unit outdoors and at the curb permitted the merchant to serve both the domestic user and the automobile owner with greater convenience and less fire hazard.

The pump in this new cabinet was much improved over the original model. Providing intermediate stops made it possible for the retailer to deliver quantities smaller than the full stroke of the piston. A rack and pinion with a crank had been added which greatly increased the ease of filling a container. The designer also added a hose so that gasoline could be measured and delivered directly to the auto tank, thus eliminating the spillage involved in transferring by use of a measure and funnel. In 1905, the manufacturer started labeling the cabinets "Filling Station" and the name has stayed with us.

The measuring pump of these two dispensers consisted of a cylinder with a piston. As the name implies, the pump served to not only measure the liquid, but also to lift it from the tank into the container or through the hose. For this type of device to measure accurately, it was necessary to maintain a column of liquid above the level in the tank. The bottom head of the cylinder had valves for this purpose. They had to seat firmly, because, of course, any leakage resulted in measurement error.

Shortly after the turn of the century, someone developed the idea of burying the storage tank and mounting the self-measuring pump directly above it. Such an installation provided more storage and required less above-ground space. However, lowering the storage tank increased the height of liquid column to be maintained. This aggravated the problem of manufacturing the tight-fitting valves required for maintaining the necessary column level. This problem resulted in the development of the foot valve located on the bottom end of the suction pipe. The manufacture of tight-seating foot valves became a real art. Later, weights and measures developed tests for checking the holding efficiency of these valves.

The curb-pump idea received instant approval and rapidly gained in popularity. Reasonably satisfactory hose was soon developed, so that gasoline could conveniently be accurately delivered directly to automobile tanks without excessive danger of spillage.

Early piston pumps delivered one gallon per stroke, but this soon increased to two gallons and then five gallons per stroke.

In using these original pumps, the operator had to count the number of strokes in order to determine the volume delivered—5 strokes of a 1 gallon unit for 5 gallons. Later, a dial was added which totalized the gallons.

The piston pump became known as a "blind" pump, because the customer could not see the gasoline as it was delivered to his car. After considerable public pressure, a sight glass was added where the hose connected to the pump. This sight glass served two purposes: First, it, of course, showed the buyer that gasoline was being delivered and second, it indicated whether the pump was properly primed. An empty glass indicated the valves were leaking. The hose of a piston pump had to be drained at the end of each delivery and it was to the customer's benefit to make sure this had been done thoroughly.

This type of measuring pump was the standard retail unit until well into the 1920's. It was also adapted to delivery of lube oil, paint thinners, solvents, and many other liquids. Its principle remained the same; changes were only a matter of refinements in materials, design, and workmanship.

By 1920, there were over 9,000,000 automobiles on the highways and gasoline consumption had reached 300,000 barrels per day. The first filling station, as we know them today, was opened on the West Coast in 1907.

By 1920, the gasoline pump industry had become highly competitive. Many engineers and manufacturers had been attracted to it. New personnel brought new ideas and innovations, the visible pump being the first radical departure from the piston pump.

In a visible pump, measurement was accomplished in a glass cylinder. Original pumps permitted a 5-gallon delivery; this later increased to 10 gallons. Inside the glass cylinder were 2 or more sets of markers indicating the level for each gallon. One gallon was the smallest quantity that could be delivered accurately. Location and design of the indicators was very important.

The glass bowl was mounted on a pedestal originally containing a hand-operated pump which was later changed to automatic operation. Liquid flowed from the bowl into the auto tank by gravity. On some models, the valve for controlling the flow was located at the base of the glass cylinder, requiring the hose to be drained at the end of each delivery. On others, the delivery end of the hose was equipped with a nozzle for control of flow and volume. These latter were known as wet hose pumps, the hose remaining full of liquid.

Some of the early models made it possible for the operator to divert and return part of the glass bowl contents back to storage while making a delivery to an automobile tank. Weights and measures officials soon outlawed pumps with this feature and the pump manufacturers conformed quickly.

The visible pump had advantages as well as some shortcomings. The public liked it because they could see what they were getting. The customer could check the level in the glass cylinder before and after delivery. To him it was a distinct improvement over the "blind" pump. However, if a customer wanted more than the contents of the glass cylinder (5 or 10 gallons), he had to wait until the operator filled it a second time. Measurement always had to start from the top and progress downward.

The Meter Pump

The engineers, even during the popularity of the visible pump, were continuing in their efforts to produce better means of measuring and handling gasoline. The ideal appeared to be a continuous flow device which would not only provide better accuracy of measurement, but also speed up delivery.

As a result of this effort, the meter pump was introduced in the late 1920's and early 1930's. One of the first employed the conventional nutating-disc water meter. It did not survive long, because of inaccuracies at slow-flow rates. It was not a proper measuring device for a high priced commodity like gasoline.

With one exception (the oscillating piston meter used for a number of years), the meters that did meet the accuracy requirements for the service were specially designed positive-displacement meters. Most of these designs are still in use. These meters were of the reciprocating piston type, with a single valve for directing liquid flow through the cylinders.

The meter was mounted in a housing with two dial indicators, one on each side of the pump. The dial had a short pointer, or hour hand, for indicating the full gallons and a long, or minute hand, for fractions of gallons.

These meter pumps were continuous flow devices and required a power source. Electricity was not then available in all parts of the country and small electric motors were not yet completely reliable, so the manufacturers turned to other sources. City water pressure was tried for awhile. It worked, but was not well accepted by owners, operators, or the public. All were afraid of the possibility of water in the fuel.

Air pressure directly on the liquid in the storage tank was next employed in some of the early installations and, like water, moved the gasoline satisfactorily. Unfortunately, gasoline under continuous pressure absorbs air, resulting in very inaccurate measurement. The idea was quickly abandoned.

Manufacturers next buried a small, forty- or fifty-gallon pressure tank close to, and just below, the storage tank. Gasoline was siphoned from the storage tank to the small pressure tank. The gasoline within the small tank was under air pressure only during the period of delivery. Absorption of air was insignificant and the idea worked, but the siphons proved unreliable, causing the pump to lose its prime; therefore, this principle was dropped.

Next, the small pressure tank was mounted inside the storage tank, so that it could fill by gravity. This eliminated the troublesome siphon. The system worked well, but was very difficult to maintain. Besides, a reliable small motor had become available, so all manufacturers turned to the electric motor for the power source.

When the manufacturers turned to the continuous flow, power-operated pump, they immediately recognized the necessity for an air eliminator. A positive displacement meter will not only measure the liquid, but also any air contained in the liquid. The automobile owner had to be protected against the possibility of paying for air. An efficient air eliminator is still a necessary part of the filling station pump.

The sight glass continued to be a necessity. It was an indication to both the operator and the public that a pump was properly primed and ready to make an accurate delivery. Later, the sight glass, or visi-gage, included a spinner to further insure the purchaser that gasoline was flowing.

Within a few years after the introduction of the meter pump, the clock-like dials with moving hands were changed to rotating counter wheels which were much easier for the public to read. Then, the computing counter was introduced. The motorist knew how many gallons he received, the price per gallon, and the dollar value of the quantity delivered.

The basic elements of the filling station pump of the late 1950's was the same as those of the early 1930's. There were changes in styling and design, with improvements in workmanship and materials, but the basic elements were the same.

FIGURE 2. *Domestic oil delivery, ca. 1935.*

The consumption of domestic and industrial fuel oils paralleled the growing demand for gasoline. Fuel oils and gasoline were transported to the market in rail cars, truck tanks, and by pipeline. Faster and more accurate means of measurement were needed. The five-gallon bucket, the gage stick, and the strapped (calibrated) tank were no longer practical.

The first truck tanks built had only a single compartment tank and carried only one commodity. Later trucks frequently had several compartments and could handle several different products. These compartments were calibrated for volume by weights and measures officials. It was the usual practice to develop the volume for each inch of liquid height, and frequently for fractions of an inch. If a driver wanted to deliver less than a full compartment, he had to either carry the product in buckets or use the gage stick.

In loading trucks and rail cars, it was the practice to fill them either to a marker or shellfull. If overfilled, it was necessary to dip out the overage, which was messy and time-consuming, or ignore it; the latter was usually done.

The pipelines were checking oil volume by hand gaging storage tanks. Large volumes of both crude and finished products were sold and purchased on the basis of tank gaging.

These conditions were a challenge to the engineer. Water had been successfully measured by a meter for a number of years. The filling station pump meter was now a reality. There appeared to be no reason why a meter could not be developed for installation in a piping system which would measure liquids, gasoline, or fuel oil flowing in a pipe, and do it more accurately as well as more conveniently.

These applications presented the designer with some problems that were common and some that were not. Truck delivery to the underground filling station tanks was by gravity and has so remained. The first delivery vehicles for domestic fuel oil measured the oil into hand-carried buckets.

Some of the early bulk terminal storage tanks were elevated, so that trucks were loaded by gravity flow. Later fuel oil trucks were equipped with power-driven pumps and long lengths of hose which eliminated the necessity of hand carrying the oil to the users tank. Motor-driven pumps providing faster flow rates were soon common to the bulk terminal.

It is obvious that to be of value on any or all of these applications, a meter had to provide better accuracy than that obtained by the then-prevailing measurement methods. To be practical for truck-tank gravity operation, a meter had to offer very little resistance to flow. Its construction had to be sufficiently rigid to withstand the stresses incident to such operation.

To meet this demand, industry developed and manufactured the liquid-sealed positive-displacement meter. By the late 1920's and early 1930's, these meters were being used on tank trucks for measuring fuel oils to the consumer and gasoline to the filling station. Very shortly thereafter, they were applied to loading racks for filling the delivery trucks more accurately and faster.

After the performance and reliability of meters for these applications had been established, industry began developing accessories to increase their convenience to both the user and the consumer.

The pre-set or quantity control counter was one of the first important additions. A fuel oil delivery truck meter equipped with this accessory permitted the driver to pre-set the desired quantity in the counter and then drag the hose nozzle up a flight of stairs or to the rear of a home and deliver the desired amount without being within sight of his truck. Flow stopped automatically when the pre-set quantity was reached.

Then, someone developed the idea that a meter should provide a printed record of a gasoline or fuel-oil delivery. Besides the convenience, a printed ticket would better protect both the buyer and seller. It would be unnecessary for the buyer to witness the delivery to be certain that he was getting what he was paying for, and the seller would be better guaranteed that his customer had been delivered the correct volume. So the printing counter was developed and introduced. It served its purpose well and became very popular in a short time. It is still used extensively in an improved and more foolproof form.

More Automobiles

By the mid-1940's, the number of cars on the American highways was approaching 40,000,000. Gasoline consumption was increasing proportionately. Fuel oil consumption was averaging about 2,000,000 barrels per day. Operations had to be speeded up in order to meet these increased demands. The small meters and low flow rates of the original installations could not handle the increased volumes. Larger pumps, pipelines, and meters were introduced, and capacities up to 1,000 or more gallons per minute soon became quite common.

In order to keep pace with the rapidly expanding petroleum industry, weights and measures regulations required frequent revision or addition. State and county meter-proving stations increased in number. Larger size meter provers began to be used. Enforcement personnel had to be increased and better trained for the operating conditions of the day.

New Requirements for Meters

During the 1930's and 1940's, other divisions of the petroleum industry were attracted by the advantages of meters in their operations. Producers started to use them for crude oil production. By the late 1950's oil royalties and taxes were being paid on the basis of meter readings. Refineries began to consider the use of meters for process control. The expanding pipeline industry needed better measuring methods and began using meters as early as 1935.

The physical and operating conditions of the production divisions of the petroleum industry were, and continue to be, different from those of marketing, which wholesales and retails finished products. Due to the large volumes involved (frequently, 100,000 or more barrels) large liquid transfers require special techniques and, where meters are involved, special proving facilities. Operations involving the wholesaling or retailing of finished products continue to be accomplished under weights and measures regulation.

In addition to the petroleum industry, meters gained acceptance in the expanding food, paint, chemical, and petro-chemical industries in the early 1940's. By 1950, they were in very general use.

Other Types of Liquid-Measuring Devices

Over the years, several other types of liquid-measuring devices have been developed and put into operation. Included in this list are venturi, orifice, variable-area, velocity, and electromagnetic meters. These are special liquid-measuring devices, used for special purposes.

During World War II, turbine meters were used for testing efficiency of reciprocating airplane engines. After the war, considerable research was directed to applying this type meter to industry. By 1960, a number of turbine meters had been put into operation in refineries and on pipelines.

Summary

Looking back, it is clearly evident that all measuring standards were developed on the basis of the requirements of commerce and the scientific ability of the people. The integrity of government and its subjects determined the manner in which the standards were applied and enforced. However, it was not until the late 19th century that liquid-measuring standards having a scientific and unchanging base were legally adopted.

Not until the approach of the 20th century did liquids in trade reach a volume and value justifying radically new methods of measurement. In fact, practically all of the progress in the art of liquid measurement, and in the development of liquid-measuring devices, has occurred within the last one hundred years.

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THE MEASUREMENT OF LIQUIDS—TODAY

by R. H. Tolson, *Assistant Manager, Construction and Equipment Division, Texaco, Inc., New York, New York*

In today's life of mechanization and technocracy, the measurement of liquids is central to technical progress.

There are many methods of liquid measurement suited to the needs of man. The use of a stick to measure depth and the resolution into volumetric quantity from previously established values is probably the oldest and most widely used method of liquid measurement. Even today, modern jet aircraft are equipped with dipsticks for secondary determination of fuel quantity.

Liquid measurement by weight is also commonly employed. The volume of a liquid can be calculated from its weight if specific gravity and temperature are known. Many liquids are handled and sold by weight without determining volume at all.

Another common method of measurement is the filling of a container to a previously calibrated level.

These and many similar methods of measurement may be satisfactory for limited purposes, but they have one drawback in common: They neither record individual operations nor totalize successive ones.

The volumetric measurement of liquids today is largely done with a meter. A meter is an instrument which can automatically measure and record the quantity of material that passes through it. In this age of automation and instrumentation, the capacity of a device to measure and count at the same time is of obvious advantage. The practice of cutting notches in a stick, placing pebbles in a pan, or making marks on a piece of paper as a means of maintaining a record is replaced by a mechanical device as a part of a meter. The purpose of this paper is to consider the application of meters to measure some of the liquids used and consumed by man.

The basic capacity of a meter to count measurement units is not the only reason for using the device. The cost of the system in comparison with other systems of measurement, and the ease of installation and maintenance, are prime considerations in the selection of meters as a means of measurement.

Meters are used for measurement of widely divergent kinds of liquids, from aromatic elements of exotic perfumes to asphaltic cement, from appetizing liquors to the ingredients of ice cream. Many of the liquids essential to man's existence and pleasure are meter measured, such as water, milk, beer, whiskey, and petroleum products, naming only a few from an almost unlimited list.

Of all the liquids essential to man's progress, petroleum products are probably the most metered of all the materials handled. In today's production of petroleum, many uses of meters are made in the process that starts with crude oil and ends with many different finished products. Water is metered into the ground to force and float crude oil into recovery pockets. The crude is metered into collection systems and into and out of pipelines to refinery centers. Many meters are utilized in refining processes for inventory and control purposes.

Liquid meters are essential parts of oil transportation systems for purposes of stock accountability, for safety, and for control of operations. Meters are used for receipts into storage of liquid petroleum products at bulk plants and terminals and for the delivery of product into pipelines and transport vehicles to consumer and user accounts.

Meter readings are generally acceptable for custody transfer or accountability at all levels of ownership. The widest application of the use of meters for petroleum products is in the sale of automotive gasolines. The use of a meter coupled with a monetary computing device has attained almost universal acceptance as a means of dispensing motor fuels to the public. The 70 billion gallons of automotive gasolines consumed in the United States annually are sold almost exclusively by meter.

It is a sobering thought to realize that, in 1963, collection of most of the 6½ billion dollars of Federal and State taxes on the sale of automotive gasolines depended on meter measurement. Thus, the meter has become a major factor in the collection of taxes. Gasoline tax amounted to approximately 17.3 percent of all State revenues collected in 1963.

In order to evaluate the use of meters for measurement, it is essential to consider some of the basic types.

Weirs or open channels in flumes are probably two of the earliest types of meters and are still used for the measurement of industrial waste and for the sale of water for agricultural irrigation purposes. Orifice meters of many types are used for gaseous materials and for slurries and high-solids-bearing streams. Turbine meters are coming into wide general use and have a large range of application.

Positive displacement meters are probably one of the most widely used of all metering devices. They are, basically, a "running total" meter indicating flow volume.

Mass flow meters have limited application at the present time, but can be used for both liquid and gas streams. Variations of density, temperature, and pressure have only a slight effect in mass meter reading; consequently, manipulation of correction factors is largely eliminated.

Laser meters may appear on the scene shortly. They are already being used as anemometers in the space industry. They may eventually be used to measure gases, fluids, and semisolids, and much more accurately than present devices.

Meter measurement devices and appurtenances should be considered as a total system. Individual components of a system may have discrete characteristics that affect performance of the whole under varying conditions of pressure, flow, temperature, and peculiar properties of the material itself. Piping, elbows, valves, strainers, air releases, flow control valves, and meters themselves all may contribute to volumetric variations in the measurement of evasive and hard-to-control liquids. In addition to the usual hardware which has been vexatious in the past, we are confronted today with remote meter counter drives, data transmission and translation, computers, memory devices, data retrieval, as well as machine invoicing, none of which existed a few years ago. As if that is not enough, data transmission systems may cross city, township, and even State lines in translating measurement by meter into customer accounts and invoicing. Under the systems concept, the question of jurisdiction can become quite perplexing.

Limitations of meter measurement systems are difficult to establish due to the many varying conditions of application. Certain types of metering systems may be sufficiently accurate for some substances and entirely unsatisfactory for other types of materials. An orifice plate meter may be satisfactory for the measurement of a gaseous material and completely unsatisfactory for the pulsating flow of a particular liquid. The choice of the proper metering system is dependent on many things, such as the physical characteristics of a liquid or the ultimate purpose of the metering system, but the choice mainly depends on the knowledge and experience of the individual making the selection.

The behavior of a liquid due to its viscosity, vapor pressure, and other properties, under varying conditions of temperature, pressure, and flow, must be taken under consideration in the selection of a meter and its accessories.

Many times, a meter manufacturer cannot know the final installation of a metering system, nor the ultimate material to be handled, and cannot label his device as to the limits of performance. Accordingly, each individual installation must be evaluated and performance criteria established for the specific application.

Vapor pressure (or volatility, as it is sometimes called) alone can seriously affect a meter's performance. In the use of positive displacement meters, the line pressure should exceed the vapor pressure of the most-volatile stream component. This condition will account for some of the apparent inaccuracies of measuring some liquids, such as automotive gasolines, from low-head supply systems.

Other limitations which affect meter choice and performance are corrosive or erosive materials, slurries, solids in suspension, or gases which perform erratically under extremes of temperature and pressure variation. Also, meter selection and application depend on the rangeability as well as the capacity requirements. Obviously, the type of meter to be used for the stop-and-go service of a slow-flow meter of 5 gallons per day for home-heating oil consumption would be entirely different from a meter handling 15,000 barrels per hour of bunker C fuel into a tank ship.

Stop-and-go operation, or pulsation, is detrimental to the accuracy of almost all flow meters. Consequently, there has been some reluctance to use certain types of meters for handling gasolines over tank truck loading racks in the petroleum industry, as well as for other applications where high levels of performance are required.

Stop-and-go operations are an inherent part of the process in the petroleum industry, due to the necessity of using safety controls to prevent the spillage of a flammable liquid. The use of the automatic nozzle on the dispensing hose at a retail gasoline service station pump is a good example. Shut-down of delivery occurs before a full tank level is reached. The operator "milks" in the remainder when having been asked to "fill it up."

Accuracy requirements of measurement systems have a great deal to do with the selection of types of metering devices and auxiliary equipment. Inferential meters, such as orifice meters, thermal meters, venturi meters, etc., which measure some property of the flowing stream that varies with flow rate and infer rate of flow from the measured property, are used where only reasonable accuracy is satisfactory.

Positive displacement meters that continuously separate the flowing stream into parts of equal volume, and count the parts, are satisfactory where a high degree of accuracy over a wide range of flow is desired and where a measurement of total quantity passing the meter is of primary interest.

Accuracy capabilities vary with service requirements. Water meters used by utilities are permitted accuracy tolerances, in sale to customers, of up to 3 percent. Similar tolerances are permitted by utilities for the sale of energy commodities such as electric power and gas, while competitive sources of energy, such as coal and oil, are restricted to more severe tolerances in measurement by weight or volume.

Meter proving systems are inherently a part of the use of meters, since evidence must be made available that the device is able to deliver the quantity represented.

The ability of a meter to repeat itself, commonly called "repeatability," is of concern primarily to the manufacturer. The repeatability of some inferential meters may fall within 1 percent, while the accuracy of repeatability of a positive displacement device may range from 0.02 percent to 0.1 percent, depending on the particular liquid with which it is tested in the laboratory.

(Repeatability capacity of a meter should not be confused with the accuracy of a measurement system, which includes not only a meter, but may include an air eliminator, strainer, flow-rate valve, and a preset-stop device. Temperature and gravity adjustment mechanisms, as well as remote data transmission and handling facilities, are sometimes essential parts of the measurement systems.)

While water is the usual liquid with which volumetric measures are calibrated, water's characteristics are not always identical to those of the liquid being dispensed by the system under test. Water as a proving liquid is virtually incompressible. However, this is not the case with a liquefied petroleum gas or a volatile gasoline, and a fundamental requirement of proving a meter measurement system is that the proving conditions be as close as practicable to those of operation. Accordingly, in the development of tolerances for metering systems, due consideration must be given to the following factors: (1) Testing is usually done on a "spot" basis (that is, on a predetermined volume such as 50 or 100 gallons, depending upon prover size), and (2) the normal test is not a continuous operation which is adjusted to accommodate for each change in condition of flow, pressure, temperature, and the varying characteristics of the flowing liquid.

One of the most important single ingredients to the meter proving system is man—the man installing the system, the man maintaining the system, and the man testing the system. It is unthinkable that such high levels of performance would be demanded to make the complete process an impossible task. Accordingly, tolerances for meter measurement systems must first take into account that man, too, is subject to error. It would be unfair to restrict tolerances to such an extent that all the deviations from accuracy are used up by mechanisms and the behavior of the liquid being measured, with nothing left for the operator.

The benefits of meter measurement systems for the handling of liquids are prodigious. The reduction of the labor involved in maintaining and proving container-type delivery systems are substantial. The advantage of proving and holding a single meter system within tolerance—a system used to fill millions of containers with legal amounts of liquid—is very obvious. Consider the convenience of proving those metering systems used for the dispensing of millions of gallons of automotive gasoline today as compared to the use of visible glass bowls on service station pumps thirty years ago.

The preservation of commodity, quality, and purity is one of the principal benefits of liquid metering systems today. The advent of conservation loading systems, such as the bottom loading of petroleum products in tank trucks, and the use of closed overhead vapor recovery systems for the same purpose, reduces the loss of valuable volatile components of the liquid and precludes contamination by moisture and atmospheric dust.

The accuracy of liquid metering systems reduces human operational error. In the loading of a properly calibrated 5,000-gallon single-compartment tank truck to a marker, variation of as much as 10 gallons can result from individual interpretation as to what "to the marker" means.

The ease of verification of "correct" measurement is enhanced by the use of liquid meters. Master meters can be used in series with questionable equipment over long periods of time without constant attendance by personnel. The same can be done with "pipe prover" systems where their application is feasible.

The use of liquid meters for manufacturing purposes at point of sale is becoming increasingly important. The gasoline-blending dispenser at service stations is a good example of the capabilities of such mechanisms. Blends of asphalts, heating fuels, liquefied petroleum gases, and mixtures including lubricating oils and additives, are a few of the many materials being delivered to customers through the use of meters.

Inventory ownership by the supplier at point of sale is another advantage to the use of liquid metering systems. In the oil industry, supplier ownership of the petroleum product in the storage tanks is made possible by relying on meters for custody transfer. The advantage of such a system is manifold, but the principal point is that the operator does not have his capital tied up in liquid product. Accountability for the product sold is determined by the dispensing meters, and Federal and State tax responsibility may also be determined in this way.

Improved safety is usually a side benefit from the use of meters for the measurement of liquid. This is especially the case in the petroleum industry, where flammable or combustible products may be spilled and possibly ignited. The use of preset or control mechanisms, to arrest starts and slow down delivery rates before final shutdown and to complete delivery of a predetermined quantity, is of major benefit to the petroleum industry.

The high rates of flow necessary to modern-day liquid transportation systems require controls against sudden shutdown, shutdown that may result in ruptured components due to pressure and surge conditions. Liquid meters serve as useful control mechanisms for such purposes.

Economic justification is one of the principal concerns of industry in the use of liquid metering systems. Many advantages and side benefits may accrue from the use of meters, but the acid test comes from their capacity to pay their way. All the reductions in costs of operation and all the advantages in application toward automation, together with the benefits for safety, can be lost in the costs of installation and maintenance of liquid metering systems. Restrictive controls and unreasonable demands for unattainable performance may negate all the advantages promised by the use of liquid metering systems, and industry may be forced to use other means of liquid measurement.

Accordingly, it behooves governing authority to be moderate in its requirements for metering systems, to permit manufacturers of equipment to be competitive, so that buyers and sellers of liquids alike will benefit and neither party to a transaction will suffer injury.

It has been said that diamonds are a girl's best friend. Liquid meters are certainly a weights and measures man's.

THE MEASUREMENT OF LIQUIDS—TOMORROW

By E. F. WEHMANN, *Assistant Chief Engineer, Neptune Meter Company, Long Island City, New York*

In looking to the future in the area of product planning, one realizes these plans must tie in with the basic interests and needs of industry wherever and whenever liquid products are shipped, refined, stored, processed or sold. To cover the field broadly would include petroleum, chemical, and food products. This phase of liquid metering alone would account for the measurement of billions of barrels per year without including drinking water measured by the privately and municipally owned water works industry in the United States. In liquid measurement, the products are often measured several times in the course of processing, distributing, and marketing before reaching their end use. Aside from the water works field, the large volumes metered are represented by motor fuels and heating oils. Apart from the meter itself, it is necessary to bear in mind the related metering accessory equipment used on transport vehicles, loading terminals, unloading terminals, and in process plant facilities.

It is also necessary to consider the special problems in handling liquefied petroleum gases, petro-chemicals, corn and sugar syrups, industrial chemicals, solvents, and milk products.

Earlier, the needs of industry in terms of liquid metering were mentioned. Meter applications in industry satisfy the need for inventory, accounting, and process control. The future depends on a greater application of liquid measurement to process the product, know how much is being processed, know where it is located at any given time, and know when it is sold, and how much is invoiced and paid for. The ultimate in our free enterprise business cycle is to produce an item for sale at a profit. The metering system is truly the cash register in this cycle.

Meter Requirements

It was true in the past, is true at present, and will continue to be true in the future: For any liquid measurement system there are fundamental requirements.

1. Accurate flow measurement.
2. Faithful recording.
3. Economy.
4. Safety.

Each of us has our own concept of what "accurate" means. The word by itself is not really a definitive expression of measurement characteristics. Measurement is an approximation of an exact amount. To arrive at a more complete interpretation, the engineer breaks this down into terms such as linearity, hysteresis, range, environmental effect, signal flow ratio, and percentage registered.

In metering industrial products, we simply want to know how much of each product is transferred in any particular container, batch, or shipment. We want this information regardless of what the product is, what the environmental conditions are, whatever the total volume happens to be, and at whatever flow rate is practical.

The requirement for reliable recording or registration is straight-forward. The ramification of what is to be recorded and how and where it is to be recorded are not so obvious. Product identification, system identification, date, time, temperature, customer, pricing, discounts, and tax all come under consideration. The recording may be visual and/or recorded on tickets, IBM card, and plastic or paper tape, be printed with carbon or inked ribbon perforated or magnetized.

Economy is a word for which each of us has his own understanding. It may be simply defined when applied to equipment as "that which performs the desired function at the lowest overall cost." Many of us can still remember dip stick measurements of fuels. From a first cost standpoint there was nothing better. Certainly, maintenance of this device represented the ultimate in economy, and record keeping was simple. Even with cheap labor in days gone by, costs per delivery were double the amount considered tolerable today and minimum wages are now far higher. Therefore, the overall economy of the system function must be kept in mind even though we know compromises in favor of lower first cost are made.

Considerations of component and system safety have also been kept uppermost in equipment design and application. Safety will continue to be a controlling factor in a future that will see increased flow rates, more volatile fuel, more aggressive chemicals, and more automatic systems. There is no substitute for good, human judgment, but the elimination of the human element in routine operational cycles leads to a safer operation when the "good judgment" feature is built into the system. The safety of our space astronauts depends on answers derived from complex problems placed into and solved by computers.

These are the factors fundamental to metering. We realize very often that compromise of one factor against another must be made and will, of necessity, continue to be made. Progress will be made on the basis of keener and fewer trade-offs with these fundamental factors.

Current Trends

In order to determine future product needs it is essential to evaluate significant trends and developments in all the industries that store, process, market, and transport liquids, regardless of present methods of liquid measurement.

Using, again, one portion of the petroleum industry (that of transportation), we can assay significant trends in product loading, transports, and unloading.

1. Increasing terminal size.
2. Increasing payload capacity.
3. Faster "turn around" time.
4. Increasing automation of operation and recording.
5. More tailored and special products.
6. Multi-use transports.

In recent years, the number of new, moderate sized bulk plants have leveled off, but there has been an increase in the number of larger terminals. Maximum flow rates at plants have increased from the 350 to 650 gallons per minute range to the 650 to over 1000 gallons per minute range.

Greater use of replacement transports and semi-trailers is reaching the stage of maximum permitted size and axle load limitations. Where axle load limits have already been reached, attention has been given to the reduction of tare weight in order to increase payload.

Decreasing transport delivery time is not easy to achieve when one considers that the time to unload is only a portion of the total "turn around" time of the vehicle. Unloading rates are also controlled to a large extent by the capacity (sizes of fill connection and vent) of the receiving installation. Alterations here are numerous and expensive.

Increasing the efficiency of the bulk terminal is further brought about by greater use of supplementary accounting controls which permit 24-hour operation of the metering system. Large haulers, through the use of special control means, are authorized to load on a self-service basis.

The advantages of tailor-made and special equipment versus the flexibility of multi-use transports used by the "common carrier" does not detract from the virtues of each approach.

LP Gas transports can only be efficiently designed for use with high vapor pressure liquids. Likewise special materials and design requirements must be maintained for milk transports. The high speed gravity discharge system developed by Socony-Mobil for motor fuel service is an example of tailor-made equipment.

Where transports are not fully utilized due to seasonal demand, economic need for the more flexible multi-use transport arises. Petro-chemicals, solvents, liquid fertilizers, and liquefied gases other than LP Gas, all may fit into these extraneous seasonal categories.

Without limiting our scope to the transportation areas of petroleum products, we can easily expand our thinking into other industrial fields and other levels of measurement. In petroleum, there are the large areas of measurement in refining and pipeline operations; in marketing (at the retail level), of gasoline, fuel oil and LP Gases. In the food and chemical products industries, rising costs have brought about a greater awareness of the advantages of metering equipment in plant processing control and measurement.

All of these trends are generated by:

1. The growth of the industries (in both the number of new applications and volume).
2. A continuing effort to reduce unit costs in light of rising labor rates.
3. The availability of new products through technology.
4. The desire for more accurate and convenient measurement.

Metering Equipment—Plans and Progress

Metering, as discussed here, is generally accomplished with the positive displacement measuring principle of which there are several designs in use today. Regardless of the field in which meters are employed, the fundamental needs for accurate measurement, faithful recording, economy, and safety are the same. Suppliers of metering equipment and related system components have for years concentrated on product economy, long, reliable life, and ease of maintenance and adjustment.

In the petroleum field, flow rates moved up from the 2-inch and 3-inch meters to the 4-inch and then to the 6-inch meters to meet the need for rates in the 1,000 gallons per minute area on loading racks. In some instances, a bank of two or more meters in parallel has been used to achieve higher rates. As rates increase, it has been essential to pay closer attention to low flow performance and extending the meters linear range.

We are now reaching the stage where we feel it is necessary to supplement—not replace—the tried and proven positive displacement meters with other principles more amenable to higher flow rates. A prime candidate is the in-line turbine.

Turbine meter designs developed and produced by water meter manufacturers have been successfully used for 50 years or more in the water works industry to measure drinking water moving at high flow rates through supply mains.

The in-line turbine saw use in more recent years for a specialized application: Fuel measurement in the "buddy refueling" system during the closing days of World War II and the Korean crisis. In the last 12 years, after extensive field evaluation, the turbine for pipeline measurement has come into use and has been applied more extensively, along with the positive displacement meters.

In general, positive displacement meters have been applied to widely varying operating flow rates and have handled products with very different physical characteristics (for example, from the high viscosities of heavy oils to the low viscosities and lubricating qualities of propane). Turbine meters have been preferred for high flow rates in pipelines where rates of flow are relatively constant.

First attempts to use turbine meters on loading racks were not highly successful. Recent developments in design have resulted in performance characteristics such that this type of meter may be seriously considered for high rate bulk terminal use in the near future. Prototypes have been operating continuously on varnolene for 18 months with no appreciable signs of wear. In one pipeline field trial over 150 million gallons of gasoline, kerosene, and fuel oil have been measured by a 4-inch size turbine meter with no maintenance and no change in calibration.

Positive displacement meter designs are not being neglected, however. In our case, applied research on the internal hydraulics of the oscillating piston meter have given us leads on improved performance and wear. Studies of meter materials to handle nonlubricating liquids have led to plans for further improvement of low flow accuracy (increased range) in a design already recognized for its excellent performance in this regard.

In the metering of chemicals, solvents, fertilizers and food products, meters of special materials, design and sizes are continuing to be developed and tested. In this area, new materials (including alloys, treatments, finishes, and coatings) are actively being sought and tried. New varieties of plastic compounds, new formulations, new methods of molding, forming, and fabricating are also being considered in new products. In many instances, a combination of new materials and fabrication either permit or dictate design modification.

Sacrifices in designs often must be met and made in order to handle industrial liquids. A process liquid may carry a precipitate or a low percentage of solids. Each year, however, more types of industrial liquids are being metered.

In processing plants, more attention is being given to the overall system function and its application to measurement and control. In the future, we can expect to see more completely engineered systems for "in-plant" processing where liquid and dry ingredients are measured and fed automatically, in prescribed proportion, for batching. The sequence of operations may be push button controlled, automatic, or completely automated. It follows that, in addition to the meter itself, attention is being given overall—to the measurement system. Much of this is in cooperation with the efforts in the various industries to improve their metering operation and their efficiency.

Time will not permit discussion of various systems, what they are designed to accomplish and how they operate. It is not the intent of this presentation to dwell on these details, but rather to establish the direction in which we are headed.

There are certain relationships, however, between needed system components and meters. The first of these is control and recording. The increased use of centralized systems has led to electronic signal generation, transmission, recording, and control, that has in turn led to the system flexibility obtainable by direct mechanical means (stepping motor drive). Where the size of an operation so justifies, this centralization becomes a trade-off between first cost to obtain better performance and lower overall costs. A by-product of auxiliary components such as, the meter operated pulser, is the feasibility of much wider use of in-line blending and automatic additive and odorant injection systems.

The second relationship is the need for more uniquely controlled electrical functions such as, remote operation of valves for slow starts, stops, throttling, and blocking. Safety is often the welcome by-product of system features resulting from good valve control.

The third relationship is the need for more rapid and efficient calibration systems. With the high vapor pressure liquids and increased flow rates, it becomes increasingly apparent that prover tanks are cumbersome and the techniques time consuming. Only part of the answer will come from meters with longer life, requiring less frequent checking. There is promise of improved techniques in meter proving and equipment in sight. Great strides have been made in satisfactory use of single and bidirectional piston provers in pipeline meter calibration and the use of loop provers for portable operation. In the production testing of meters, the feasibility of automatic proving has already been accomplished. How much of this will be used in the weights and measures area is difficult to predict.

The fourth relationship is the growing awareness in the marketing area of metering systems engineering for the design and fabrication of systems that perform properly. With larger capacity vehicle tank trucks and the drive for higher delivery rates, more ingenuity will be applied to the design of pressure (pump) operated systems. This type of design has been recently accomplished on gravity units. Air entrainment in metering systems has plagued certain system designs. Advances are being made in air elimination and modern tank sump and piping design and will continue to do much to alleviate or eliminate this problem. Present air release units, at times, coupled with automatic flow regulators, do a commendable job. Improvement can and will be made.

In years to come, more compact, higher speed registering units will be available. Part of this development is related to automated record keeping and billing.

Conclusions

In conclusion, it should be understood that every meter supplier is still searching for the ideal meter; the liquid meter that will have a high degree of accuracy, require little or no maintenance, will cause no perceptible restriction to flow, will measure any material (whether it is gasoline, propane, glue, syrup, or a gas) under all or any environmental conditions and at virtually any flow rate. This meter would have no moving parts, nothing to wear out and above all else, would be inexpensive to manufacture.

Needless to say, we, at Neptune, have not yet found this meter, but I would like to offer a little evidence to indicate that we are trying.

There is a new flow measurement concept that is currently under development. It is referred to as Neptune's "The Flow Measurement Concept." This is a thermal device which measures any fluid passing over a solid surface.

Some of the characteristics of the device are as follows:

1. Flow range in excess of present day meters.
2. Substantially zero pressure drop (equal to a spool piece of the same length).
3. No moving parts, components permanently potted and sealed.
4. May be constructed of materials best suited to the fluid to be metered.
5. Operates with low wattage on any regulated A.C. or D.C. power sorce.
6. Supplies an electrical signal in the usable 10 millivolt range, proportional to the flow of any particular fluid.

People in research are giving careful consideration to new concepts to develop the theories necessary before considering possible application to the fluid measurements field.

THE INSTRUMENT SOCIETY OF AMERICA—ITS ORGANIZATION, PROGRAM, AND RELATION TO WEIGHTS AND MEASURES

by W. A. CRAWFORD, *Principal Instrument Engineer, Engineering Department, E. I. DuPont de Nemours and Company, Wilmington, Delaware, and President Elect of the Instrument Society of America*

The Instrument Society of America is a nonprofit professional society, international in scope, dedicated to advancing the arts and sciences of instrumentation and control. It is concerned with the theory, design, manufacture, and application of instruments and controls in all the sciences and technologies.

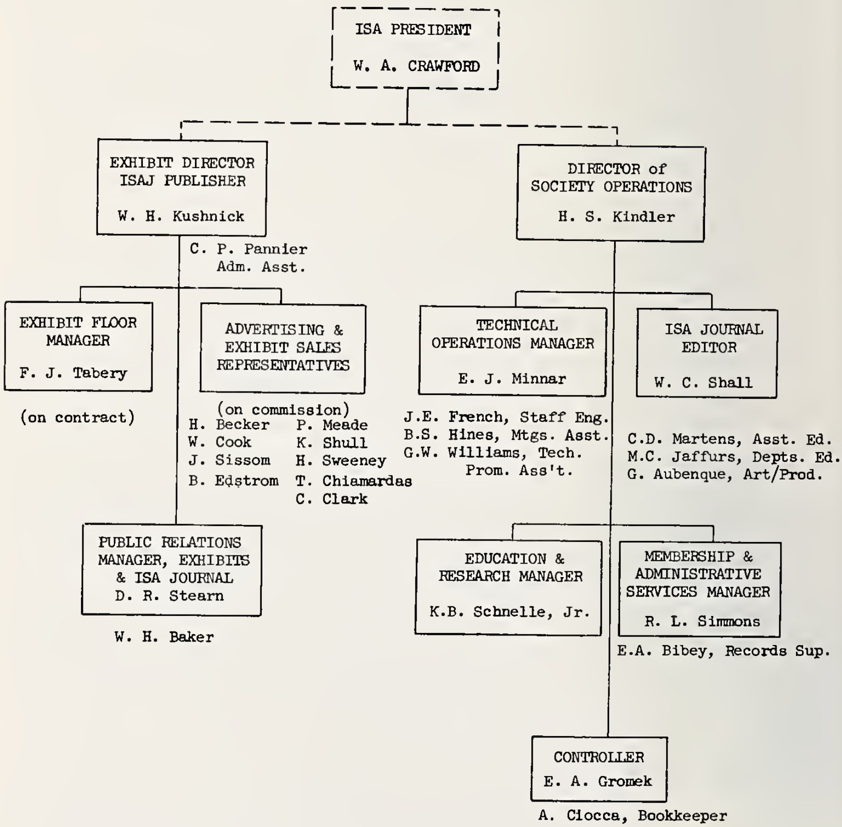
Our membership includes more than 15,000 scientists, engineers, and technologists. They represent both users and manufacturers of instrumentation, a combination that has produced a healthy interchange necessary to the progress of both groups. The Society has 117 Sections in the United States and Canada, the latest of which was chartered on February 10 at Cape Kennedy, Florida.

Our Headquarters, located in Pittsburgh, is manned by 43 employees who carry on the normal functions of a headquarters staff such as keeping membership records, developing yearly conference programs, printing and disseminating our many publications, and managing our annual exhibit.

Our monthly magazine is called the ISA Journal. We publish also a quarterly periodical called the ISA Transactions, and disseminate to all our members printed copies of our Standards and Practices work. In addition, we print proceedings of major technical functions.

The Instrument Society of America also has a birthday this year—this being our 20th year as a Society. We were formed in 1945 by the merging of several local instrument groups, from the major cities in this country, into our present national society. Although the early technical interests of our members were in the chemical and petroleum fields of instrumentation, the growth of instrument use in the country has been very rapid in other fields since our formation. We now devote much of our technical effort to the newer sciences such as aerospace, biomedical, marine, and nuclear sciences.

ISA HEADQUARTERS ORGANIZATION CHART



In addition to our own internal technical work, we cosponsor, with several other societies, conferences on engineering in Medicine and Biology (with IEEE), the National Telemetering Conference (with IEEE and AIAA) and the Automatic Control Conference (with IEEE, ASME, AIChE).

At our Annual Meeting, we frequently entertain several cooperating societies such as the American Meteorological Society, the Precision Measurements Association, the National Council of Standards Laboratories, the Institute of Environmental Sciences, and the Society for Photographic Instrument Engineers.

The technical value and significance of our Society's efforts are that we stress the application of industrial, laboratory and scientific instrumentation and control. We discuss the successes and failures of applications of instrumentation to particular services . . . the problems involved with the maintenance and calibration of plant instrumentation to maintain a high state of productivity . . . the theory of automatic control concepts . . . the practicality of digital versus analog control, etc. In addition to this, we feel it absolutely necessary to provide some media for our members to keep current with the fast changing new product and instrumentation lines being developed each year, and we provide an exhibit at our annual meeting for this purpose.

In the Technical Department, the first Division which touches on instrumentation of the weight and measure type is that of the Instrument Operating and Maintenance group who devote their interest to the plant problems of maintaining equipment. The next Division in our Technical Department which may be of interest is that of the Measurement and Control Instrumentation Division, who have a subcommittee on weighing and control systems. This subcommittee devotes its efforts to intransit weighing and feeding systems required for solids handling. Such devices as belt conveyor scales and unitized belt scale meters are the primary sensing devices. Included in their scope are the controllers and operating devices such as vertical gates, vibrating feeders, rotary vane feeders, etc., to adjust solids flow and maintain continuity.

The next Division in the Technical Department of interest is the Measurement Standards Instrumentation Division. In this Division are the Physical Measurements Committee under James L. Cross of the National Bureau of Standards here in Washington, and the Recommended Environments for Standards Committee under A. D. Isaacs, Instrom Instruments Company. The next Division in our Technical Department, Physical and Mechanical Measurement Instrumentation, includes the Committee on Physical Testing and Inspection Instrumentation under Marvin B. Levine, General American Transportation Corporation; a Committee on Shock and Vibration Measurement under Ralph M. Morrison, Sandia Corporation; and a Committee on Strain Measurement Instrumentation under Darrell B. Harking, of the Boeing Company.

In our Industries and Sciences Department, the various forms of weighing and measurement are discussed as they apply to the industry or science that is involved. Weighing and measuring systems are found in many forms in each of these fields. From my own experience in the chemical industry, I might point out that weighing has in the past been a primary means of confirming the amount of raw materials shipped into our plants or inventoried and shipped out of our plants. For many years weighing has been used in fluids handling. In recent years, more accurate flowmetering devices are available and fewer of the awkward remote reading process scales are now found. Our principal flowmetering devices, however, still read in pounds-per-hour of the fluid being handled.

To go on to the last Department, the Standards and Practices Department, in our Aerospace Committee there is some work going on in Strain Gage Force Transducer Standards under Joe Arbogast of the Hercules Powder Company.

Weights and measures is, of course, associated with our work whenever calibration of measuring instruments is carried out. Each instrument engineer specifying equipment must understand the accuracy of the device he is buying. He will specify and select an instrument to satisfy the application on the basis of the accuracy required. For industrial processing type instrumentation, an absolute accuracy of about 1 to 2 percent of the full scale of the instrument is probably all that will be required, provided the instrument is reliable and unaffected by ambient outdoor conditions. Here, because our industrial plants operate 24 hours a day, precision or high accuracies are sacrificed to achieve reliability.

Each one of our industrial plants, however, maintains the standard weights and measures necessary to verify the accuracy of the instrumentation. The instrument shop will be equipped with the degree of instrumentation necessary to calibrate every type of industrial instrument in the plant. For example, many of the shops include precision manometers, deadweight gage testers for pressure calibration, stirred temperature baths with National Bureau of Standards quality glass-stem thermometers for calibrating thermal instruments, precision potentiometers and Wheatstone bridges for checking electrical measurements, precision oscilloscopes for necessary electronic instrument calibration, and many, many other devices.

Many industrial plants such as aircraft factories have found it necessary to incorporate on their sites standards laboratories capable of measuring and calibrating extremely precise quantities. For example, Grumman Aircraft on Long Island has a very complete laboratory designed to facilitate the calibration of many types of precision instruments provided on the aircraft and in flight-testing as well.

Our Society is working with many other societies to try to promote better criteria for accuracy. For example, this year we are entertaining at our Annual Meeting in Los Angeles a seminar on this subject with American Standards Association, National Council of Standards Laboratories, National Bureau of Standards, Scientific Apparatus Makers Association, Institute of Electrical and Electronics Engineers, American Society for Quality Control, American Ordnance Association, and Precision Measurements Association in an effort to determine how we can speed up the development of standard terms involving accuracy. We also will discuss how we can broadcast and use these standard terms as well as how we can establish standard methods of calibration and checking to provide specified accuracies.

At our annual Exhibit, every leading manufacturer of instrumentation demonstrates his new lines of equipment. It provides an opportunity for all of those interested in instrumentation of any type at all to see the new developments during the past year. Precision equipment by suppliers such as Beckman, Hewlett-Packard, Leeds & Northrup, etc., is exhibited as well as industrial equipment by suppliers such as Taylor, Foxboro, Honeywell, etc.

Each one of these suppliers works with us on our standards and practices activity to try to make our standards meaningful to all levels of instrument use and widely accepted throughout our industry. Our standards and practices have been able to establish a strong tie between users and manufacturers that has been instrumental in developing good working practices between both groups to advance the technology of the industry.

Measurement and control progress has been massive and dynamic these past 20 years. Progress made during the war that seemed so technically exciting in the earlier days of our Society's history has long since been dimmed by the achievements that have occurred since then. New processes and whole new industries have needed, and in some cases have been founded on, new measurement and control techniques. I dare say that there is scarcely a research effort or industrial process in any of our country's enterprises that does not depend in a major way on some facet of instrumentation for its success and effectiveness.

The ISA has played a vital role in all of this progress and its own growth has matched, and frequently has stimulated, the growth of instrumentation technology.

It seems entirely appropriate that the Instrument Society of America and the National Conference on Weights and Measures should explore together means and methods for a cooperative effort directed to improved precision, greater accuracy, and better understanding in the technology of measurement.

MEASUREMENT IN A DYNAMIC SOCIETY

by D. A. SCHON, *Director, Institute for Applied Technology, National Bureau of Standards*

My children have a tendency to embarrass me when they come home from school and ask questions. My daughter came home the other day and said, "Why do they call a ruler a ruler?" and I didn't know. She said, "Well, it's very simple. It is because there was a Babylonian king when they first started the business of measurement and it was his foot or his arm or his hand that served as the measure for length, and so it was the ruler's measure that was the ruler." I have no way of checking on her accuracy except by going to see the teacher, and so I believe her.

I think there is an interesting connection here that is still pertinent. As standards of measurement became objective, after having been arbitrary and dependent on a ruler, so did we move from an arbitrary government to a government by law; and physical measurement, physical standards, legal measurement, legal standards, governmental standards, have developed together.

I am interested to see, by the way, that history in many respects remains the same. When Mr. Renfrew in his most interesting talk pointed out the fact that it used to be true that merchants had one set of standards for buying and another set for selling, I heard a loud voice next to me say, "So what's different?"

What I would like to talk to you about this morning, and briefly, is this: Our national measurement system is as important to our national goals as our systems of transportation, housing, or waste disposal; the measurement system is being forced to change as society changes its demands on technology, and therefore you and we in the National Bureau of Standards are in the business of attempting to adapt that system to the changing demands of society.

That system always consists of at least four parts. It consists of the language of measurement, the methods of measurement, the instruments of measurement, for measuring all the things that society wants to have measured; and then it consists of the data of measurement which result from the use of those methods.

My colleague, Bob Huntoon, at the National Bureau of Standards, whom some of you know, has said this better than I can say it, and I want to read very briefly how he describes it. He says:

> Measurements fall into two main categories—(1) immediate-use measurements which are essentially consumed on the spot; for example, the weighing of potatoes or the measurement of piston diameter; and (2) deferred-use or reference measurements which, once made correctly, can be used repeatedly by many people. The user with a measurement problem can be given a solution in either of these two forms, as the capability to make the measurements with calibrated instruments, or as the record of some previous measurement data. If the answer can be given as data, making one operation serve a multitude of users, there is an enormous reduction in cost, both in time and facilities. Thus, two basic aspects of the National Measurement System have developed. One is aimed at giving the customer the ability to measure, the other at reducing his need for the first by providing him measurements ready made where possible. The first aspect is developed around the concept of a central national laboratory, providing the national standards and the national calibration network. Initially this function could be handled by one central laboratory doing most of the calibration in house. Now national needs have grown so diverse and so complex and of such a magnitude that the central laboratory serves to lead and steer our complex national system.
>
> The second—data aspect—started on a scattered basis with many laboratories making and publishing measurements of properties and constants. It grew out of the general recognition of the need for such reference measurements. This system has grown so that many centers developed such measurements and their conflicting results often confuse the user. This data aspect needs central leadership, a basis for resolving conflicts, and a central place where customers can turn to the reference measurements.

Thank you Bob Huntoon.

Measurement of what? It seems to me there are five sorts of things that we are interested in measuring. One is physical quantities—length, mass, velocity, temperature, the stock in trade of the National Bureau of Standards. The second is properties of materials—for example, hardness, PH, thermal conductivity, porosity, and the like. The third is quantities used in commerce, measures used in metering gasoline or milk, packages in which goods are sold. The fourth is the performance characteristics of products, and this in two parts: Performance of components, like the structural strength of a beam, and performance of systems, like the performance of an environmental control system, including hopefully, the ability to ventilate without deafening.

The fifth kind of measurement is the measurement of programs, the measurement of human activities, as a company attempts to measure the performance of its marketing effort or its advertising, or as a nation attempts to measure its defense program, the benefits and the costs of those programs.

All of these are measurement problems, and all of them in various ways are being pressed to their limit by the things that are now going on in our society.

Let me at breakneck speed now romp through the five categories and tell you how I think it is that this seems to be happening.

In the area of physical measurement, the measurement of physical quantities, the pressure is coming both from the movement of scientific theory, with its new experimental requirements, and also from the engineering requirements, and primarily the engineering requirements of the Defense Department and the National Aeronautics and Space Administration.

Examples. In vacuum: The needs of the space program have strongly pointed out the deficiencies of our current ability to measure vacuum.

In voltage, electrical power transmission over the country is moving to ever higher voltages for increased efficiency.

Our calibration services and measurements capability must be pushed to the one megawatt level.

Length. Lasers have opened up new possibilities for greater precision in length measurements.

Time. In spite of rapid recent advances, the space and defense programs still seek improvement in frequency measurements by a factor of 100.

Temperature. The demands for higher temperature measurements continue to increase. We must extend the range to 5,000 degrees and improve the thermodynamic scale accuracy up to 1,000 degrees.

Let's look at the properties of materials and think about electronics and electronic components. As we have moved from vacuum tubes to transistors to micro-electronic devices—and by the way the National Bureau of Standards shows that you can see this movement in terms of the people who are around, because the fellows who developed measurement methods for vacuum tubes are there, and the fellows who developed measurement methods for transistors are there, and the fellows who are developing measurement methods for micro-electronics are there—as we have moved from one type of component to another, we have become concerned with the purity of materials and are now having to measure it not in terms of parts per thousand, as initially, or parts per million, but in terms of parts per billion in the new micro-electronic materials. This puts a strain on the theory of measurement itself, on the instruments (the resistivity probes which we have traditionally used and which no longer work), and on our ability to produce standard reference materials. And these requirements are of central economic importance to the industry. They can mean, for example, the difference between a 20 percent and a 90 percent rejection rate in the production of electronic components.

Let's turn to the area of greatest concern to you: The measurement of quantities used in commerce. I was struck again by Mr. Renfrew's talk with a thought that hadn't occurred to me before today: today's packages are tomorrow's units of measure. This was true of the Egyptian vase and it was true of the tank car, and I think therefore, it is no accident that you and we are concerned with our ability to measure the contents of packages.

This has two aspects to it. One of them is the proliferation of consumer goods, with the proliferation of packaging, and the other is the development of new technologies of packaging, such as aerosols.

The fact of the matter is, I think we will all agree, that our ability to measure the contents of packages in normal commerce, and to make those measurements known to the people who use them, is inadequate. This is, moreover, a gap we don't yet appear ready to fill. When Esther Peterson was here last year, as I remember, she indicated something of the same sort. I suspect we are moving now toward a period in which we will be ready to attack this problem on a broader public scale than in the past.

Let me move next to the issue of performance characteristics of products and systems.

The rate of technological change, as you have been hearing over and over again, is increasing. In order to cope with it and to increase it further, we need to develop standards of compatibility and criteria of performance.

We have created Federal responsibility at the National Bureau of Standards for computers and automatic data processing technology. The Nation uses $15 billion worth of computers and software each year. The Government uses $3 billion worth of computers and software each year. The number of programming languages, the languages the machine speaks and understands, is currently 102. The cost of programming in Government is about $640 million a year. The amount of duplication among programs is enormous. That duplication hinges on the lack of compatibility of programming languages, which are tied to computer hardware, and the lack of standards for the languages, for the data format, for the tapes, and the like.

On the other hand, people in the automatic data processing business are concerned about the development of standards which might have the effect of freezing the technology. And yet if we don't in some way freeze the technology, we have this large programming bill, with which we don't wish to be stuck. Answers appear to be in the direction of developing performance characteristics for languages rather than specifications for languages.

With respect to the performance-based standards as an incentive to new technology, think about building, an item with which I guess all of you have some concern. Within the last three years, to my knowledge, Monsanto, Union Carbide, Koppers, Johns-Manville, and at least one other major chemical company have dropped between one and eight million dollars in the attempt to introduce new building systems, systems which would promise major cost reductions, for example in low-cost housing.

Each one of these companies, without exception, has had to get out of the business and to accept its investment as a loss. Why? Because there are between two and five thousand local building codes in this country, all of them different, none of them based on the same standards, and while Koppers can sell its new foam-core system in Duluth by going to the local building code officials and pointing out how this system will work, when they finish doing that they have to do the same thing again in Keokuk and the same thing again in Baltimore and the same thing again in Buffalo. By the time they have done all that, the cost of selling these products is so great that it overbalances any conceivable benefit. The lack of performance standards in this field and the lack of codes based on those standards is a major obstacle to the introduction of technical change.

As a counter-example, in the State of California a bright young fellow associated with Stanford University got fifteen school districts to combine their purchases of schools and said, "Gentlemen, let's buy on the basis of performance criteria for school systems, not specifications but performance criteria." He put together such an attractive market that he was able to attract as bidders companies like Inland Steel and Hauserman Partitions. When they bid, the cost per square foot of school was a third less than it previously had been, and even some of those companies which didn't win are now marketing the new systems they developed.

Performance criteria for measuring, not products and not components, but systems, like schools, or even subsystems, like walls, are a major incentive to the introduction of new technology.

Last example. We are concerned with the measurement of programs. You have all heard of a fellow named McNamara in the Federal Government. The Federal Government in my view is now being McNamarized. What that means is that we are beginning to be concerned with not just what are you doing this year and how many items did you process or how many units did you distribute, but what are you doing this year, next year, and the year after, and how do you measure the benefits and costs of what you do.

Now, that problem doesn't arise so much for you gentlemen because you are in face-to-face contact with your benefits all the time, but for us in the Federal Government it arises in a very major way, and we are now in the process of attempting to develop methods of measuring benefits of Federal programs and methods of measuring costs of Federal programs and in some way combining the two, and in my view this is every bit as challenging a measurement problem as determining the purity of the parts per billion in a new micro-electronic component.

On all five measurement fronts—physical properties of materials, physical quantities, performance characteristics of products and systems, quantities used in weights and measures, and programs—our society's demand for new technology is forcing the measurement system to its limits. In contributing to the development of the measurement system, we make a major contribution to the sound use of technology in our society.

THE SCIENCE OF WEIGHING—YESTERDAY

by W. A. Scheurer, *President, Exact Weight Scale Company, Columbus, Ohio*

In the Beginning

When did the science of weighing begin? When did man invent the scale, and a standard system of weights? There are no historical records to show when this momentous event occurred. It is lost in the mists of prehistory, along with those other fundamental devices without which there could have been no civilization: the wheel and axle, the lever, the screw, and the inclined plane.

The oldest known scale is a tiny equal-arm balance found in a prehistoric grave in Egypt—dated roughly at 5000 B.C. This first balance, in use some 7,000 years ago, and less than three and one-half inches long, was carved from red limestone.

And the oldest standard weight? According to the metrologist, Berriman, it is the Mina D. Found in the city of Lagash, in ancient Babylonia, it can be dated at about 2400 B.C. This pear-shaped stone is four inches high and weighs one and one-half pounds. On the other hand, Flinders Petrie claims that some stones found in 1st Dynasty Egyptian graves were used as weights. If this is true, they were in use around 2900 B.C.

It is of course obvious that the first Egyptian balance would have been useless without weights to measure the loads—and that the Babylonian Mina was used with some kind of scale, even though it is lost to us.

Two Histories: Balances and Weights

These earliest historical remains show that we are confronted by two separate histories: 1. The evolution of the scale, or weighing machine; and 2. The evolution of a standard system of weights.

The history of weights is much less dramatic than that of scales since its whole concern is with the establishment of standard units of comparison. From this standard, larger and smaller units could be derived as specific fractions or multiples of the basic unit. Even the most refined modern weights are quite similar to those ancient ones of thousands of years ago. They differ only in the extreme accuracy with which the units can be defined and the very exact ratios between them. That grandfather of all weights, the Mina, could just as well be used today in the pan balance of our most sophisticated laboratory scales.

The history of the weighing machine itself, however, has been marked by dramatic changes. A modern scale system, with its banks of control panels and hundreds of electronic and mechanical components, has no resemblance to its ancient ancestor of the Nile.

Even so, it is one of the astonishing facts of history that from that first Egyptian balance down to Roman times—about 5,000 years—the equal-arm balance was the only scale in existence. The Roman steelyard, which appeared at about the time of the birth of Christ, was the first new principle in the history of the scale since the beginning of time.

When we consider the phenomenal technical achievements of Egypt, Babylonia, and Greece: their monumental religious architecture of pyramids, zigurrats, and marble temples; their great cities with canals and plumbing; their fleets of ships and armies of soldiers; their complex and effective forms of government and legal codes; and above all their ingenious advances in mathematics and astronomy, we may wonder that they did not discover a new principle in so important an art as weighing.

But the reason is clear. For the equal-arm balance is still today the most accurate means of comparing a load against a standard unit of weight as witness its extensive use in our most modern scientific laboratories.

Curiosity and Commerce: Double Root of the History of Weighing

With no historical records to the contrary, we may assume that early man first developed a means for weighing objects as a result of his own curiosity about the world around him. He must have looked at the mountain, or the bird, or the tree and said, "How high?" At the running animal, and said "How fast?" At the lake, and said, "How deep?" At the distant forest, and said, "How far?" And he must have picked up many a stone and said, "How heavy?" He could find the answers only by devising standard units of weight and measure.

The satisfaction of intellectual curiosity has been perhaps the chief motivation for all of our great scientific discoveries. But the coming of civilized life demanded standard units of weight and measure. There can be no extensive commerce between peoples without some form of reference and comparison which will visibly demonstrate the equity of the transaction. That first Egyptian balance is testimony to the need for some more objective standard than the human senses.

Man the Measure

At the beginning of the first civilizations, man himself became the original measuring device. He found that his own limbs could provide a crude but satisfactory linear measure. From his body he developed such units of measurement as the digit,

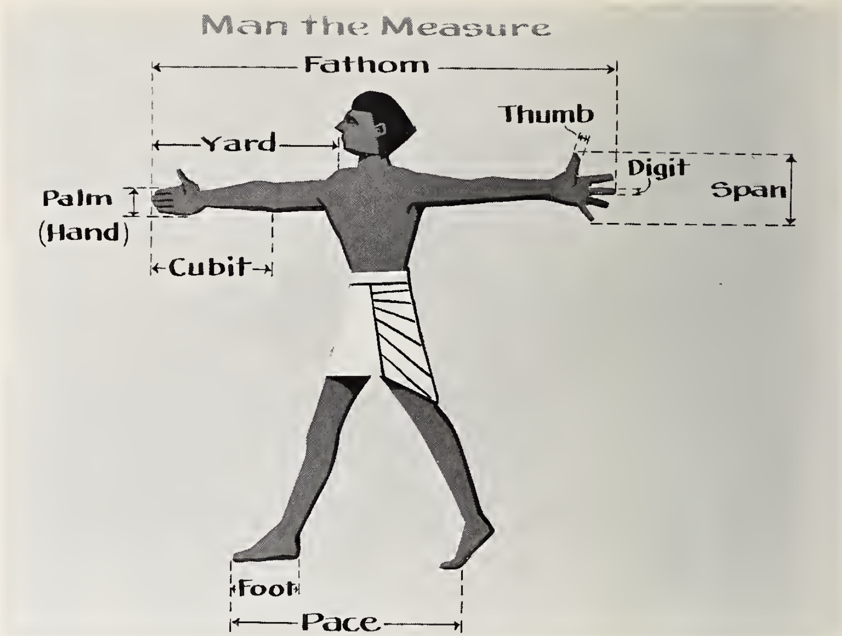


Figure 1.

thumb, palm, hand, span, cubit, yard, fathom, foot, and pace. These proved so convenient that, in spite of their obvious variability, some of them are still used today.

But it was a different matter with weights. There was nothing about the human body which offered a visible means for judging differences in weight. To compare weights, early man could rely only on his sense of "heft"—a method so arbitrary as to be almost useless in commerce or construction.

From Tote Pole to Balance

With no history to guide us, we can only assume that the first great step towards a system of weights and measures was derived from the "tote pole," or coolie yoke. Undoubtedly some primitive, but clever, fellow first learned that a heavy load could be carried more easily if it were divided, and each part hung from the ends of a pole slung across the shoulder. The more balanced the loads, the easier it was to carry them.

From the tote pole it seems to us now but a step to the equal-arm balance. By suspending the pole at its center, the load hanging from one end could be balanced against some standard hung from the other. And with this first great step we have come to the beginning of the history of weighing.

The Three Basic Scale Components

Every weighing system, from the most primitive to the most modern, consists of three basic elements: 1. the load receiver; 2. the load sensor; and, 3. the readout. Looking once again at the primitive Egyptian balance, the cord suspended from one end of the beam is the load receiver—that part of the scale which holds the load to be weighed. From the opposite end of the beam is suspended the load sensor—in this case a weight against which the load is compared. And in this primitive balance the only readout is the eye which must judge when the load is exactly balanced by the sensor. No matter how complex or ingenious our modern scale systems, they all incorporate these three basic elements of weighing. And the history of the science of weighing is the story of man's progressive ingenuity in discovering methods for conveniently holding all types of loads; more exact load sensing devices; and more accurate, faster systems of readout.

After 7,000 Years

The whole science of weighing depends upon one simple function: *accurate comparison with a standard unit.* The increased accuracy of comparison, the increased standardization of the units—this will be the measure of our progress. And how far have we come after 7,000 years? There are in use in the world today some 5,000 basic and derived units of weight, measure, and capacity. Many backward countries still use quite primitive systems of weights, having an accuracy perhaps no greater than one part in a hundred. But the instrumentation in the more technologically advanced countries provides an accuracy to one part in many millions. The number of different units is not so important—it is accuracy of comparison which counts. When we can say that one meter equals 1.093613 yards, or that one pound equals 0.45359237 kilograms, this is science. When we can say that the U.S. bushel equals 0.9689 British bushels, and that this in turn is equivalent to 35.2381 liters, our technology has realized the goal of accuracy in scientific measurement: accuracy of comparison with standard units.

Today we measure accurately the length of a lightwave, or of a gamma ray, in terms of the Angstrom unit, one ten billionth of a meter in length. Or we can measure that much of our universe which is known to us through our radio and light telescopes —and here the standard unit is the light year, a linear unit five trillion, 878 billion miles long. We can weigh the tiniest known physical particle, the electron—and find that it is 1/910, 700,-000, 000, 000, 000, 000, 000, 000, 000 of a gram (one 910,700 billion billion billionths of a gram). Or we can measure the weight of our own earth, and find that it is six billion billion grams. This is the measure of how far we have come since that first Egyptian balance.

I. THE EVOLUTION OF WEIGHTS

The Westward Course of the Evolution of Weight Systems

An investigation of the history of weights shows several significant trends. In the first place, while almost all primitive societies have, and have had, some system of weights, it is only highly-developed civilizations which can lay claim to the development of exact standards. Each of these civilizations arose from small beginnings to astonishing heights of cultural and technical achievement, creating powerful empires and great world cities—and then declined to comparative insignificance, overcome and superseded by other rising civilizations. The earliest of these great cultural units appears to have been the Babylonian civilization, or, more properly, the Sumerian-Akkadian. This first civilization began its organized evolution in the Tigris-Euphrates valley around 3000 B.C.

About a century later, the second great civilization—the Egyptian—began its recorded evolution in the Nile valley. For more than a thousand years, as far as we know, these were the only civilizations on our planet.

Then, about 1500 B.C., the Indian civilization was shaping itself in the Indus valley, and several centuries later the great Chinese culture appeared in the East.

From that time onward the rise of new civilizations followed a generally westward course. Around 1200 B.C., the Hittite-Assyrian civilization grew to power north and west of the old Babylonian. About the same time the Hebrew civilization spread over Palestine.

In the years around 1100 B.C. the Graeco-Roman, or Classical, civilization grew up on the Greek mainland and the islands of the Ionian and Aegean Seas. This powerful civilization, which died with the fall of the Roman empire, was succeeded by the Byzantine-Arabic civilization. Arising much farther east, around 200 B.C., this culture spread westward and dominated the whole of the Near East and a considerable portion of Europe until the 15th century A.D.

Still moving westward, the Western civilization began to grow from the remains of Charlemagne's loosely constructed empire, about 900 A.D.

But even before Western civilization began, far to the west across the Atlantic Ocean, there appeared the Maya civilization in Mexico, and the Inca civilization in Peru—both around 500 A.D.

At the same time that the great American civilization was beginning on the North American continent, the ancient oriental civilizations of India and China were being superseded by another, half-oriental, half-European: the Russian, which was beginning to take on a semblance of unity after the territorial acquisitions of Ivan the Terrible in the 15th century and Peter the Great in the late 17th.

What is significant for us here is that each of these great civilizations developed its own system of weights, and each, in general, retained their system in spite of the gradual spread of universal commerce.

The Rise of Standard Weight Systems

Throughout this long and shifting pattern of historical evolution, with its continual rise, expansion, and fall of great civilizations, there appears another central tendency: the gradual unification of hundreds of local systems of weights within a civilization into a general system of standards established by a central government. For example, the 17 known standards of early Egypt were reduced to eight over the course of the centuries.

While stone weights apparently were the first standard units, the cereal grain became the smallest unit of weight in many of these civilizations—a unit still used today. It was generally stipulated that the standard grain should be chosen from the center of the ear, and dried. While grains of uniform size made a fairly reliable, and universal, unit of weight, they varied according to the amount of moisture they absorbed. Today, there are 7,000 grains in the pound avoirdupois and 5,760 grains in the troy pound.

Babylonian Weights

Looking briefly at the various systems devised by the great civilizations, we find the Mina and the Shekel to be the basic units of the Babylonian system. The previously mentioned Mina D weighed 1.5 pounds. The Mina N weighed 2.16 pounds. Archaeologists have also found weights of five Minas, in the shape of a duck, and a 30-Mina weight in the form of a swan.

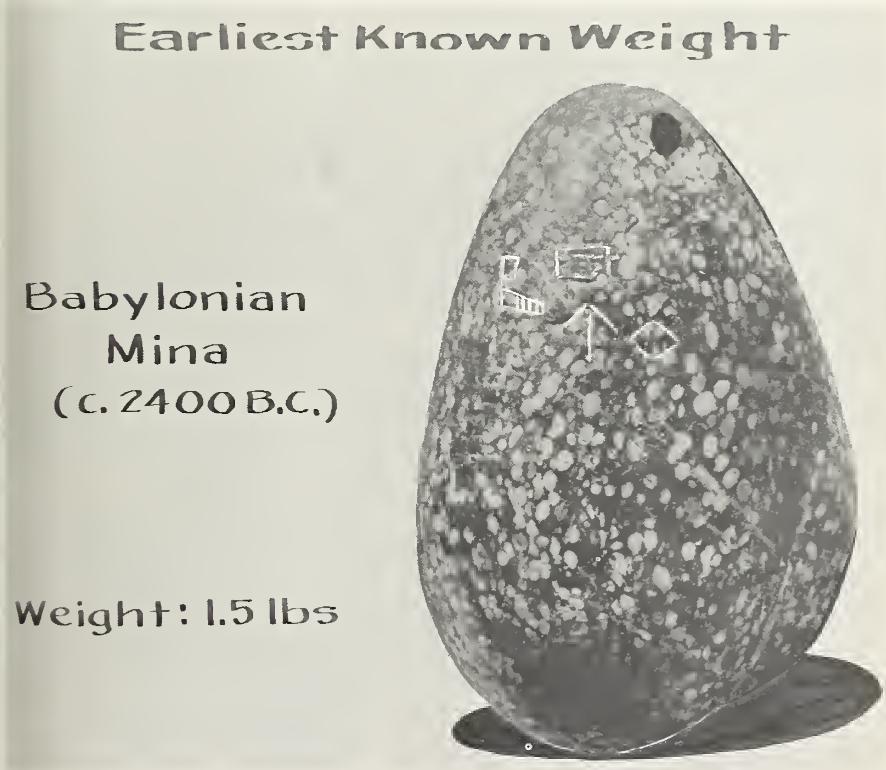


FIGURE 2.

The Shekel, familiar from the Bible as a standard Hebrew coin and weight, was one of the most ancient Babylonian weights, and was equal to 0.036 pounds, or a little more than half an ounce. In Babylonian terms, the Mina N was equal to 60 Shekels.

Egyptian Weights

Historical evidence of Egyptian weight systems is much more extensive than the Babylonian. The basic Egyptian system appears to have been founded on the Sep, the Deben, and the Kedet (or Kite). The ratio was 1 Sep = 10 Debens = 100 Kedets. However, there were many different Kedets, ranging in weight from about 70 to 292 grains. This system of standard ratios only appeared after Egyptian civilization was well advanced. In an earlier age, the gold Deben itself was the basic unit. Much later the Kedet became the standard reference.

About 3,400 different weights have been recovered from ancient Egypt, some in simple geometric shapes, others in a wide variety of human and animal forms.

Indian and Chinese Weights

Very little has been discovered about any extensive Indian weight system and still less about the ancient Chinese. Some 288 specimens of stone weights have been found in the Indus valley excavations. Although they are without rating marks, they range in mass from 1.5 to 135 grams. Since these series of cubic stones decrease in size in an orderly pattern, it is clear that the early Indians had a standard system of weight units. Centuries later there are many references to the Retti seed as a fundamental unit of weight.

The early development of a coinage system by the ancient Chinese is a clear indication that they also possessed standard weights. One such unit, the Kin, has persisted through history—a gold unit equal to one cubic inch of this metal.

Hittite-Assyrian, Hebrew and Phoenician Weights

The Hittites, Assyrians, Phoenicians, and Hebrews derived their weight systems generally from the old Babylonian measures, and occasionally from the Egyptian.

Hebrew standards were based on the relationship between the Mina, the Talent, and the Shekel. The Sacred Mina was equal to 60 Shekels, and the Sacred Talent to 3,000 Shekels, or 50 Sacred Minas. The Talmudist Mina equalled 25 Shekels; the Talmudist Talent equalled 1500 Shekels, or 60 Talmudist Minas. Since the Shekel was equivalent to one-half ounce, the Sacred Mina weighed 30 ounces, and the Sacred Talent about 94 pounds.

The historian Josephus mentions a Jewish tradition that Cain, after his wanderings, built the city of Nod and became the inventor of the system of weights and measures. There is some merit to this view in light of the fact that Cain's original difficulty came about through his inability to convince God of the equivalence in value between fruit and sheep.

The First Decimal System

During this same period, about 1,000 B.C., the Babylonians began to use the first decimal system of weights and measures. It had its origin in the Egyptian lineal measure, the Mahi, or length of the forearm. The Babylonians took the Half-Mahi as a measure of sizes and weights for containers. The Half-Mahi was divided into ten parts, each equal to one Thumbreadth. One cubic Half-Mahi thus contained 1,000 cubic Thumbreadths, and the weight of water filling a container of this size was reckoned at 1,000 Bekas. Two smaller units were then derived from this basic unit the Scruple, equal to one-tenth Beka, and the Grain, equal to 1/200th Beka. Referring to a previous system, 100 Shekels = 64 Bekas.

The Greek Weight System

By this time in the evolution of civilizations, there was extensive land and maritime commerce between all the peoples of the Near East and southern Europe. As the Greeks began to build a civilization on the shores of the Aegean and in Asia Minor, they adopted and modified the Babylonian decimal plan. The Greek cubic foot, or Pous, became the base of the system.

Since the Greek foot was equal to 12 Thumbreadths, the cubic Pous equalled 1,728 cubic Thumbreadths, or a similar number of Bekas. Or, since one Beka = 12 Scruples, one cubic Pous = 17,280 Scruples. The Greeks then divided this into smaller units: 17,280 Scruples = 60 Litra Weights; one Litra weight = 12 Twelfth Weights; one Twelfth Weight = 8 Dram Weights; one Dram Weight = 3 Scruples; one Scruple = 20 Grains.

Roman Weights

As the Greek culture was merged with, and superseded by, the rising Roman empire, the Romans altered the Greek weight system by calling the Twelfth Weight an Uncia—from which is derived our word "ounce." Moreover, they set 16 Uncia equal to one Pondus, later to become our avoirdupois pound. Sixty Pondus weights were then reckoned to be the weight of one cubic foot of cool water.

Modifying another weight system, the Romans set 12 Uncias equal to one Libra, and 80 Libra equal to the weight of one cubic foot of cool water. This 12-ounce pound became the basis of the Troy system.

Arabic Weights

As the great Roman Empire fell into decay, first the Byzantine, then the Arabic and Turkish civilization took its place as the leading culture. Now still another system of weights came into use but we know very little about the ancient Arabic standards. The barleycorn became the basic small unit of weight, and the Yusdruman pound used by the Arabs was derived from the Babylonian Mina. It was adopted by Charlemagne and remained for years the standard pound of medieval France. The Arabic, or Mohammedan, Michtal equalled 1/72 Egypto-Roman Pound, and 100 Michtals equalled one Rotl, equivalent to 7,283 grains. This Rotl became the basis of the old Germanic weight system.

The Avery Museum Collection in London contains a set of glass coin weights with rating marks of great accuracy, indicating the high standards reached in the Arabic weight systems.

The Evolution of European Weight Systems

Although the Roman empire established its system of weights and measures over great parts of the world, the rising European states in the Middle Ages never fully adopted it, and some countries retained their own local standards. Italy and France used the basic Roman weights and ratios, while England, Germany, Holland, Denmark, Sweden, and Norway used native measures.

Around 850 A.D. Alfred the Great brought considerable uniformity to the standard weight units of England. The prevailing English measure of capacity was a container one handbreadth long in each dimension. The weight of water filling this container became the basic weight unit: the Measure Weight. The set of derived units then was: one Tun Weight = 1000 Measure Weights; one Measure Weights = 1000 Skeats; One-Half Measure Weight = one Scale Weight; one Hundred Weight = 100 Scale Weights; the Half-Hundred Weight = 50 Scale Weights; and the Stone Weight = $\frac{1}{8}$th Hundred Weight.

A Revolution: The Prototype Standard

At this moment in world history a great step was taken in the progress towards more accurate weight standards. Rather than each English community constructing its own basic weight unit by rough guess, it borrowed the national standard from the royal government and made an exact duplicate of it in iron. As far as we know, this is the first instance of what might be called the Prototype Standard. The standards were carefully kept, by order of the Saxon kings, at Winchester. After the Norman conquest in 1066, William the Conqueror determined to preserve the Anglo-Saxon system of standard weights and had the prototypes moved to Westminister Abbey.

The recognition of the need for standard units of weights and measures was so great that the famous Magna Carta of 1215 stressed the principle of uniformity. Somewhat later, Henry III redefined the traditional Saxon monetary unit of the pound, known as the "pound sterling" because the English penny was called a "pence sterling." The ratios were: one pound = 20 shillings; one shilling = 12 pence—the system still used today. Also, 20 pence = one ounce, and 12 ounces = one pound. The English pound sterling had the same divisions as the *livre esterlin* of Charlemagne, unifier of Europe in the 9th century.

In 1303, when London had become one of the great trading cities of Europe, the London merchants were empowered to install a new pound weight system, consisting of 16 ounces to the pound, and called *aver-de-peis,* meaning "weight of goods" (later corrupted to its present form of *avoirdupois*). It was not from intent but from coincidence that the new English pound nearly equalled the weight of the Italian pound, called the Libra; and the English Ounce was almost identical in weight to the Italian Onzia—the Italian system having been derived from the Roman. This is why today our abbreviation for the pound is *lb* and *oz* for the ounce.

Even before the introduction of the avoirdupois system, many English port cities were using another set of units for weighing precious metals, jewelry, and drugs. This was the Troy system used by the great Hanseatic League of north German and Baltic cities which was rising to a dominant position in maritime commerce. Exact weight was so important to Hanseatic trade that scales were specially made in Nurnberg, and sets of weights were based on the German Onze, or Troy Ounce. The Troy system itself may have taken its name from the town of Troyes in France, center of the great Champagne Fairs, most famous of all medieval European trading regions.

The Hanse maintained outlying settlements in four big cities one of which was London. This part of the city was called the "Steelyard," and it is not known whether it took this name because of the metal-loading docks or because of the huge steelyard used to weigh heavy goods.

The Londoners referred to these German traders as "Easterners" or "Easterlings"—later shortened to "Sterlings." Consequently, the Luebeck coins were called *sterling silver;* the ounce was the *sterling ounce;* and the pound was the *pound sterling.*

In the 19th century, the Troy system was abolished in England, with the exception of the Troy Ounce of 480 Grains, used to weigh precious metals and stones.

The Great Metric Revolution

Following the westward course of the history of weighing, we observe a continuation of the same two trends which have threaded the whole development of weight standards: (1) The constant rise of different sets of standard units, often resembling each other, and (2) the tendency to simplify the number of units by the direction and control of a central government. Yet the only significant advance towards the goal of increasing accuracy was the English establishment of a prototype standard, and its duplication by the various communities throughout the country.

While this was an epoch-making improvement, it did nothing to establish a universal system to be used throughout the world by all peoples. Moreover, like almost all other systems of the past, its units involved fractions. What was needed was a system in which weights, measures, and volumes were immediately related by units which were always the same fraction or multiple of a single base unit.

Of all of the upheavals occasioned by the French Revolution of 1789, the most important for our history was the birth of the metric system. This system, adopted by France in 1790 was the first plan ever to relate measure, weight, and volume by the same units, each of which was the same multiple or fraction of a base unit. This basic standard was named the meter (from the French "to measure") and the derived units were decimal multiples or fractions of this standard unit of length. The meter was defined as one ten millionth of a quadrant of the earth's circumference.

To carry out this plan, the exact length of the meter was to be determined by measuring the difference in latitude between Dunkirk, France and Barcelona, Spain. After this was done, a standard meter bar was constructed. However, due to a slight error, it was found that the distance on the earth's surface from the Equator to the North Pole was not exactly ten million units of the new meter, but slightly more. But it was now too late to change the system. In 1875, the International Bureau of Weights and Measures was established, and prepared a platinum-iridium alloy bar on which two fine marks were made, the distance between them defining the standard length of the meter. This International Prototype Meter is kept at Sevres, a Paris suburb, and exact copies of it, called National Prototype Meters, are in the possession of governments of various counties.

To a great extent, the Metric System marks the fulfillment of man's long search for a universal standard of weights and measures. It is an invention almost as significant as the weight itself.

Weights in the United States

The systems of weights and measures in the United States are similar to those of Great Britain, with some variations. A resolution of Congress in 1836 approved the units adopted by the Treasury Department in 1832, which endorsed the avoirdupois pound of 7,000 grains. While Congress has never actually adopted these standards, they are in general practical use throughout the country. Congress further stipulated that each of the States was to be supplied with a complete set of weights and measures. This was accomplished by 1850. This set also included the troy pound of 5,760 grains.

In 1866, Congress approved the use of the metric system in the United States without, however, making it the standard. Thus both systems are in wide use throughout the country. The ounce-pound system is in general use in commerce and industry while the gram-kilogram system is increasingly used in science and technology. It is a curious fact that even today in the vaults of the National Bureau of Standards there is no national prototype avoirdupois pound. But there is a national prototype standard kilogram.

The National Bureau of Standards

Symbolic of the westward course of scale and weights evolution is the rise of the United States National Bureau of Standards. Once merely the custodian of standard prototypes, it has grown to become perhaps the world's largest scientific research center and testing laboratory. Its huge complex of buildings at Washington, D. C., houses a whole population of scientists, engineers, technicians, and administrators who are living witness to the fact that ours is an age of technology—and that technology is founded on accurate standards.

II. THE EVOLUTION OF SCALES

We return now to pick up the thread of that other great history, the evolution of the scale, or weighing machine. We shall attempt to trace here those revolutionary turning points which have dramatized this history and brought forth an evolving series of ingenious developments. We must distinguish between refinements and the discovery of new principles.

We have already pointed out that the equal-arm beam balance continued to be the only known weighing device for at least 5,000 years—until Roman times. This does not mean, however, that it retained its original form. Throughout these five millenia a host of refinements greatly increased the accuracy and convenience of the beam balance.

Refinements in the Equal-Arm Beam Balance

The first balance was hand held and pivoted on a knotted cord in a hole at the center of the beam. Or, it may have been suspended from an upright pole. It is also probable that baskets were used to hold the loads.

These early balances could perform the two basic scale functions: (1) adjusting the unknown load to match a predetermined weight, or (2) determining the weight of any load by adding weights of successively smaller or larger units.

Two significant refinements increased the accuracy of the early balance. One was the method of running the cord out of the ends of the beam so that they always lay flat against them. The use of the "lotus-ended beam" appeared in Egypt about 1500 B. C. A second refinement was replacing the cord pivot at the fulcrum by a dowel through the center of the beam, and at

FIGURE 3.

right angles to its plane of rotation, preventing wandering. In some cases, the dowel became a rod supported by two upright posts to give greater stability and accommodate much heavier loads.

The accuracy of the equal-arm balance depends upon the central pivot being exactly half-way between the beam-end suspensions, and also on there being the smallest possible area of contact between the fulcrum and the beam in its plane of rotation. Furthermore, for a state of equilibrium, the fulcrum must be above the center of gravity of the beam, thus ensuring maximum sensitivity.

The First Indicating Scale

The next advance in scale history was the improvement of readout by an indicator. Egyptian wall paintings and bas relief show a small tongue hanging down from the center of the beam and perpendicular to its longitudinal axis. A short plumb line and plumb shows that the scale is in exact balance when the indicator tongue is coincident with the plumbline. Another device was a plumb suspended by three cords. When the beam was balanced, all three cords were taut; when it was out of balance, either of the outer cords would become slack.

The Coming of the Unequal-Arm Beam Balance

For thousands of years the equal-arm balance was the only scale in use throughout the world. The increased use of metal provided sturdier and more accurate beams, but the principle remained the same.

Sometime around the birthyear of Christ, there appeared the first new scale principle: the steelyard. The steelyard has its equivalent in the ancient Danish bismar, and there are no records to show which came first, or indeed whether the Greeks or Romans invented the steelyard.

The steelyard is based on the principle of equal moments. A scale beam is, after all, a lever, and the principle of the lever is that of a force acting through a distance. This product of force times distance is called a "moment," and if the sum of two moments is equal, the system is in equilibrium. For example, a two-pound weight five feet from the fulcrum will exactly balance a ten-pound weight one foot from the fulcrum ($2 \times 5 = 1 \times 10$).

The steelyard also used for the first time the principle of the sliding counterpoise. This eliminated the need for pans.

The great advantage of the steelyard was its ability to weigh very heavy loads by much smaller weights. The beam of the equal-arm balance is a simple lever, with a ratio of 1:1. The steelyard beam, however, is a multiplying lever and, in the case given above, the ratio is 5:1.

The Danish bismar uses the basic steelyard principle except that here the weight, or load sensor, is fixed while the fulcrum is moved until the beam is balanced.

The Danish skale, which came into use somewhat later, is a type of steelyard in which the beam was notched on its underside and could be moved into different positions over a knife-edged pivot, thus changing the ratio, or multiplication factor.

The steelyard marks another significant advance towards more accurate readout. It became customary to cut notches along the top of the weight side of the beam to set the weights for predetermining the required load. This was the first calibrated readout even though it was probably not originally marked with numbers.

The Great Revolution: Self-Balancing and Self-Indicating Scales

The evolution of scales throughout history parallels those great advances in technology and the expansion of commerce. The first refinements of the equal-arm balance were made by the Egyptians at a time when they were rapidly growing to become the first great world empire and their commerce had spread over the whole of the Near East and as far as Crete in the Mediterranean.

Similarly, the steelyard appeared at a time when the Graeco-Roman civilization was rising to dominate the whole of the known world, and Greek and Roman commerce had expanded to include a great part of Europe as well as the Mediterranean and the Near East.

The Danish bismar was in use at a time when Denmark was a dominant force in the north, and had conquered Ireland and ruled a large part of England for two hundred years in the 9th and 10th centuries.

And now again a great new principle of the scale was discovered, and by an Italian at a time when Italian commerce dominated all European markets and the Renaissance was in full flower. It was perhaps about 1490 that Leonardo da Vinci, probably the most universal talent in the whole of history, designed the self-balancing, self-indicating scale.

In the self-balancing scale, the load sensor automatically balances the load without the necessity of moving or adding weights by hand. Leonardo's scale took two forms, but both operating on the same principle. In one, a semicircular disk was suspended from an upright post by means of a pivot at the center of its diameter. A weight suspended from one corner of the disk causes it to rotate, thus gradually increasing the mass opposing the load. Rotation stops when both masses are balanced. Another design uses a triangle suspended from its apex, and the load suspended from one corner of the triangle base. In this case the load causes the triangle to rotate about the pivot in the same manner as the semicircular disk.

Leonardo had here discovered the principle of the pendulum-resistant scale which was to become so widely used in the centuries to come. For both the semicircular disk and the triangle behaved as pendulums.

Just as significant as the self-balancing principle was its corollary, the self-indicating readout. Leonardo marked the arc of the disk and the base of the triangle with a calibrated scale to show the amount of rotation caused by the load and give an immediate indication of its weight.

Leonardo's great contribution to the science of weighing was not put to practical use for nearly 400 years, and he never built a model of it. It was just another sketch among hundreds in his famous Notebooks. Quite recently working models were made from the sketches, and they operated perfectly. And so this revolution in the art of the scale was just a paper revolution. But the self-indicating scale is today probably the most widely-used of all scale types—with the possible exception of the equal-arm balance found in laboratories.

The Knife Edge—Key to Accurate Balance

The next significant advance in weighing devices probably occurred near the time of Leonardo's invention. This was the use of the knife edge in both the central pivot and the beam ends of the equal-arm balance. The wooden wedge supporting the beam of the ancient Danish skale was an early use of the knife-edge principle. But a steel balance employing knife edges is first seen in a painting by Hans Holbein in his portrait of George Gisze, a Hanseatic merchant. Holbein's painting was so detailed and accurate that a working model was constructed from it and is now in the famous Avery Museum in London.

The metal equal-arm balance with knife-edge pivots is still the most accurate of all weighing devices. It is limited primarily by the exactness of the readout (which can be resolved by optical or electronic instrumentation) and the fact that so much time is required for the beam to come into balance after its oscillations.

The Next Step: Roberval's Mechanical Linkage

Five thousand years elapsed between the first known equal-arm balance and the appearance of the steelyard. And another 1,500 years passed before the invention of the self-indicating scale. But the time between new inventions was becoming shorter, and 200 years after Leonardo's invention, the Frenchman, Gilles de Roberval brought forth another new scale principle: a mechanical linkage equal-arm balance, known in his time as the "static enigma." Here two parallel equal arms, each pivoted at their centers to an upright post, are joined at their beam ends by vertical rods to form a parallelogram. Fixed to each vertical rod is a horizontal bar, one of which carries the load and the other the weight. This development had two great advantages: 1. the load and the weight could be suspended at any point along the rigid horizontal bars without changing the equilibrium of the scale, and 2. the load and weight bars always remained in a horizontal position, no matter how far they were raised or lowered.

Roberval's balance immediately opened the way for the familiar counter scale in which the pans are above the fulcrum, eliminating the need for chains and swinging pans.

Roberval's ingenious invention suffered the same fate as Leonardo's self-indicating scale, for it was not put to practical use for more than 150 years. After the beginning of the 19th century, however, it was adopted as the basis for all counter scales.

In the middle of the 19th century, a French scalemaker, Joseph Beranger, devised a scale consisting of a complex system of levers which provided each pan with four points of support, increasing the stability and accuracy of the system.

The Spring Balance

About 100 years after Roberval invented the mechanical linkage there appeared one of the simplest of all self-indicating scales: the spring-scale. Just as the pendulum offers increased resistance against the load as it is displaced, so the spring increasingly opposes the load until both come into balance. When the spring is extended, a pointer fastened to the load end automatically indicates the weight on calibrations on the chart.

There are many varieties of the spring scales besides the one developed by Salter in 1770: Sector, Mancur, Siebe, elliptical, and a spring scale with a circular readout. The circular reading face permits several sets of weight calibrations to be arranged in a concentric fashion so that as the spring is extended the dial pointer makes one revolution for lighter loads and more revolutions for heavier loads. The spring is also widely used in conjunction with lever systems—an example being certain types of personal-weighing scales.

Revolution in the Heavy Load Receiver

Almost the whole of our outline of the long history of scales and weights has been concerned with two of the basic scale elements, sensors and readout. But the increasing need for accurately weighing heavy loads as well as light ones required a new principle.

Up until recent times, and even today, huge steelyards were used to weigh very heavy loads. However, it was time consuming and inconvenient to unload a cartload of material onto the load receiver and then reload the cart. It was simpler to weigh the cart empty and loaded—then calculate the difference. Even so, this meant the tedious chore of unhitching the horses.

With the English Turnpike Act of 1741, which provided for the collection of tolls on the basis of vehicle weight, it became imperative to find a quick, easy method for weighing heavy loads. The solution came with John Wyatt's invention of the first true compound lever platform scale. This first platform scale called a "weighbridge," was built at Birmingham, England in the 1740's. The platform was flush with the road and the cart was simply halted on it and weighed immediately.

The weighbridge consisted of a large load-receiving platform and two large V-shaped levers which were pinioned through their apexes to one end of a third lever. The opposite end of this lever held a small circular table upon which were placed the various weights. Each V-shaped lever was supported with its ends resting on pivots. The platform supports rested on the V-shaped levers some distance from the ends. The principle of the platform weighbridge is that a load at any point on the platform is transmitted equally to the load end of the third lever and can be balanced by the weights at the opposite end. The V-shaped beams are levers of the second class in which the load is applied between the fulcrum and the power point. The power point of this system then becomes the load point of the lever of the first class, since the fulcrum here is between the load point and the power point.

Wyatt's compound-lever platform scale principle is used in most modern vehicle weighing machines, for it has the advantage both of equal transmission of the load at any point on the platform, and of the fact that the platform is always in a horizontal position.

The Ratio Beam Scale

In the 1820's, the American, Thaddeus Fairbanks, made the next important advance in scale history by combining the compound-lever platform with the steelyard to produce the ratio-beam scale for convenient weighing of heavy loads.

Fairbank's method of using fixed and sliding counterpoises replaced Wyatt's circular table with its loose weights. Soon the weight end of the steelyard beam was formed into two parallel beams so that heavy counterpoises could be positioned along the lower beam while lighter weights were moved along the upper beam for a fine reading.

Combination Scales

No less revolutionary than the discovery of the basic weighing principles is the combination of various principles to form families of scales for particular uses. For example, the compound-lever platform was combined with the self-indicating pendulum and circular reading face to produce the modern scale for weighing people.

Semi-self-indicating platform scales combine pendulum resistance with sliding counterpoises. Typical retail counter scales may use two pendulums rotated by a rack and pinion system, or a cam fastened to the lever system by a steel ribbon. A pointer attached to the cam swings through an arc to give the readout on a fan-shaped chart.

The Self-Computing Scale

The purpose of most retail scales is to show price as a function of weight. In the past it was left to the clerk to multiply the indicated weight by the price per unit weight. Early in this century the self-computing scale was designed to automatically indicate price as well as weight.

Price computation is purely a matter of readout, and two new types of readout were devised. Both consisted of a chart, or matrix, in which weight was indicated by horizontal rows and price by vertical columns. In the fan-type readout, the total weight of the item was shown at the top of the pointer while the total price was read off at some point down its length. The drum-type readout was a rotating horizontal cylinder which came to rest when the weight balanced the load. Price and weight were indicated through a window stretching along the length of the drum.

Both readout systems are widely used in counter scales. They mark a significant advance in the science of readout because they quickly show the price for any one of a wide variety of items.

The Great Turning Point in the History of Weighing

Looking back over our outline history of the significant revolutions in scale development, we can summarize these momentous advances in terms of the three basic scale elements: (1) the progress in the evolution of the load receiver from the primitive cord-suspended basket to the delicate knife-edge suspension of the modern pan balance; the Roberval linkage which permitted the pans to be fastened directly to the beam ends above the fulcrum while always remaining in a horizontal position; and the development of the compound-lever platform for the quick, convenient weighing of heavy loads; (2) the long series of improvements in load sensing, culminating in the self-indicating scale; and, (3) the evolution in readout systems from the arbitrary judgment of the human eye to the self-computing scale.

Two significant facts emerge from these observations. The first is that all of these advances have been mechanical. They depended upon the use of simple levers, compound levers, pendulums, springs, and pointers. The second is that, up to this point, the function of the scale was simply to weigh and indicate weight, or weight and price. The scale was a system in itself.

From World War I on, and particularly during World War II and the years immediately preceding it, the science of weighing was completely revolutionized. This revolution was to affect all three scale elements: Load receivers, load sensors, and readout. And it changed the scale from a system in itself to the scale as a component in much larger systems which carried out many other functions besides weighing. Yet the scale would remain as the brain and nerve center of these complex new systems.

Printed Readout

Symbolic of the new age was the combination of the scale with some form of typewriter to give a printed record of the readout—an achievement of the 1930's. Today the meats and cheeses in almost every supermarket are automatically weighed, packaged, and marked with a printed ticket showing weight, price per unit weight, and total price.

The Automatic Scale

The automatic scale is another example of the scale as the control component in a system. Generally called "batch weighing," the scale not only weighs material in a continuous flow, but controls the amount of material in each batch so that it will meet a predetermined weight. Here the load sensor is also the load controller.

While the first automatic scales were in use at the end of the 19th century, they more properly belong to the new era of mass production and automation.

From Mechanical to Electronic Systems

The transformation of the scale from a system to a component in a system has paralleled the transformation from mechanical to electronic technology. Electronics has completely altered the structure and operation of the basic scale elements. It permits us to weigh much heavier and lighter loads accurately and quickly. Electronic load sensors are so refined that readout is only possible through electronic instrumentation.

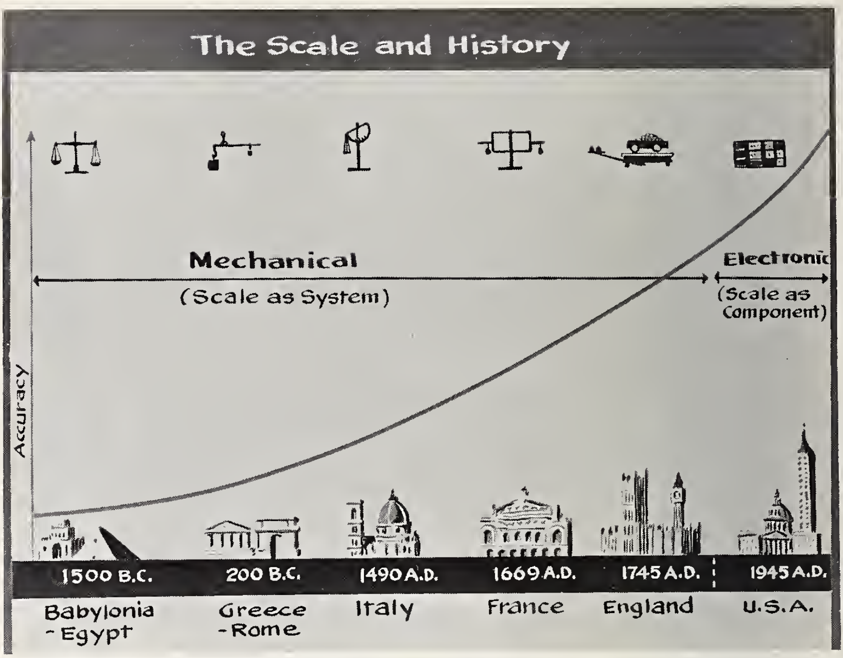


FIGURE 4.

The Load Cell

The load receiver in the past has almost always consisted of a platform or pan joined to a lever system. It transmitted energy from one point to another. The load cell transforms energy from one form to another. It is therefore often called a transducer. The thermostat which controls the temperature in your home is a transducer, transforming heat energy into control energy. The cell in your photographic light meter transforms light energy into the electrical energy which actuates a mechanical pointer.

Modern electronic load cells usually employ a strain gage. This sensor makes use of the principle that the resistance of an electrical conductor increases with tension and decreases with compression. Such a cell consists of perhaps five inches of fine wire, one-thousandth of an inch in diameter, arranged as a grid no larger than a postage stamp. When the grid is compressed by the pressure of a load, the electrical resistance of the wire is decreased, and the current flows more freely. The difference in resistance is measured in terms of the weight of the applied load.

The strain gage load cell can be used to weigh very heavy loads by making use of another principle. This is the fact that a steel column is deformed in direct proportion to the amount of stress, or pressure, applied to it. That is, the steel column can be compressed like a spring, but the contraction of the column is so slight that it can only be determined by very sensitive means. For example, a load of 50 pounds on the column may compress it only twenty-five millionths of an inch.

A strain gage bonded to a steel column provides a compact, fast-response system for weighing loads, such as heavy vehicles, railroad cars, or even whole lengths of track. The strain gage combines load receiver and load sensor into one unit. This is a revolutionary advance.

The Differential Transformer

Another new type of load sensor makes use of the principle of electromagnetic induction—discovered by Faraday a century and a half ago. A bar magnet moved through a coil of wire sets up an electric current in the wire. The differential transformer consists of a tiny iron bar fastened to the load receiver. The load moves the bar through a coil of wire, changing the inductive coupling between the primary and secondary windings of the coil. The change in electric signal, both in amplitude and phase, is proportional to the distance the bar is moved by the load, and can be read out on a meter.

From the Past to the Present

Having come in our historical journey from those prehistoric mists of the past, through those scattered records of thousands of years ago and the confusing abundance of information on the recent past, we stand now at the doorway to the present.

Our feeling must be one of wonder at man's ingenuity and perseverance as he has transformed the Egyptian balance into our modern systems of incredible complexity, accuracy, and flexibility. Yet we can also observe that each new device did not supersede the others, for the equal-arm beam balance is with us today as it was thousands of years ago. And throughout the world many a market woman weighs fish on a steelyard almost identical to that used in ancient Rome. The simplest types of Roberval and Beranger scales are still found on retail counters everywhere. So we may say of scales, as we cannot say of humans, that most of the past generations are still with us in the present.

Throughout our story we have shown time and again that the greatest developments in weighing machines occurred in those nations which were rising to a dominant position in commerce and technology. Thus it is no chance coincidence that the great revolution in scale elements and automated systems is taking place chiefly in the United States. For this revolution was born of the invention of interchangeable parts by Eli Whitney, of the production line by Henry Ford, and of the electronic computer by the scientists of IBM and Harvard.

Ours is not only the history of the science of weighing—it is also the history of the increasing importance of that science. For the need and the desire to weigh almost everything has become so much a part of our civilization that we are scarcely aware of it. Yet if we begin with our own persons and extend our thinking to our environment, we find that everything we eat, everything we wear, every material in our houses, in the cars we drive, and the roads they travel, has been weighed at some point in its processing. More than this, our whole society, with its systems of government, codes of law, its huge cities, and its astonishing technology which is now reaching through space towards other planets than ours—all of these are unthinkable and impossible without an accurate standard of weights.

Nothing, perhaps, is more symbolic of the meaning of weights to civilization than the age-old figure of Justice holding in her hand an equal-arm pan balance, with her eyes blindfolded so that she will not let her emotional judgment interfere with the impartial verdict of the scales.

The Bible makes it clear that a solemn and heavy responsibility has been placed on those of us in the scale profession. But it implies that, if we live up to this responsibility, we will also live longer than others. For it says, "But thou shalt have a perfect and just weight, a perfect and just measure shalt thou have; that thy days may be lengthened in the land which the Lord thy God giveth thee."

THE SCIENCE OF WEIGHING—TODAY

by C. G. Gehringer, *Sales Manager, Hobart Manufacturing Company*

Modern-day weighing has departed from the old concept of adapting an existing piece of equipment to do any job required. True, over the years various types of weighing equipment were developed to handle particular classes of weighing. The portable scale, the dormant or built-in scale, the hopper scale, the motor-truck scale, and the railway track scale are illustrations of this kind of development. In the past, when a particular weighing job was required, one of these classes of scales was used even though it did not particularly fit the job to which it was applied. Weighing today has progressed to the point where, when necessary, the final instrument is a marriage of a wide variety of load receivers, sensors, and readouts, assembled to properly perform a function that satisfies a particular job.

While a scale no longer need be a packaged unit, but frequently is an assembly of various components, this does not mean there are no uses for standard scales. Many applications can still be handled best by an "off the shelf" unit.

The Scale

To better understand the application and use of scales today, let us examine the main component parts which make up all weighing instruments and see how these are used in various combinations to meet a variety of jobs. As we look to the history of weighing, we see that scales are made up of three main components: Load receivers, load sensors, and readouts. Each of these components can be of various construction, some better fitted for one application than another. To obtain the picture of scales as used today, we will discuss designs generally known and used, including a few designs that are strictly experimental.

Load Receivers

The first component to consider is the load receiver, of which there are two kinds—levers and load cells.

Levers.—The designs available in levers, ignoring materials, utilize the commonly known laws of statics. To provide the necessary fulcrum, load, and power points that a lever requires, knife edges, flexures, or ball bearings are most generally employed.

Knife Edges.—As a purely mechanical bearing, the hardened knife edge supported by a hardened flat steel bearing probably provides the most frictionless bearing obtainable. Knife edges range in design from a 90-degree angle to as low as a 15-degree angle edge. The actual finishing of the edge varies from a straight side to a hollow-ground edge. Occasionally, a definite radius in place of a sharp knife edge is used on very heavy-capacity load receivers. For very sensitive scales, very sharp, even hollow-ground, pivots are employed to obtain great sensitivity. The degrees of angular movement through which the pivot must move frequently dictates the type of edge employed. The greater the angle of the knife edge, the smaller the angle between the side of the knife edge and the supporting bearing.

Pivots are made of materials to meet the conditions under which they must operate. A very high-carbon tool steel is usually employed where conditions are dry or the pivots can easily be protected from moisture, corroding fumes, etc. Where there is a great deal of moisture, or where corrosive or erosive agents come in contact with the knife edges, stainless steel is generally employed.

A very hard knife edge on the pivot to prevent rapid wear is desirable. High-carbon tool steel will produce an edge in excess of 60 Brinell hardness, while certain types of stainless steel can be utilized to produce a hardness of between 55–59 Brinell.

The pivots in modern scales are machined to definite size and are held in their levers by machined ways of various types.

The opposing bearings to the pivots are generally made of the same material as the pivot, but in some instances, where shock loading is not a factor, hard smoothly finished agate is used.

Like pivots, steel bearings are made of various types of metal with a hardness equal to the pivot. Also like the pivot, the back of the bearing usually is soft metal, while the bearing surface itself is hardened. This prevents cracking under shock load.

Flexures.—In some scales, in place of a knife edge with its opposing bearing, machined plates, fastened rigidly to the lever and the fulcrum stand, load point, and power point, are used. These plates work best when the scale operates on a null balance principle. As a lever is displaced due to the load being applied or removed, it tends to rotate and causes a flexing of the plates. The load and power plates are usually restrained so they maintain a vertical force on the lever. Steel used in flexures varies, but it must have the characteristic to withstand this flexing.

As a plate flexes, it sets up a resistance. When the lever is returned to its null or horizontal position, this resistance disappears, so there is no effect on the weight transmission from the resistance caused by bending of the plates. This does not mean a lever fitted with flexures cannot be used to weigh with the lever displaced from its normal horizontal position. In utilizing the lever in this manner, the resistance of the plates must be taken into consideration. This resistance in properly manufactured flexures is linear and can be included in the sealing of the lever.

As the plates are rigidly fastened between the lever and its fulcrum or between the lever and the load or the lever and the power., precautions must be taken to prevent horizontal displacement of the lever, load or power. This normally is accomplished by having rigid checks on all elements, which hold them in their place. Any serious displacement in a horizontal line can result in cracked plates, which, of course, destroys the plate as far as flexing is concerned. Flexures are not subject to the usual wear found in other types of mechanical bearings, and, when properly protected from corrosive and erosive elements, will maintain the same sensitivity throughout the life of the flexures.

Another type of flexure commonly used in even-balance type load receivers is the torsion tape. In this construction, a relatively thin steel flexure is fastened horizontally in tension between two stands. The lever is supported by this steel flexure and fastened to it. As a load is placed on one side, the flexure is twisted, and when the load is counterbalanced the flexure resumes its normal position. This results in a highly sensitive unit.

Ball Bearings.—There are times when ball bearings are used to provide fulcrum to levers. Frequently, when a ball bearing is used to support a lever and provide a fulcrum, the load and power are applied to knife edges, but there are also times when both a load and power are applied through ball bearings. The use of ball bearings as fulcrums generally is the result of a high thrust on the lever. Often, such as in certain types of levers where a heavy weight is attached to the side of the lever, the moment arm of the weight is such that the lever would be unstable with a knife-edge fulcrum. In such cases a ball bearing provides a means of holding the lever in place. At other times, horizontal forces that might be applied to the lever which could displace it are overcome by the use of ball bearings. The ball-bearing fulcrum has a higher degree of friction than either the knife edge or the flexure plate.

Load Cells

The next type of load receiver commonly used is the load cell. Load cells offer certain advantages over levers. They are compact and consequently require considerably less space, especially in the very heavy capacities where exceedingly heavy levers are required to sustain the load. They are easily portable, whereas the lever scale is rather cumbersome. They provide an entirely different type of result than the levers. Whereas levers give a reduction of actual load, the load cell transmits the pull of gravity into a pressure or electrical signal.

There are three basic types of load cells employed in weighing today. These are electric, hydraulic, and pneumatic. Each one has its own characteristics.

Electric Cells.—The electric load cell in general use consists of a metal base that will flex under load. This metal base may be one or more steel columns, a proving ring, or of a cantilever construction.

Column.—The principle behind the steel-column cell is the change in the length of column when it is placed in compression or under tension. Actually, a column acts as a spring and is subject to hysteresis, zero drift, temperature and humidity changes, the same as any spring. To measure this change of length, thin-wire resistance strain gages are bonded to the sides of the column. These strain gages are insulated from the column itself, but elongate or compress in direct proportion to the column. A low-voltage electric current is passed through the strain gage. As the strain gage is compressed or elongated, it changes diameter and offers less or more resistance to the flow of the current. The change in resistance in the strain gage is proportional to the change in the diameter, which, in turn, is proportional to the amount of compression or tension that is placed on the cell. This, then, is the basic signal that is transferred into a weight unit. Depending on the amount of current passed through the strain gage, the change in resistance varies from approximately 6 millivolts to 24 millivolts from zero to full capacity.

Proving Ring.—On some capacities, the column actually is of the proving-ring design rather than being a solid rectangular column. Strain gages bonded to the proving ring change their diameter as the ring is compressed or elongated, and the results are the same as with a column.

Cantilever.—In using a cantilever-type construction, which normally is a steel bar bent into the shape of a C, with the top and bottom flat, the bottom arm of the C becomes the base, and weight placed along the top arm causes the steel cantilever to flex. This movement is quite great in comparison to the amount of elongation or compression of a straight steel column. The greater movement makes it possible to utilize a linear differential transformer at the open end of the C. As the slug of a differential transformer moves up or down in the coil, a varying signal is produced. This varying signal is then transmitted and converted into a weight indication proportionate to the amount of deflection caused in the cantilever arm.

In both the strain-gage and the linear-differential-transformer load cell, the signal is relatively small; and in order to utilize it and break it down to the minimum divisions required for the capacity of the scale, the change in current output is amplified to usable magnitudes.

Electric load cells are normally enclosed in a sealed case to prevent the entrance of moisture, which might cause errors in conductivity in the electric elements.

Hydraulic Cells.—Hydraulic load cells consist primarily of a standard hydraulic cylinder. As a load is applied to the hydraulic cell, a corresponding pressure is exerted by the fluid through lines leading to a load sensor. The manufacture of these cells for weighing requires great precision and excellent sealing to eliminate outside friction and to insure against loss of fluid and make certain the transmission of full pressure applied by the load placed on the cell. In practically all instances, these are compression units.

Pneumatic Cells.—Pneumatic load cells are utilized in numerous instances as load receivers and operate similar to hydraulic cells, with the exception that they use air or gas in place of fluid.

Both hydraulic and pneumatic load cells are capable of withstanding great overloads without injury.

Load Sensors

The signals from the load receivers must be received, transmitted, and processed into a usable output that can be interpreted by a readout. Various load sensors are available to handle the different types of output produced by load receivers. These load sensors can be broken down into three main categories, which are manual, semiautomatic, and automatic. Let us consider each one in turn.

Manual—Weighbeam.—The most commonly used manual sensor is the hand-operated weighbeam. A weighbeam is a lever equipped with a movable weight which is used to apply power to the lever along the power arm, thereby providing an adjustable power point. Attached to the lever is a bar graduated in weight increments. As the weight, called a poise, is moved along the power arm of the lever, it will, when it brings the lever to a null-balance point, indicate the value of the weight on the load receiver. This whole assembly is known as a weighbeam.

Weighbeams come in various types of construction utilizing one or more graduated bars attached to the weigh lever. In order to get a minimum graduation small enough to accommodate light loads, yet provide a sufficient amount of capacity to weigh larger loads, and at the same time restrict the length of the weighbeam to practical limits, weigh levers are at times equipped with an additional stationary power point. This stationary power point is normally located beyond the travel of the poise. It is known as a counterpoise and is designed so that known weights, with the value of the load they will offset marked on them, can be placed at this point to compensate for most of the load placed on the load receiver. The value of the weight in between the increments established by these counterpoise weights is then determined with the sliding poise.

Other weighbeams are so designed that the full capacity of the load receiver is graduated on the weighbeam itself, and there is no need for counterpoise weights.

The hand-operated weighbeams generally are designated as single where there is one graduated bar and counterpoise weights are used, and double where two graduated bars are furnished and counterpoise weights are used. On the double beam, the one bar is normally used to offset the weight of a container or load carrier which may be on the load receiver, so the net weight of the load can be obtained by the use of the second bar and counterpoise weights. A full-capacity weighbeam is one which uses no counterpoise weights and can be equipped with one, two, or more graduated beams. When equipped with more than one graduated beam, one beam is used for net weighing, while the balance of the beams are used for tare purposes. A multiple beam is used when it is desired to weigh more than one weight, applied successively to the load receiver without removal of previous loads. With the multiple beam, the weight of the first load can be balanced and the value obtained on one beam. When the second load is put on the receiver, this can be balanced with the second beam and the load noted.

Electric.—Another type of manual load sensor is the hand-operated electrical balance. In this type of sensor, a signal is received from an electric load cell or other electrical transducer. The hand-operated electrical balance provides a null-balance system in which the signal received from the transducer must be offset by an equal signal being manually introduced into the system. This is normally accomplished by the operator operating a graduated knob attached to a potentiometer. As the potentiometer is adjusted to provide an equal opposing current to that being received from the transducer, the operator reads the figures graduated on the adjusting knob to obtain the weight.

Semiautomatic—Manual Ranges.—The next type of load sensor to consider is the semiautomatic. The semiautomatic load sensor is usually a combination of fully automatic and manual units. A good example is an automatic sensor of relatively low capacity that utilizes manually applied ranges, drop-weights, or counterpoise weights to expand the capacity of the system. As we will see in readouts, this will encompass certain dials and fan-type units.

Automatic.—The automatic load sensors cover a wide variety of units, among which are mechanical, mechanical-electrical, electrical, hydraulic, hydraulic-electrical, pneumatic, and pneumatic-electrical. Considering these in turn, let us take a brief look at the most popular automatic mechanical sensors.

Mechanical.–Practically all mechanical sensors are of the null-balance type. The signal from the load receiver is offset by an equivalent signal produced by the automatic indicator. The most commonly used sensors to produce this signal mechanically are pendulums and springs. A pendulum mechanism is basically an automatic weighbeam. Pendulum units utilize weights to provide power. These weights are automatically positioned to offset the load received by the pendulum mechanism. Either one or two pendulums can be used for this purpose.

The spring is a force transducer based on Hook's Law and, through elongation, provides the necessary power to offset the load being transmitted to it. The amount of elongation is in direct proportion to the applied load. It can be a single- or multiple-spring sensor, depending on the capacity, travel desired, etc. Both the pendulum and the spring are highly sensitive, accurate load sensors. Units using these principles range from the common bathroom scale to complicated center-of-gravity units.

Mechanical-Electrical.—Frequently, to utilize the information obtained from the load receiver to the best advantage, an automatic mechanical-electrical sensor is employed. Mostly, these use one of the two automatic mechanical load sensors as the mechanical part. In addition, however, one other type of mechanical equipment, the weighbeam, may be utilized.

On the pendulum and spring units, as a load is applied and the pendulum or spring offsets the signal obtained from the load receiver, transducers or other controls are actuated. On the weighbeam the poise is motor-driven, and, as the load receiver sends its signal to the weighbeam, the weighbeam goes off balance. The electrical equipment immediately senses this out-of-balance position of the weighbeam and actuates a motor which drives the poise, usually by means of a finely threaded screw. When the poise is driven to the point where the beam will balance, the electrical connection is broken and the movement of the poise is stopped.

A scanner system is employed at times. As an automatic mechanical sensor reaches a balance point, it exposes a number of lines representing the percentage of capacity of the sensor offset by the load on the load receiver. These lines are then scanned and counted electrically to produce a signal which can be converted to a weight. Sometimes when, due to outside forces such as vibration, the sensor cannot reach a stable balance, the varying number of lines uncovered are scanned repeatedly and fed to an averaging computer to arrive at a weight, even though the sensor never can come to a complete null-balance.

Recently, a continuous instantaneous weight sensor has been introduced. It employs a microscopic binary code, representing weight, photographed on a glass disc which is rotated by an automatic balancing system. The code is projected on a glass screen behind which is located a series of photo cells. These cells, in various combinations set up by the projected code, instantly transmit the weight signal to a readout.

Transducers are attached to the pendulum and spring mechanism, as well as to the driven screws on the electrically operated weighbeam. These transducers, consisting of potentiometers, servo-systems, linear differential transformers, and scanners, then convert the load-sensing signal into signals that can be used for other means. Electrical contacts can be used to automatically add or deduct automatically applied ranges or drop-weights.

Electrical.—A fully electrical automatic system frequently employs a null-balance principle. In this system, an electrical signal is received from the load receiver and amplified. The current is then directed to a small servo-system which positions the potentiometer. The potentiometer provides a null-balancing signal to offset that which is received from the load receiver. As soon as the signal produced by the potentiometer equals that obtained from the load receiver, the system ceases to operate.

Other automatic electrical systems are in use to a limited extent today. These consist of magnetic units in which the current produced operates a precision magnet to offset a load. Still others utilize the signal generated by crystals to produce a readable electrical output which can be converted into weight. These latter are very much in the minority at present and are not generally part of today's weighing.

Hydraulic-Pneumatic.—The hydraulic load sensor is an automatic unit utilizing a pressure cylinder to convert the signal received from the load receiver to an output that can be converted to a readout. The automatic pneumatic load sensor operates on the same principle as the hydraulic load sensor in that it, too, is a pressure cylinder which converts the signal received from the load receiver to one utilized for readout. The fundamental design of both of these sensors is the same as the cylinder used with a pressure gage. Of course, great refinements are employed in manufacture of these units to produce the accuracies required for today's weighing.

Hydraulic-Electric—Pneumatic-Electric.—The hydraulic-electric and pneumatic-electric automatic load sensors use pressure cylinders, and the output of the pressure cylinder is utilized to operate certain electrical equipment. One of the most popular is the utilization of the output of these cylinders with Bourdon tubes which accept the signal and, in turn, operate linear differential transformers. These transformers, of course, then produce an electrical signal which is converted to a usable output for operating certain readouts.

Readouts

Load sensors, of course, feed into the readouts. There are many different types of readouts, but in today's weighing the two principal types are those that are on the site as an integral part of the weighing system itself and those that are remote.

On-the-site readouts include beam faces on hand and automatically operated weighbeams, sensor-operated dial charts (such as those utilized with pendulum and spring scales), sensor-operated charts themselves (such as the strip-chart recorders and circular-type recorders), sensor-operated digital readouts (which are essentially similar to a Veeder-Root counter or the odometer as used on an automobile), and scoreboard-type and sensor-operated projections (which can be practically any type of mechanical sensor that operates a projection system, projecting the converted values which are now weight increments onto screens of various types). In addition, digital printed weights, either with or without charts or projections, are used extensively. These employ the step-cam system or a binary coded disc.

Remote sensor-operated readouts and printouts normally are electrically actuated. Even though they are located right at the scale, they are considered remote because it is as easy to utilize those away from the scale as it is at the scale. These electrical remote readouts usually operate dials, charts, projections, digital indicators, typewriters, light banks, adding machines, tape punch machines, computers, etc.

To fit the problems of today's weighing, the utilization of the various load receivers in combination with various types of load sensors and readouts provides a very pliable system that can do the job required in the best manner.

The utilization of the various types of scales plus added equipment has truly made the scale a factor so vital in today's economy that, without these, this economy could falter.

Today's advances in knowledge, techniques, and modern technology make weighing equipment absolutely indispensable. Life itself depends on weighing today. Agriculture depends on it, industry depends on it, trade and commerce depend on it, your government depends on it, and, without it, our advances in science would be impossible.

The Scale Today

We mentioned that life itself depends on the scale. One of the first things that happens to a child after it is born is the determination of its weight. Frequently nature produces a child that is not yet ready for life. The struggle to maintain life in many instances is completely guided by weight. A constant check on the weight of the child denotes, in these instances, the progress the child is making in its fight for life. If the scales reveal the desired result is not being obtained, new formulations and new attacks on the problem are the result.

Many adults today owe their lives to the fact that scales revealed what had to be done in order to save them. In the operating room, one of the most important things is the measurement of the loss of fluids. A patient's life depends on this knowledge. Doctors are constantly checking weight; and to give them this knowledge, some special scales have been designed. New drugs on the market are so powerful that the amount given to each patient is critical. This amount is determined by weight. Frequently physical problems require a close control on the intake of certain foods. Such diets are based upon weight.

The use of the laboratory balance, both mechanical and electronic, the use of the dietary scale, the use of the person-weigher, all play very important roles in the maintenance of life itself. Even in death, weight again plays a part. Frequently, the amount of embalming fluid injected into the body is determined in proportion to the weight of the body. Autopsy scales provide medicine with information which helps extend our life span.

Agriculture could not succeed without weighing. Today, to grow the amount of food required on the available land, we are producing seed to give us greater yield. In the production of these seeds, both weight and count are important. Small laboratory scales and counting scales are used for this purpose. The amount of seed to plant per acre in order to obtain the best results is determined by weight. The amount of fertilizer to be used per acre in order to properly nourish the crops to produce the greatest amount of food is determined by weight. Even the feeding of stock is by weight, because it is necessary for the farmer to keep a record to determine whether weight is gained at the speed required. Those that do not gain must be eliminated. Those that do gain do so on a weighed amount of feed given to them daily. The mixture of the feed to produce the most rapid gain in the cattle is also formulated by weight. For this, the motor-truck scale, the stationary and portable stock scale, the hopper scale, and the truck-mounted scale are all utilized.

The wholesale and retail distribution of food is controlled by weight. The farmer, delivering his crops to the grain elevator, weighs them on motor-truck scales. His cattle, when sold, are weighed on cattle scales. As the animals are killed and processed through the packing plants, they are weighed frequently to determine yield, grade, the amount of loss, and shipping weight. Produce is purchased by weight by the processor and wholesaler and is resold to the retailer by weight. The retailer, in turn, sells it to the consumer by weight. Truly, without scales agriculture would come to a standstill.

One of the most prolific users of weighing equipment is industry. Consider everything around you that is not in its natural state. (Probably the only thing you will see that is in its natural state is wood; and even this, in many cases, has been processed.) The paint on the wall, the glass in the window, the tile on the floor, the metal in the chairs, the nylon in your suits and dresses, the paper in your hand, the plastic in your glasses frame, the synthetic covering on your chair, the rubber on the heel of your shoe, the money in your pocket, the rouge and fingernail polish on the ladies, the aftershave lotion on the men, the lead in your pencil, the toothpaste you used this morning—all are products of formulation. None of these items is found in its natural state. They are manufactured, and they are proportioned. Every single one of these items has been made by weight. Not only once have they been weighed, but many times.

Let us consider briefly how these are formulated. In today's economy, with the high production required to satisfy the needs of our people plus the necessity for keeping costs down, these products are formulated automatically by scales. Not only are they formulated by scales, but scales probably have controlled all or a great part of the manufacturing.

Examining a few batching or formulating systems, one can see that a lot more than a scale is involved. One or more of the load receivers, one or more of the load sensors, and one or more of the readouts are utilized in these systems. In addition to this, many outside controls also are employed. As an example, let us consider the problems facing the producer in a concrete batch plant. Not all concrete delivered to a job is of the same formulation. The engineer today demands a formula which is the best for his project. How does he specify? He specifies each ingredient used in the formula by weight.

To automate the concrete batch plant, a punch-card or formula-capsule system, which contains the various formulas, frequently is used. Different aggregates and different cements are used. Sand is a very important part of the final product. The amount of water used in the mix controls the time required for the concrete to set up and attain its required strength. Formulas differ not only in the products used, but in the total amount of concrete desired. Sand absorbs moisture, and this moisture will go into the final product and must be taken into consideration.

Today the formulation and the amount of each ingredient is put on a punch card or formula capsule. These are then inserted into readers, which immediately sense how much weight of each ingredient is to be used in the final product. The system automatically starts up and the scale tells the system when the proper amount of each ingredient has been delivered. The scale also controls the conveyors and other material-handling equipment that delivers the various materials to the multiple weigh-hoppers. The system automatically determines how much moisture is in the sand and allows for that moisture, so that, when water is added to the mix, only that amount is added which will bring the final total of water to exactly what is required by the formula. When the final ingredients are in the batch, the scale tells the system to dump this into the mixer. When the proper mixing time has elapsed, the completed batch is delivered to the carrier, which, in turn, delivers it to the job. The heart of this whole system is the scale. The scale determines when things happen, determines how much of each ingredient goes into the formula, and delivers the final product as it is specified.

The same general procedure holds true for the glass, rubber, plastic, steel, chemical, bakery, paint, and other plants.

Power plants located near mines receive fuel, weighed over conveyor scales, direct from the mine.

Practically everything you receive today is packaged. These packages must be filled. Almost all packaged goods are sold by weight, so the proper amount must be delivered to the package. Consider packages of flour. Each of these has been filled by weight. As an illustration, the automatic bagging scale takes the ingredient, weighs it, and then delivers it to the bag. All of this is done automatically. The scale controls the flow from the supply hopper, the scale trims the load to the proper amount, and the scale delivers the load to the package. In addition to this, interlocking controls prevent the scale from delivering when the package just filled has not yet progressed far enough to allow the system to accept another package. The scale shuts down the whole system when an insufficient amount of material is available for a continuing process. The scale again is the heart of the whole system, and the scale delivers at a high speed and low cost the packages which make it possible for the manufacturer to provide the consumer with a product that is within the reach of that consumer's purchasing power.

Not all packages are weighed as they are filled. Volumetric filling is frequently employed. These machines are designed so they can be adjusted to deliver more or less material. To check the amount of material placed in the container, special checkweighing scales have been developed. Since these scales need to indicate or read out only a small amount of weight on either side of a target quantity, they usually are of the restricted-movement type, in which there is no scale response unless the commodity is within a small range, plus or minus, of the predetermined setting.

As production-line speeds of food products, chemicals, automotive parts, and the like, increase, checkweighing scales are required to perform weighings in ever shorter time intervals. Speeds on the order of 100 to 400 per minute are quite common, with some production lines running even faster.

The importance of proper weights at such speeds can be readily realized if one considers the cost to the producers of even small amounts of overfill. For example, a food product worth 50 cents per pound on a relatively slow 100-per-minute line is worth $50 for each minute of production. Even a small overfill of 1 percent, or approximately $3/16$ ounce, can cost that producer $30 an hour, or $240 in an 8-hour shift. Such a loss projected over a 300-working-day year, on one shift only, amounts to $72,000. There are, of course, many other important considerations such as guarding against short weight for the consumer.

Faster weighing operations required many significant changes in scale design. The older principles of weighing with systems that involved large masses in motion and lever-restoring force from pendulums are no longer adequate. Inertia in the lever systems was reduced, and the movement of the mechanisms per unit of weight applied was greatly restricted. Restoring forces usually are produced by springs in one form or another. Even on systems which are essentially even balance, where an unknown weight is compared with a known counterweight, the small range of variation indicated on predetermined-weight and checkweigh scales is usually controlled by a spring-restoring force.

A scale can be likened to any tuned oscillatory mechanism involving mass and restoring force. It can be seen that virtually any such mechanism can be made faster by increasing the restoring force, even after the mass in motion has been reduced to the minimum practical. Obviously, if that device is a scale, the motion, or mechanical sensitivity, per unit of weight applied will decrease as restoring forces and speed are increased.

The need for lower mechanical sensitivity with increased speed of response led to the development of electrical and electronic indication, readout, and control systems. With modern checkweighing machines, weigh cycle time intervals are in the order of 0.1 to 0.5 second, and mechanical movements in the load receiver are sensed electrically to 0.0001 inch with great reliability.

Another development in connection with fast checkweighing of commodities in motion is the refinement of transfer systems which move the commodities on and off the scale. It is necessary to allow only forces related to weight to register on the scale. Impacts, the sloshing of liquids in containers, the rocking of a tall box, or even the aerodynamics of the package can introduce errors if they translate to vertical forces on the scale. Many and varied conveying and transfer means are employed to eliminate these factors.

Vibration in supporting framework or in floors can be detrimental to the fast-response, restricted-motion scale mechanism. More or less elaborate means are employed in the mechanical dynamics of the system to offset these effects. Also, some systems filter out, electrically or otherwise, the vibration-induced signals from the weight signal, though this is often impractical, especially if the disturbance frequency approaches the weigh-cycle frequency.

Modern checkweighing machines utilize a great many of the techniques in general use by the instrumentation and control industry. Weight readout and display systems of nearly every type are used as accessories. Statistical control techniques and computers monitor commodity weights automatically and effect corrective action at fillers ahead of the weigh stations. Rejection and segregation of commodities by weight into many channels are commonplace.

It is worth noting that the scale industry is often called on to produce overall system accuracy to a much higher degree than most typical electrical and control instrumentation used in other industries. One-tenth percent (0.1 percent) is a common requirement for scales, and often the requirements are much tighter. Modern weighing equipment has kept pace with these stringent needs. The buyer of scales today can specify phenomenal speeds and can get readout information in many forms—decimal, binary, analog, or in combinations—to feed into computers or control systems of his choosing.

No one has estimated the value of goods that is produced each year for distribution in predetermined-weight lots. None will deny that such goods are worth many billions of dollars. The potential for savings to the producer and the consumer are tremendous. No longer is it necessary for the management of any company to wonder how much of his production has gone to his shipping department either slack-filled or overfilled. Automatic checkweighing machines keep a constant and tireless account of the efficiency of production machines. Not only do they attack the weight problem through the first step (measurement of the commodity); they also analyze the error pattern, and they initiate corrective action by means of auxiliary control systems. Modern checkweighers are tuned with the times.

With the prodigious consumption of materials today, one of the biggest problems of industry is to keep a balance of inventory to permit continuous manufacture at high speed. Incorrect inventory or lack of inventory can cause layoffs with consequent loss of money to the stockholders of the company, and loss of work to labor. Inventory control, therefore, becomes a very vital concern to every company. Again, scales become the deciding factor. Raw materials are received into the plants and checked in by railway-track scales, motor-truck scales, hopper scales, built-in scales, conveyor scales, etc. The amount of each item is recorded by the scale either at the scale or at a remote point where inventory control is established. As the material flows in, the equipment records the weight, and credit is issued to the inventory. As the raw material is removed from the inventory, it is moved over scales in order to formulate it and produce the final product. As each scale weighs out an identified material, information on how much of that material has been weighed out is transmitted to the inventory control department and goes on the debit side. This provides an immediate check by the inventory control department and makes it possible to route the proper material to the plant in time to keep the plant producing at full capacity. Just another instance of weighing today accomplishing something other than producing an indication of pounds and ounces.

Trade and commerce could not exist without scales. The tin coming from Bolivia, the rubber coming from Malaya, the raw materials coming from all over the world to the United States or going from the United States to the other countries of the world, or between other countries, moves in terms of weight. The life blood of freight transportation depends on weight. The railroads do not haul wheat, stone, iron ore, machinery, food, oil, etc. Railroads haul tons. So do ships, trucks, and planes. The life blood of these companies, the thing that produces the revenue for them, is the weight they haul. Every single bit of revenue reverts to this. The government even fixes the rates they are allowed to charge by weight. Not the amount they are allowed to charge per bushel of grain, per gallon of oil, per foot of steel, but in terms of pounds.

Money is only a medium of exchange. Weight becomes the important factor. Scales are designed to automatically convert from metric to avoirdupois weights. The shipment of diamonds, radium, nuts, fruit—in fact, the complete international exchange—depends on weights. Trade and commerce might easily be described as the exchange of weights.

Your government could not exist without weighing today. Tax is collected on vehicles weighed over motor-truck scales to determine the licensing fees. Highways are built for definite weight capacities, and trucks are tested constantly by axle-load scales to assure they are not overloaded. Tolls on bridges are collected by weight. The amount of gold our government owns is determined by ounces. The amount of various metals used in each coin is determined by weight. The tax collected on whiskey and tobacco, two of the greatest sources of revenue of our government, is determined by weight. Even the size of a loaf of bread that is being sold is set by the government according to weight. The letter and parcel post move by weight. Truly, the functions of the government are today closely tied to weighing.

Today we speak of the atom, of space travel, of exotic materials, much as we speak of the weather or of food. The scientific marvels of our age are being accepted as commonplace. Science could not have progressed to its present stage without modern weighing equipment. As an illustration, the knowledge gained through research into the atom has been closely connected with weight. Uranium 238 and 235 are strictly weight designations. The proper mixture of various items to make up fuels for the launching of our space ships is determined by weight. The main reason for miniaturization, which has been carried to such a great extent in our missile program, has been because of weight considerations.

The measurement of mass on the moon and planets is of great importance to science in our future space exploration. The knowledge we have today, brought about by scientific research into the wonders of the world, is directly connected to weighing.

Without a doubt, weighing today is responsible for most of the tremendous progress made in the 20th Century. Think of synthetics, a mixture of materials by weight to produce the final product. Think of air travel, the new designs of planes to provide greater lift, to cut down drag, all brought about through the use of scales testing the lift, drag, pitching and yawing moment, the center of gravity. Think of the new lighter, stronger materials such as titanium and magnesium made possible through the use of weighing equipment to formulate them. Think of the tremendous progress made in steel with the new basic oxygen systems where the whole process, including computers, is tied into weighing. Think of our present high standard of living brought about by the ability to produce the synthetic materials, food, etc., at low prices we can all afford. Weighing equipment has made this possible.

Little of our scientific and technological progress would be possible today without modern weighing equipment.

We could go into greater detail on individual applications of weighing equipment, but we would only touch a fraction of a percent of the total. We could write books on the use of weighing equipment in one small industry.

The scale is no longer a piece of machinery used only to obtain a weight. It is an instrument designed to do a specific job in a specific way and to provide to the user exactly what he needs, whether it is a weight alone or the complete control of a system.

Weighing has always played a very important part in the lives of people of the world. It has become increasingly important in the 20th Century. What does the future hold? This we cannot say. But if history is prologue, weighing will become even greater in importance as we continue to progress.

THE SCIENCE OF WEIGHING—TOMORROW

by V. C. KENNEDY, JR., *Executive Vice President, Streeter-Amet Company, Grayslake, Illinois*

When we speak of the future we are, at best, looking through a cloudy crystal ball. The further ahead we look, the less we can project with any reasonable degree of accuracy. Fortunately, information in science and technology is nearly always ahead of its practical implementation. We can also look into the future with demographic projections and consider the trends in modern technology.

There is at least one way of making use of the past to determine the future, i.e., major technological breakthroughs that have occurred, but have not yet been applied in industry. The speakers who have covered the past and present of weighing have discussed classical and modern weighing techniques. As we project into the future, we can make use of these past breakthroughs as a tool to see what may lie ahead in weighing.

In order to look into the future of weighing, it might be desirable to make an initial step forward 20 years to the year 1985. In order to establish a frame of reference for this period, it is possible to make some conjectures on what the world environment will be during this period, with particular emphasis on the United States.

Demographic indications are that, by 1985, the population of the U.S. will range from between 250 and 275 million. We will be a nation of young people, with a median age well under thirty and approximately 50 million males in the age group from 17 to 50.

Better than 80 percent of the population will live in or near the major metropolitan centers which exist today. The majority of this growth will not take place in the central cities, as they now exist, but will be an expansion of the suburban sections of these cities which will lead to the establishment of the increased number of major city complexes or "megalopolis."

The training of engineers, technicians, and scientists will be one of the major problems of this era. We can look forward to a college and university population at least four times as large as it is today. If this projection is reasonable, we can predict that, in the 80's, the 15 million or so college graduates that will leave school each year will barely fill the requirements for industry and related technical activities. To further complicate the shortage of skilled people, there will be a tendency to reduce the work week, and particularly heavy increases in more spare time for recreation and, hopefully, education.

Economists indicate that the total production of goods and services in the United States will exceed one trillion dollars in 1985. This is approximately double the current Gross National Product. As a result, there will be an appreciable increase in per capita income and, consequently, in terms of general living standards.

The rapid increase in industrial growth will cause major changes in the labor force of the United States. It is projected that the number of farm employees will be reduced by half. The size of farms and requirements for capital will have greatly expanded. There will also be major reductions in manual work in manufacturing, mining, and other heavy industries. Fewer men with more sophisticated equipment will be doing much that unskilled labor does today. As a result of automation, there will be major changes in clerical personnel and activities by reduction of routine work. On the other hand there will be a tremendous increase in the areas of automation, machine control, and inspection.

There is no doubt that automation, which has started to play a major role in the second half of this century, will be greatly expanded. Automation's most important impact will not be on total employment but rather on the qualifications and requirements of the skilled employees. Large numbers of well educated personnel will be required for new jobs such as, designers, technicians, systems engineers and, above all, individuals with managerical ability who are capable of analyzing problems, making decisions, and assuming risks.

Much study has been made as to the resources of the future. Based on known and blocked out resources, we can project that raw materials will be available to satisfy the growing and nearly insatiable American economy during this time period. Part of this will be due to the development of new techniques, the use of currently marginal resources, or by substitution of various materials for those that become in short supply. We also will have an ever increasing demand for the import of raw materials from the less developed countries. The by-product of this is that there will be great emphasis on conservation of our national resources with an increasing tendency to bring raw materials to the United States from abroad.

Experts in the field of power project that electrical demand in this period will be better than three times that of today, or perhaps 700 million kilowatts. Although there will be a steady tendency to the increased use of nuclear power, the major fuels for power production during this period will be fossil fuels, primarily coal.

One of the most important characteristics of the period will be greatly improved transportation. There is little doubt that the majority of the transportation systems in use then will be not dissimilar from those of today. There will be, however, many changes in increased efficiency and new techniques that will allow modern transportation and methods to meet the demands of this period. We can project that while mail and freight rail transportation will be substantially improved, passenger rail traffic will continue to decline except for mass transit systems in the urban areas. It is also probable that improved techniques and equipment will allow the speed of railroads to be much faster than is possible today. There will, of course, be many alternate methods of transportation such as, pipelines, for gas, oil, and other liquid materials, as well as for the transportation of coal and other fluidized solids.

Although American industrial production will have probably doubled by this period, there will still be approximately 500 major corporations that will produce in excess of 70 percent of the total American industrial product. These corporations will be larger, more complex, and closely tied together by a network of communication, equipment, and computers that will allow them to operate efficiently on not only a national but an international basis.

Sophisticated, computerized control systems will be the dominant factor in industrial production. The basic oxygen systems, continuous casting and rolling techniques in the steel industry, completely automatic chemical complexes will do much to change the appearance of the industrial world. Light materials such as, plastics, aluminum, and high strength steel will tend to reduce the overall percentage requirements of basic steel, but steel will still be the backbone of industry.

By 1985 there will be major advances in communications. We can look forward to reductions in the cost of long distance calls, extensive use of video telephone service in industry, and a great expansion in international communications facilities. In this connection, we can hope that our international relations will be greatly eased by expansion of the use of English as a common language throughout most of the world and an ever increasing use of computer translators to assist humans in translating large masses of literature. As a by-product of the expanded computer and communication facilities, it is possible that the nationwide distribution of daily newspapers may have great impact on our life and cause great changes in the speed and extent of news coverage.

Between now and 1985, science and technology will grow. However, the rate of growth of knowledge compared with the last few centuries will probably slow appreciably. Much of this will be due to the shortage of skilled personnel and the necessity of applying knowledge that already exists. Scientists and technicians will be relatively scarcer in the United States than today. There will consequently, be great competition for their services. While much routine work that is now carried on by engineers and other technologists can be carried on by machines, the demand for these people will be far greater than in the world today.

Weighing in 1985

Now that we have generally considered a synthetic world of 1985, let us become more specific as it relates to instrumentation and, specifically, weighing. Instrumentation and computers will be the backbone of industry. As a result, weighing devices will be more and more associated with data handling of process control equipment. In order to be compatible with computers and communication links, there will be an increasing tendency to emphasize direct reading, projection, digital presentations, or other digital presentation of weight information.

Large dials as primary indicating will become increasingly obsolete. Improved instrumentation will make it possible, in many cases, to achieve greater accuracy. On the other hand, for the control of instrumentation there will be a definite tendency for the establishment of different classes of weighing equipment that are not necessarily designed to meet commercial tolerances. This will be particularly true when they are tied directly into process control and computers.

Force transducers can be expected to be changed tremendously by this time. It may well be that electronic load cells or force transducers will be entirely semiconductor which may allow direct reading devices without the need of any amplifiers or complex circuitry. We can also assume that much of the instrumentation will involve micromolecular modules that are designed for ease of maintenance and immediate replacement.

Force transducers will definitely not be limited to strain gage devices. There will be great advances in the art of hydraulic and pneumatic transducers. These will be particularly important in process industries where there is a high degree of danger from fire or explosion. It is also probable that totally new techniques not presently used in the scale industry will be replacing conventional weighing methods. We may be determining weight by indirect means such as, changes in the molecular structure of materials, piezoelectric effects, magnetostrictive characteristics of materials, radiation absorption, and perhaps on other techniques that will be developed as a result of our increased knowledge of gravity and related phenomena.

In the next twenty years there will not be a giant step that will replace existing equipment and techniques. A large number of the scales that are in service today will be in use at that time. In this connection, it might be interesting to note that today there are many thousands of electronic and other load cell scales in use, not only in the United States, but all over the world. As a matter of fact, there is far more written in the technical journals in Europe on load cell scales than has been written in the United States. We cannot be complacent about foreign competition. Even today there are aggressive and very competent foreign firms that are rapidly establishing a beachhead in the United States. We also should note that in Europe there are far more load cell scales of European manufacture than of United States manufacture.

We can project that low capacity and even laboratory scales may well be using electronic instrumentation. Currently, in a number of laboratories throughout both this country and in Europe, rapid advances are being made in the development of electronic instrumentation for very low capacity scales, ranging from checkweighers to laboratory instrumentation. These should be in wide use within 20 years.

In view of the fact that there will be a significant increase in needs of transportation and the overall problem of logistics, we can look forward to greatly improved equipment in connection with transportation. The improved systems may include weighing devices that will be able to weigh motor trucks and railroad cars at full road speed. We may also see that fluidized coal and other materials carried in pipelines can be weighed by such techniques as gamma ray absorption. Gamma rays may also be extensively used in connection with belt conveyor scales.

One of the greatest complications of this period will be the tendency for the weighing industry to be greatly expanded by instrumentation manufacturers currently in other fields. Even today there is a great tendency for the instrumentation industry, as a whole, to be moving into the historic area of the scale industry. We can expect to see more and more of this as time goes along. Certainly by 1985 there will be little difference in instrumentation concepts whether the physical quantity being measured is weight, heat, electric current, or any other.

One of the most important improvements in all weighing systems will be greater emphasis on improved reliability and dependability with particular emphasis on ease of maintenance if and when required. In 1985, there will be much greater realization and emphasis on total system reliability. This will be materially aided by the concepts that are extensively involved in the design of missiles and space stations today where extremely high system and component reliability is a major design criterion. Although in most industrial instrumentation there is not a great need for miniaturization, in view of the great increase in miniaturized components, we can expect an automatic by-product of this to miniaturize and modernize all weighing instrumentation.

We can expect all classes of scales ranging from grocery stores to the heaviest of industry to tend toward automatically generated printed records with a by-product consisting of punched tape or magnetic tapes that can be fed directly into computers for inventory control, costing, and related accounting and reorder problems. In this connection, the automated grocery store and drug store of the future will be a distinct reality. Much work has been done in recent years to develop these, but by 1985, we can expect the housewife to be able to do her shopping directly from display cases by pushing buttons or otherwise storing her needs which will be automatically selected. The weight and price will be computed and her order bagged and delivered to her by the time she reaches the door.

Perhaps, through improvements in communication networks, it may be possible for the housewife to have a telephone type directory of the products she requires and, using the keyboard on the telephone, to complete her order and have it packaged and ready for delivery in a matter of seconds.

Some of the greatest problems in forthcoming years will be presented by a major reorientation of scale manufacturing. In heavy capacity systems, the use of foundries and heavy machine shops will be practically eliminated, although structural steel fabrication will be used for large platforms. On the other hand, there will always be a certain place for beam scales and low cost scales for certain applications. However, in commerce, industry, and science in the United States, the mechanical scale will tend to be an increasingly minor portion of the market.

Much of the improvement of the weighing industry will be as a result of good competition, not only from those who currently identify themselves with the scale industry but, more importantly, with those who will bring new concepts from related industries into the design, manufacture, and functioning of scales. It will be increasingly important for users, manufacturers, or weights and measures officials to eliminate obsolete concepts and to adopt new and even radical techniques.

Weighing as it Relates to Space

By 1985, we can expect to have moon stations established and orbiting space stations. We will be well on the way to making probes for exploration to the more distant planets. There will, of course, be much interest in gravitational field measurements which are directly or indirectly related to the weighing industry. Perhaps more important will be the ever increasing demand for more accurate weight and force instrumentation in connection with the space vehicles themselves and with problems associated with their launch and, most critically, a determination of payload. Space vehicles require thousands of pounds of thrust for each pound of payload, particularly during lift off.

There is no doubt that, by 1985, fuels will be available that will be more efficient than today; however, the thrust requirements will still be the same in order to place an object in orbit or to reach a given celestial target. One thing we can be sure of is that the space traveler in the future will not be allowed any 40 pounds in his baggage except as it relates to life support. In fact, every fraction of an ounce of weight that is carried as payload will have to be critically determined. High accuracy and dependability of this determination will be a problem of the first order. We can expect that information of this type will be fed directly into computers, so that last minute changes can be incorporated into corrections in the computation of the path of the vehicle.

Although we do not normally consider thrust measuring devices as being within the purview of the weighing science, they are, in fact, insolubly linked. Thrust measuring devices will be of the most importance in space vehicles, not only at the time of launch, but also during their free flight through space. Of course, in these cases, the emphasis on microminiaturization for reduced weight and volume will be the primary design consideration. High dependability and reliability as well as accuracy will be far greater than any normal need of science and industry.

While today the United States and a portion of the old British Empire are still plagued with the English measurement system, we can hope that, by 1985, the world will fully have converted to the metric system. Although this may be wishful thinking, due to both political and economic considerations, we can certainly expect a broad acceptance of both systems and major interchangeability in data presentation. If, by that time, we are in a period of transition, it would be very simple to merely have a selector switch on any weighing instrument to switch it from the metric to the English system depending on the needs of the user at that moment. Today, we are seeing a definite trend towards greater acceptance of the metric system and, to a much greater degree, decimal dimensions in the English system. For instance, all range, trajectory and other calculations in the Space Agency are metric. Our military maps are all metric. As a result of this, military fire control systems are becoming entirely metric.

As a partial step toward decimal systems, industry is rapidly eliminating the use of halfs, quarters, eights, and thirty-seconds and going to tenths and hundredths of inches. This is becoming practically universal throughout the electronic industry. At least we are taking steps in the right direction and we can hope that, by 1985, we will have fully converted to a truly universal system of measurement.

As we can see, the world of tomorrow will be an era of extensive instrumentation. This will impose an ever increased consciousness on science and industry to use good standards. Although weight and mass may be measured indirectly, by comparison, the necessity of positive standards of a high degree of reliability will be imperative. As a result of this, the scope and activities of weights and measures officials and other agencies interested in reproductibility, accuracy, and particularly, dependability will become increasingly important. One major problem that will have been resolved by this time is who will be responsible for measurement standards. Will weights and measures officials expand their activities into the broad field of instrumentation or will they continue to limit themselves primarily to the field of commercial weighing? This is a question that should be resolved in the near future.

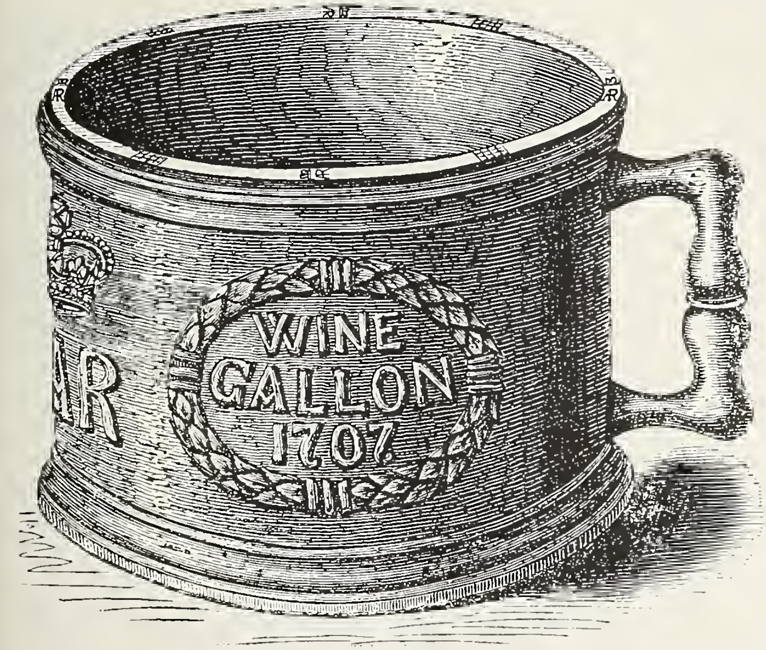
Today, we find many of the major government contractors establishing excellent standards laboratories. In most cases, these are far superior and go far beyond the scope of the calibration capabilities of any regular weights and measures facility except the National Bureau of Standards.

As we all know, today, we are in a period of transition. More new techniques and technical installations have been introduced than in any other period in history. As we look forward, we must be prepared for even greater changes. The philosophy of a solid and unchanging industry will have long been a thing of the past. Engineers, technicians, managers, and, certainly, weights and measures officials will be oriented to the requirements of industry and science, and to the equipment that will be available. No industry can remain static and live. We must be responsive to the future and to the many advancements that will be available to meet the needs of industry and technology.

AFTERNOON OF WEDNESDAY, JUNE 23, 1965

No Business Session

GOLDEN ANNIVERSARY CONFERENCE BANQUET



Wednesday evening at 7:30, the Golden Anniversary Conference Banquet was held in Sheraton Hall. Guest speaker was Mr. Bryce Harlow, Director of Governmental Relations, Procter and Gamble Manufacturing Company, Washington, D.C., (former Deputy Assistant to the President of the United States), who entertained the delegates with his comments on his 25 years of experience in the Federal Government.

MORNING SESSION—THURSDAY, JUNE 24, 1965

(W. I. THOMPSON, *Vice Chairman*, Presiding)

REMINISCING

by JOHN P. MCBRIDE, *Past Chairman of the National Conference on Weights and Measures, and retired Director of Standards, Massachusetts Department of Labor and Industries*

The most poignant memories are those of the persons with whom you have worked and who have contributed so much to the weights and measures cause.

The first to come to mind are the members of the old Specifications and Tolerances Committee with whom I worked for some fifteen years. Some of these men were Fay Holbrook of the National Bureau of Standards, Joe Rogers of New Jersey, and Morris Fuller of Los Angeles (all of whom have now passed on to their eternal reward), George Austin of Detroit, and Ralph W. Smith of NBS. It must be said of Ralph Smith that he was an indefatigable worker, painstaking and thorough, always cognizant of the long-range view. If such there be, he surely is Mr. Weights and Measures. In later years Bill Bussey and Mac Jensen, both very able men, came to this Committee with Mac Jensen the only member still in the harness as an active official at NBS.

The Committee on Specifications and Tolerances convened three or four days before the Conference and undertook the task of preparing the language covering proposed codes in what was often referred to as understandable English, or the lack thereof, to cover all situations that might develop. On the one hand was industry in its competitive field looking for workable controls, and on the other hand, the weights and measures officials seeking the utmost in consumer protection.

Specifications governing devices cannot be beyond reasonable expectation of possibility of compliance and should be consistent with good engineering practice, but must not be readily susceptible to the perpetration of fraud. This latter phrase brought in the so-called "human element" and offered the greatest difficulty, provoking most of the floor discussion among delegates and industry members.

I recall one incident involving a demonstration to show the necessity of air separation and elimination on a motor-driven gasoline dispenser. The air-elimination unit was not used in this showing, the result being an appreciable discrepancy between actual delivery in the test measure and the indicated amount shown on the reading element of the device. Apparently, a member of the press was present at the meeting and, lo and behold, in the next day's edition of the local paper was a picture of the dispenser with some of the delegates standing alongside. The accompanying headline read that gasoline dealers were mulcting the public. The newsman had missed the point; perhaps he was confused by the discussion, but he created an embarrassing situation.

As we look back, it is apparent that weights and measures began to take shape on the national level in an appreciable way with the first National Conference in 1905, when the National Bureau of Standards entered the field, establishing with the delegates the practice of annual National Conferences with speakers and exhibits and publication of educational material to weights and measures officials aimed toward uniformity in basic requirements and methods of tests. State conferences subseqently developed, although a few States had started prior to this. (Massachusetts held its first in 1898). The Southern Conference became the largest regional conference, beginning in 1946. Industry and a member of the Office of Weights and Measures always attended and participated in these meetings. The National Bureau of Standards became the weights and measures reference bureau and, with its scientific staff available, was of immeasurable value to officials with technical problems, providing expert counsel on requirements for mechanical devices, and thus encouraging the competency of officials in their various duties.

The National Bureau of Standards has certain statutory authority under its Organic Act to cooperate with the States in securing uniformity in weights and measures laws and methods of inspection, and its Directors, Dr. Stratton, Dr. Burgess, Dr. Briggs, Dr. Condon, and presently Dr. Astin, have always acted in a most cooperative and helpful manner. Field work of the Office of Weights and Measures consisted of surveys in the States, followed by recommendations, helpful suggestions, and various kinds of technical training. The work was largely coordinated with the activities of the National Conference and its standing committees. This was supplemented by periodic visits of representatives from OWM to the State and local offices for observation and discussion and by publication from time to time of handbooks of instruction embracing the duties of officials.

While earlier reference is made to the so-called "human element," a term that usually applies to the user of the device, I recall one instance where this might be applied to the manufacturer. This involved an early computing scale wherein the money-value indication on the scale appeared wrongly calculated on breakage (fraction cent), and the sealer in Cambridge, Massachusetts, condemned the device on the ground of arithmetical inaccuracy. The manufacturer challenged this action on the ground that it was beyond the scope of the sealer's duty, he being confined to checking the accuracy of the weight determinations only. The Massachusetts Supreme Court, however, sustained the sealer, and ruled that he had the right under the covering statute to test computing scales as to correctness of both indicated weight and value.

The computing scale was indeed a remarkable innovation, but it brought problems of its own. In order to attain maximum efficiency, it needed a weighing range that would cover the field of most transactions, and needed to embrace the widest scope of price per pound of retail commodity and total price. This was attempted on a chart of about 27 inches in length, needing space for 1700 to 1800 characters. A field of magnification was needed to satisfy dimensional requirements such as width of graduations, intervals between graduations and indicator wire, so that compliance might be had therewith yet have the user visibility necessary to enable proper reading, accomplished by proper lens power. The NBS Division of Optics and Metrology was very helpful in the code development for actual and apparent dimensions. While the specifications required visibility of a specified range of the weight values on the customer side, it is interesting to note that one company went beyond this and showed money value in addition to the weight value far beyond this limit as an advantage to the consumer. According to some sources of information, this did not prove very popular with a few retailers. To meet the code requirement of reducing parallax effects to a practical minimum, one method offered was two parallel indicating wires, spaced apart, employing the same theory as applies to sights on a rifle. An interesting feature developed in certain types of this scale whereby it was possible, with certain commodities, to so far extend over the load-receiving element as to lock it against the drum as the load was applied which prevented oscillation and thus indicate in excess of actual weight. This resulted in the requirement of the so-called New York platter guard, to prevent overhang. When we view the modern computer we can appreciate the progress industry has made in this field.

Springs in the scale weighing operation presented difficulty and, at one time, scale competitive advertising carried the slogan "Honest Weight—No Springs." Springs of that time were susceptible to temperature change, and one company had affixed to its scale a means of adjusting the scale to the temperature at the place of weighing. The so-called peddler scale was a great source of trouble here as it was used largely outdoors. While the code took cognizance of this, it was not entirely satisfactory, and finally the temperature-compensated spring was developed and proved to be the answer.

With the passing of the so-called hay wagon in favor of auto trucks, the problem of adequate platform length and approach for vehicle scales arose. Some scalemen merely lengthened the existing platform without regard for the understructure of the scale and its weighing capacity. This necessitated regulation by requiring reference back to the manufacturer's design of the particular scale, and perhaps was the forerunner of requiring licensing of scale repairmen.

As truck-load weights increased, adequacy of testing equipment became a must and several States developed special test trucks with test weights of 500- and 1000-pound denominations, with various types of power hoists and power drops for placement of the weights on the scale platform. The Office of Weights and Measures surveyed the field on this matter and acquired a test unit which was sent, with a special instructor, to the various States for the promotion of uniformity of test and equipment.

While the established procedure would be to send in weights to the Mass Section of NBS for calibration, it was no easy task to send in these large weights and NBS produced the Russell equal-arm balance by means of which tests could be accomplished by the State and local authorities at their own location. With modern equipment, weight placement now is a push-button operation.

The automobile raised the problem of gasoline measurement. The first development here was the "blind pump" of the one-gallon and five-gallon type. The difficulty was leakage back from the measuring chamber between periods of delivery. Holding valves did not function satisfactorily, and special tolerances were set up for specified elapsed times. Operators were advised of the necessity of periodic priming of the unit, but this, in some cases, had the effect of encouraging short measure, and precipitated the development of the decoy fuel tank in sealers' automobiles; early morning checks were fruitful in controlling this feature.

The visible pump offered more problems in that public safety requirements prohibited the product from remaining in the glass cyclinder overnight. This necessitated a means of returning the product to storage by a valve-control line. The result of this was that the dishonest operator, during delivery to the customer's tank, could also open the valve on the return to storage with the product going both ways and full delivery indicated. The only preventive here was warning signs and locked delivery positions, but both were dependent on customer observations and did not work out too well. A self-service pump, coin-operated, was developed by two former members of this Conference, but the fire hazard involved precluded its use (although I recently read that such a device is operable in Tennessee).

The big development in gasoline dispensing was the motor driven pump with price-per-gallon and total sale price indicated, and the volume in gallons and tenths of a gallon. This power-driven unit made possible the passage of air with the liquid and hence required a means of separating and eliminating the air before reaching the measuring chamber. This was successfully accomplished, although there were ways of blocking this unit from so functioning. The visigage which serves under certain circumstances to indicate the passage of air, came into being. Further problems on this type of device were the wet-hose with product in the line to the discharge nozzle with possibility of hose distortion; interlocking devices on return to zero, manual or automatic. Competition between the manufacturers for equipment attractiveness brought about various size units, so it became necessary to prescribe an angle of vision and minimum height to assure visibility of the reading elements to the motorist. The blending pump that came later was a remarkable innovation in this field, determining quality by proportional means, as well as determining quantity.

Solid fuel, such as coal, coke, etc., presented its problems of checkweighing on the road, with an occasional driver with two certificates, and coke with its moisture-absorbing characteristics.

Fuel oil, however, became the predominant home heating commodity and home deliveries were accomplished by trucks equipped with motor-operated pumps, and the measuring element was a meter with air separator and eliminator. The first effort to afford visibility of the measuring element to the householder from within the home was a large dial-indicating element, but this was susceptible to breakage and more cumbersome than useful, and was later abandoned for the rotor type and ticket printer. Household tanks were generally of 265-gallon capacity and the individual deliveries were quantities in excess of 50 gallons, which necessitated again adequacy of testing equipment to meet prescribed methods of test, and portable provers ranging from 50 gallons were developed. Retailers of this product bought from bulk distributors by truckload, and larger portable provers ranging from 500 gallons came into being.

In Massachusetts, we purchased our first 1000-gallon prover in 1938, and one large oil company had a permanently installed 3,000-gallon prover for barge deliveries. Massachusetts is one of the largest markets for this product and, as in all devices, determination must be made as to whether there is susceptibility to fraud. On trucks with more than one compartment it was found that compartment line valves, where one or more compartments were empty, could be manipulated to introduce air beyond the capacity of the air separator and eliminator to function, and valve control was required so that only one compartment line might be opened at any one time.

After World War II, housing developments grew apace and, in many cases, were located away from the regular supply lines of gas manufacturers. Liquefied petroleum gas hit the market as a home heating fuel. Deliveries of this product were first made in cyclinders, but this became inadequate and metered delivery by truck became the practice. This was a commodity delivered and measured under pressure, and NBS, through its various divisions, was of great help on this question of method of test, whether it should be gravimetric or volumetric. This problem took much time and experiment, as the testing equipment was expensive, and final determination was the volumetric method.

The farmer was not left out in the march of progress and the time-honored practice of putting out his 20 and 40 gallon jugs of milk at the farm for the handler to pick up, with quantity determined at the latter's plant, gave way to the permanently installed farm milk tank at the farm. The questions here presented were possibility of distortion of tanks, location and marking of gage rods, and permanency of level of the tank. In some areas farmers resented weights and measures entry, regarding it as a contractual matter between the two parties involved, but it was deemed a matter of public interest and jurisdiction was taken. Special provers were developed and methods of tests prescribed. Some of these farms were low on water and were located too far out of the way and the 1000 or so gallons of water necessary for test purposes was a drain on low water supply. The gage-rod measuring method is an improvement over the previous one, but is not all that is to be desired, and a more satisfactory way would be to measure the milk by meter. Development along this line has been slow.

In the field of liquid measures, the single-use measure container, generally of paper-board type, found a ready market in competition with other types, and raised the question of rigidity of its parts as a measure. A special method of test was prescribed in such cases to so restrain the container under test that it will maintain its normal assembled shape and its sides will not bulge when filled with water, thus simulating actual use conditions.

The weights and measures official is not confined to the perfunctory task of testing devices, and his field covers the whole scope of what happens in packaging, methods of fill of containers, apparent against actual quantity of content, slack fill, etc. Even the corner store had a method of compressing the sides of berry boxes to add design attractiveness, and sometimes sold peanuts in the liquid quart measure.

Marking of packages as to net quantity of content was a vexatious problem. Emphasis has seldom been extended to this phase by the packers. The Federal Food and Drug Administration also has jurisdiction in this matter, but the code language "plain and conspicous" is equivocal and, at one time, this agency issued publications containing interpretations and decisions which it had arrived at on questionable compliance. These were very helpful in the aim at uniformity. It is pleasing to note that this subject is now regarded of major importance again and Federal legislation is being proposed. I believe manufacturers are making every effort to remedy this problem. Several years ago I attended and spoke to several meetings of the American Management Association where this problem was discussed. A representative of the Federal Food and Drug Administration also addressed these meetings.

The problem of shrinkage and who bears the loss appeared as one of the insolubles. Before the advent of the self-service stores a product was packed at the place of sale in many instances, and the question was thus centered. The factory-filled package offered the difficulty. The Food and Drug Administration, in its code, recognized variations due to ordinary and customary exposure which normally occur in good distribution practice.

Moisture content of the product is of course an important factor. A nationwide flour survey, sponsored by the National Conference, was made at the retail level, this product having a maximum allowable moisture content of 14.7 percent. The survey was confined to the 5-pound package and included products of large and small mills. The net weight of the flour was determined at the time of taking, as was also the moisture content and, where possible, the code number of the packer. Some 430 samples were obtained and data submitted from 34 states. The computed results showed 16.8 percent weighed 5 pounds net at the retail level, the balance weighed less than 5 pounds, and the average weight of all was 4.96 pounds. Where packer codes made possible comparable data with the mills, results showed net weight packing at the mills 5.04 pounds and average moisture content of 13.79 percent. Of course this product is highly hygroscopic and can be affected by geographic location, weather conditions, handling, and storage.

Other products too have their characteristics in this direction, although I recall hearing one national meat packer state to a

National Conference that his company found no problem here due to their controlled method of overpack. There is, of course, a shrinkage problem but it can be minimized.

Undercover buying had its problems in properly acquiring the necessary evidence for prosecution, but the self-service supermarket has eased this problem in that the evidence is right on the table, package all wrapped, price and weight marked thereon, merely awaiting the taking thereof and determining the weight, with a case for either attempt to sell or sale, as the official may make his case. I understand there are about 300,000 supermarkets in the Nation, and this offers a wide new field for reweighing which the officials have taken advantage of.

At the repeal of prohibition it was felt that the lapse of time between prohibition and repeal was sufficient to destroy all previous custom and stock of containers, virtually starting from scratch, and therefore a good time to endeavor to attain standardization of bottle sizes. The effort was not entirely successful, although this industry more nearly approaches weights and measures ideals in this respect than almost any other. Only recently the Distilled Spirits Institute successfully contested an effort to break down the present sizes and, as part of their argument, used material from National Conference reports on the subject of standardization of sizes. The then Chairman of the National Conference, Rollin Meek, represented the Conference at the hearing, and opposed the suggested changes. Standardization of package sizes for all consumer commodities was submitted for Federal legislation during the early forties, but it failed of success.

A word of appreciation must be extended for the work performed by Dr. Leland J. Gordon, Director of Weights and Measures Research Center at Denison University, Granville, Ohio. He has conducted two national surveys of weights and measures work as it affects consumer economy, visiting many State officials. He has made a thorough study of the problem from all angles from the standpoint of the public interests and has published reports thereon.

I have great faith in the future of weights and measures. It is at last receiving more public notice, due in no small part to government-sponsored consumer representatives. New York State was the first in this field, with the appointment of Mrs. Persia Campbell as consumer advisor to the then Governor, followed by a similar appointment of Mrs. Helen Nelson by the Governor of California. A consumer council in Massachusetts first operated, with ten members, from the Attorney General's department. Now there is a council authorized by statute attached to the Executive Department, with one member an active weights and measures official (Frank Hirons, City Sealer of Gardner). On March 15, 1962, the late President Kennedy sent a Consumer Message to the Congress in which he directed that the Council of Economic Advisers create a Consumer Advisory Council. This was the first such council on a Federal level. All of these groups have weights and measures as a subject within their authority.

We are living in a rapidly changing world, and technological changes continue to occur in weighing and measuring devices.

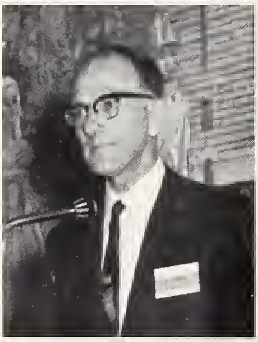
In the perhaps not too distant future in the commodity field in this nuclear age we may have atomic energy as the source of power for automobiles, as well as for home heating. What will be the method of dispensing and measuring this element? There is indeed need for schools of instruction and home study courses as recommended by the Conference Committee on Education. However, the Conference is now operating under a good organizational plan, and the new National Bureau of Standards facilities at Gaithersburg will be in readiness to meet these new problems.

This paper has been necessarily only surface scratching, and I will close with a note of appreciation to all the delegates, members of industry, the National Scale Men's Association, and the Director and all the staff of the National Bureau of Standards for their contributions to the cause of weights and measures.

THE HISTORY OF THE ENGLISH SYSTEM OF WEIGHTS AND MEASURES

by W. J. Owen, *Chief Inspector, Weights and Measures Office, Bradford, England*

The Pound, Yard, and Gallon



The whole of the modern English weights and measures system is based on two basic standards: The imperial pound and the imperial yard. All other weights and measures, including measures of volume, are derived from these two measures.

The Weights and Measures Act, 1878, defined the imperial pound standard as "The weight in vacuo of the platinum weight (mentioned in the First Schedule to the Act) and by this Act declared to be the imperial standard for determining the imperial standard pound, shall be the legal standard measure of weight, and of measure having reference to weight and shall be called the imperial standard pound, and shall be the only unit or standard measure of weight from which all other weights and all measures having reference to weight shall be ascertained."

The Weights and Measures Act, 1963, carries a similar description of the pound, but, in addition, defines it as being equivalent to 0.453 592 37 of a kilogramme. What developed as an arbitrary standard over many decades has now become precisely defined.

The imperial (avoirdupois) pound of 7,000 grains was first legalised by the Standards Act, 1855, although it was commercially used long before. This Act followed the recommendations of an 1838 Commission appointed to consider what to do about the loss and damage of the former standard in the fire that destroyed the Houses of Parliament in 1834.[1]

At the time of the fire, the standard pound had been the Troy pound of 5,760 grains and had been legalised by the Weights and Measures Act, 1824. The change to the avoirdupois pound was no more than legal confirmation of the commercial position then in existence, a position that was emphasized in 1841 when the Commission reported that:

> The troy pound is comparatively useless even in the few trades and professions in which troy weight is commonly used and to the great mass of the British population it is wholly unknown. The statements of medical men and those persons concerned in the trade of bullion show that even to them the troy pound is useless. The avoirdupois pound on the other hand is universally known throughout this kingdom. We see it our duty therefore to recommend that the avoirdupois pound be adopted instead of the troy pound as the standard weight.

Prior to its adoption in the 1824 Act, the troy pound had been used as a reference weight for 66 years. It would have been legalised in 1760 but for the interruption of parliamentary business caused by the sudden death of George II.

The avoirdupois pound, which had been in commercial use from time immemorial, was recommended as the legal standard of reference in 1841 and was finally legalised by the Weights and Measures Act, 1878.

The United States pound is the same as the United Kingdom pound, and, by the terms of the 1893 Mendenhall Order, was defined in terms of the kilogram—something the United Kingdom decided to do 70 years later.

The United States yard and the United Kingdom yard are also identical and, by the same history of events which affected the pound, are both now related to the metric system.

The yard was defined, in 1878, as "The straight line or distance between the centres of two gold plugs or pins (as described in the First Schedule of the Act) in the bronze bar by this Act declared to be the imperial standard yard measured when the bar is at the temperature of sixty-two degrees of Fahrenheit's thermometer, and when it is supported by bronze rollers placed under it in such a manner as best to avoid flexure of the bar, and to facilitate its free expansion and contraction from variation of temperature, shall be the legal standard measure of length, and shall be called the imperial standard yard, and shall be the only unit or standard measure of extension from which all other measures of extension, whether linear, superficial or solid, shall be ascertained." In 1963, it came to be defined as: "the yard shall be 0.9144 metre exactly."[2]

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[1] This fire on 16th October was caused by excessive stoking! The House had ordered the destruction of a store of old tallies, and they were being burnt in the heating stoves.

[2] The figure of 0.9144 has been accepted for all the purposes of the Act as the fixed ratio between the metre and the yard. If the length of the metre is changed by international agreement, then the length of the yard will change. The figure of 0.9144 is given in this form so that certainty of calculation may be assured. It is the figure accepted for scientific and technological purposes by the National Standards Laboratories of the United Kingdom, the United States, Australia, Canada, New Zealand, and South Africa. The United States, on 1st July, 1959, declared this figure to be the one to be used for all purposes except geodetic surveys.

FIGURE 1. *Queen Anne Wine Gallon.*

In 1824, there were at least four different gallons in use: The Winchester corn gallon of 268.8 $in.^3$; the Queen Anne's wine gallon of 231 $in.^3$; the Ale gallon of 282 $in.^3$; and an older wine gallon of about 224 $in.^3$.

In that year, Parliament made an effort to alleviate the confusion by providing for one gallon only. It was defined as that volume occupied by "10 imperial pound weight of distilled water weighed in air against brass weights with the water and the air at a temperature of 62 degrees of Fahrenheit's thermometer and with the barometer at 30 inches." This same definition was also in the Weights and Measures Act of 1878.

The Act of 1963 referred the gallon also to the metric system by defining it as "the space occupied by 10 pounds weight of distilled water of density 0.998 859 gramme per millilitre weighed in air of density 0.001 217 grammes per millilitre." In the same Act, those imperial weights and measures which shall be lawful for use in trade in the United Kingdom are defined. All are derivatives of the three aforementioned standards.[3]

Early History

Although it has often been suggested that the British system has been arbitrarily conceived, it is certain that there is a relationship between the British system of weights and measures and the older civilizations. There is evidence of deep-rooted

[3] See Appendix A.

associations with the cubits and talents of the ancient and medieval Eastern kingdoms. The history of these latter extends over more than 50 centuries, from before the building of the Great Pyramids to the tenth century.

The Egyptian Cubit of 18.24 inches was derived from the length of the bent forearm, from the elbow to the fingertip. The Greek Olympic foot was 12.16 inches or two-thirds of a cubit.

The origin of the British weights and measures system would be difficult to trace in detail. But there is no doubt that the system was influenced by the Phoenecians, the Romans, and the Scandinavians. When the Saxons arrived in this country in the fifth century, they adopted the weights and measures already in use, as did the Normans some six centuries later.

The first recorded law on weights and measures is dated 965 A.D., in the reign of King Edgar, when it was decreed "that only one weight and one measure should pass throughout the King's dominion." The desire for uniformity existed many years before this, and in the reign of King Athelstone, who succeeded to the throne in 925 A.D., the pound, bushel, quarter, mile, furlong, and acre were in common use.

In 1066, William the Conqueror made no attempt to change the existing system, but he did ordain "that they shall have throughout the whole kingdom most accurate and stamped measures."

One measure of length known to be in existence at that time was the perch of 11 cubits used for the measurement of land. The records of the Domesday Book (1085) show that this measure was the same before and after the Norman conquest.

There is no further historical reference to standards until the reign of King John. In the Magna Charta of 1215 it prescribes that the measures of corn and wine should be corrected. Later, when this clause of Magna Charta was amended in the reign of King Henry III, it was stated that there should be one measure for wine, one measure for ale, and one measure for corn, "and it shall be of weight as it is of measure." Amongst other things, the width of cloth was fixed at two cubits.

A few years later, a royal ordinance of considerable importance was issued. This was entitled "Assize of Weights and Measures" and contained the first real definition of English weight and measure. It was to remain in force for nearly 600 years until repealed by the Weights and Measures Act, 1824. The credit for this may be ascribed to Henry III (1216–1272). He was the first to make and prescribe a standard yard and to define the length of a foot.

The definition was as follows: "And it is to be remembered that the Iron Yard of our Lord the King contains III feet and not more; and the foot must contain XII inches by the correct measure of this kind of yard, that is to say one thirty-sixth part of the said yard makes one inch, neither more nor less. And five and a half yards make one perch, this is sixteen and a half feet in accordance with the above described Iron Yard of our Lord the King."

The measures were, therefore: Three barley corns = one inch; 12 inches = one foot; three feet = one yard; five and one half yards = one perch; 40 perches = one rood or acre's length.

These units are all still used today—even the reference to barley corn. The sizes of shoes in England progress in thirds of an inch.

Two different pounds are described in the "Assize of Weights and Measures." The troy pound was used for weighing gold and silver bullion and certain drugs. This was divided into 12 ounces, each ounce being 20 pennyweights and each pennyweight consisting of 32 wheat grains. The second pound was one used by merchants for other types of goods, and it consisted of 15 troy ounces.

The "Assize of Weights and Measures" also described certain measures of capacity, but in this case it is not clear whether the gallon—there being only one mentioned—was for corn or wine.

Following the setting up of the standards of weight and measure, copies were made and sent out by the Exchequer to the cities and boroughs of the Kingdom with instructions as to their use and with instructions to certain trades such as "Statute concerning Bakers etc." and the "Statute for Measuring Land." This was about the year 1250.

An extract from the Ordinance relating to bakers is of interest, as it refers to the sealing of weights and measures at this time:

> The standard bushels, gallons and yards which have been sealed with the iron seal of our Lord the King, are to be kept diligently and safely under the penalty of £100. And let no measure be made in a town unless it agrees with the measure of our Lord the King, and is sealed with the seal of the Corporation of the town. If any person buys or sells with measures that have not been sealed, and that have not been inspected by the mayor and the bailiffs, he will be severely punished. And all measures and yards, greater or less, are to be inspected and carefully examined twice every year. The standard bushels, gallons and yards, and the seals with which they are sealed, are to be kept in the custody of the mayor and bailiffs and of six legally sworn citizens of the town, in whose presence all the measures must be sealed.

These ordinances were included in later Acts of Parliament, one of the earliest of which appears to be the Statute of Wales of 1284. The important Act of 1340 was passed during the reign of King Edward III and contained references to uniformity of weights and measures throughout the country. This Act also includes penalties as: "that is to say, one greater to buy and one less to sell with shall be imprisoned as a deceiver and grievously punished."

An incursion into the rights of local authorities commenced about this time by the granting of statutory power to certain trade guilds, usually in the City of London, to inspect and supervise weights used in the trade represented by a guild.

For example, the charter of the Goldsmiths Company dates from 1327; and until 1679, all "troy" weights used in London were sealed at the Goldsmiths' hall.

The Coopers' Company obtained powers in 1531, the Plumbers' Company in 1611, and the Founders' Company in 1614. Lineal measures were once tested by the Merchant Taylors' Company.

The reign of King Edward III (1327–1377) was notable for several Acts relating to weights and measures, and in 1353 appears one of the earliest references to avoirdupois:

As we have learned that some merchants buy *aver de pois* goods such as wools and other merchandise by one weight and sell by another and also use deceitful practises in the matter of weighing; and they have illegal measures and yards to the greater deceit of us, and of all the community, and of honest traders; we will and ordain that there shall be one weight, one measure, and one yard throughout all the land. And that wool and all kinds of *aver de pois* goods are to be weighed by the balance in such a way that the tongue of the balance is even, without inclining to one side or the other, and without touching the same with hand or foot, or in any other way; and that he do the same to the damage of the seller shall forfeit the goods so weighed and measured; and the complainant shall receive four times the damage, and the delinquent shall be imprisoned for one year and shall be released at our pleasure.

In this context the word *aver de pois*—the old spelling of avoirdupois—related to the nature of the goods and not the particular kind of pound to which reference has already been made. Under the terms of the Weights and Measures Act, 1878, all articles sold by weight had to be sold by avoirdupois weight, except:

1. Gold and silver, and articles made thereof . . , platinum, diamonds, and other precious metals or stones may be sold by the ounce troy . . ; and
2. Drugs when sold by retail may be sold by apothecaries' weight.

(Metric weighing became permissible for all goods, as an alternative, under the terms of the Weights and Measures (Metric System) Act, 1897.)

Acts of Parliament in the reign of Henry V (1413–22) made the first official reference to the troy pound of 12 ounces and the "Tower" pound, used for bullion at the Royal Mint. The relation between the former and latter was in the proportion of 32:30.

In 1492, Parliament ordered that new bronze standards of weight and measure were to be sent to every town of importance in the country, and four years later 43 towns were listed where the standards were kept in charge of the mayors and bailiffs. This arrangement resulted in serious discrepancies between the measures in use in different places. In 1496, a royal commission sat in the Star Chamber at Westminster Palace to enquire into the whole British system of weights and measures. The main outcome of this enquiry was the acceptance of the troy pound of 12 ounces (each ounce of 640 wheat grains) and the avoirdupois pound of 16 troy ounces. There was no reference to the merchants' pound of 15 troy ounces or the avoirdupois pound of 16 avoirdupois ounces.

Accompanying new standards sent out to various towns were instructions that all old weights and measures were to be destroyed. This explains the difficulty one encounters in finding examples of English weights or measures before 1497. One well-known exception, due to disobedience of royal commands, is to be found in the City of Winchester, where is the finest collection of pre-Henry VII standards and the only known set of weights of the reign of Edward III.

At about this time, the use of multiples of the pound were fashionable for the weighing of certain commodities. In one Act there was reference to "weights of sack, half-sack and quarter, pound, half-pound and quarter according to the standard of the Exchequer." It is probable that the time coincided with the reception by Winchester from the Exchequer of the set of avoirdupois weights consisting of 56 lb., 28 lb., 14 lb., and 7 lb. Winchester was also important as a wool-trading centre and it is interesting to note that the stone of 1415 and the clove of seven pounds were recognized as the units of weight for wool and merchandise. More recently, at the beginning of the nineteenth century, the woollen industry moved to Bradford and the unit of weight for wool weighing was the tod of 28 lb. In modern times, the unit of weight for weighing wool has become the pound alone.

In 1588, during the reign of Elizabeth I, new sets of standards were made and, by Royal Proclamation, were dispatched to 57 towns and counties. These included 56 lb. and 7 lb. bell-shaped and 8 lb., 2 lb., and 1 lb. flat-shaped weights, all of brass. An issue is still preserved at Winchester.

The most ancient measure in the Winchester collection is the standard yard, a hexagonal bar of bronze, considered to be the original yard of Henry I (1100–1135) and later adjusted and lengthened by means of a new iron end in the reign of Edward I (1189–1199).

Perhaps the most interesting in the collection is the 91 lb. weight. Its origin is, again, connected with the wool trade of that period when a bale of wool consisted of 26 stones or 364 lb., a quarter of which is 91 lb.

Measures for the measurement of land remained untouched for several centuries until 1963, when the rod, pole, and perch were abolished. The acre, the breadth of which was four perches and the length of which was 40 perches, was known before 1272. One improvement came in the seventeenth century when Professor Gunter had the idea of taking the acre's breadth of four perches, which he called a chain, and dividing it into 100 links. This made the acre ten square chains and the square rood, or furlong, ten square acres. Gunter's chain was legally adopted in the Weights and Measures Act, 1878.

No revision of weights and measures law was found necessary for 200 years after Elizabeth I. But, in 1701, an act was passed defining the corn bushel—now famous as the Winchester Bushel—as "Any round measure with a plain and even bottom, being 18½ inches wide throughout and 8 inches deep."

Similar methods were used to define the wine gallon in 1707, when it was described as a round measure having an even bottom and containing 231 cubic inches. This definition was abolished in 1824.

The Act of 1824 replaced an earlier statute, and the Imperial System of Weights and Measures was introduced. The standards approved were a troy pound of 5,760 grains and a yard measure of 36 inches. In 1855, the new pound of 7,000 grains was legalised.

In 1866, the custody of the standards was given to the Board of Trade and four copies of the standards were made and deposited at the Royal Observatory, the Royal Mint, the Royal Society, and the House of Commons.

Inspectors of Weights and Measures

During the past thousand years, many laws have been made relating to standards of weight and measure. Over the centuries, it has been proclaimed that "measures should be true" or that merchants should not "buy by one weight and sell by another" or that "he shall be convicted of having double measures." It is obviously insufficient to make such proclamations without providing enforcement, but it is only within comparatively recent times that any serious effort has been made to provide efficient inspection.

Powers were given to town authorities to inspect weights and measures in the Saxon period. William the Conqueror had ordered that weights should be true and stamped. In 1266, six men were appointed to inspect all the measures in London. Edward I ruled that measures should be stamped. Succeeding monarchs imposed similar regulations. Powers of inspection were usually vested in the Mayor and Aldermen of a town, but, as these gentlemen had much other business, it is apparent that inspection of weights and measures was neglected or ignored altogether.

Henry VII appointed men known as "Tronators" to visit various parts of the country, but their main function was to weigh the wool clip and to assess the King's tax on it. In markets, the "Clerk of the Markets" inspected all weights and measures whilst the owners of the markets checked cloth, bread, and ale.

In country districts, the Courts Leet could appoint juries to inspect weights and measures. As already mentioned, some companies and guilds could inspect their own weights and measures.

Not until 1795 was the first serious attempt at inspection made. "Examiners" of weights and measures were appointed by justices at Quarter Sessions, and these men were the first full-time inspectors. Inspectors of Weights and Measures, by that name, were first appointed by the Acts of 1834–35, when duties of stamping and inspection were combined in one person.

Administration was inefficient, however, and complaints multiplied. It was not until 1878 that weights and measures administration was given a qualified and efficient inspectorate who were supported by a coded statement of law. The Act of 1878 was supplemented by many other Acts, Acts dealing with weighing and measuring appliances and commodities of many kinds.

All of these Acts have now been repealed and brought up to date by the Weights and Measures Act of 1963 and the numerous regulations now being issued under its authority. The protection which this law provided is now enforced, uniformly and efficiently, by the modern, well-qualified Inspector of Weights and Measures.

Today, the British Inspector is concerned with weighing and measuring throughout the whole of trade. Not only is he concerned with the accuracy of standards and of weighing and measuring appliances, but also with the difficulties and peculiarities which may be associated with a particular commodity.

For example, moisture content is always a problem, especially in a commodity like wool, which is so very hygroscopic, and in solid smokeless fuels and many other domestic commodities. In this respect, the Inspector is further assisted by codes of practice and standards which are produced by the British Standards Institute and which the Inspector himself frequently helps form. During the last ten years, the British public has become suddenly and acutely conscious of trading practices which affect the pocketbook to a considerable degree. The continually increasing prices of everything has caused attention to be directed not only to price and weight, but to quality of goods and services.

For the most part, the Inspector of Weights and Measures has been charged with the responsibility of ensuring that standards of quality are maintained as described and to prosecute any misdescription.

For example, he may concern himself with the misdescription of cloth, or the adulteration of liquor or milk, or the upgrading of solid fuel (of which there are five principal grades), or the testing of goods for which special safety standards are claimed, or with many other matters for which claims are made.

This surge of public opinion is directed at protecting the consumer against sharp practices of all kinds, with the result that the Inspector of Weights and Measures now finds himself to be an Inspector of many kinds of trading standards of which weights and measures constitute but one category.

The title of Inspector of Weights and Measures—albeit an honourable title—is fast becoming a misnomer so far as Britain is concerned, and possibly the title of "Inspector of Standards" may emerge in order to more adequately describe the functions for which he is now responsible.

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APPENDIX A

Measures and Weights Lawful for Use for Trade in the United Kingdom

Part I. Linear Measure

Imperial system:

1. Measures of—

100 feet	10 feet	1 yard (0.9144 metre)
66 feet (Chain)	8 feet	2 feet
50 feet	6 feet	1 foot
33 feet	5 feet	6 inches
20 feet	4 feet	1 inch

Metric system:

2. Measures of—

20 metres	3 metres	1 decimetre
10 metres	2 metres	1 centimetre
	1 metre	

Part II. Square Measures

Imperial system:

1. Measures of, or of any multiple of, 1 square foot.

Metric system:

2. Measures of, or of any multiple of, 1 square decimetre.

Part III. Cubic Measures

Measures of, or of any multiple of, ¼ cubic yard.

Part IV. Capacity Measures

Imperial system:

1. Measures of—

Any multiple of 1 gallon	8 fluid ounces	⅖ gill
1 gallon	⅓ pint	⅓ gill
½ gallon	6 fluid ounces	¼ gill
1 quart	1 gill	⅕ gill
1 pint	4 fluid ounces	⅙ gill
½ pint	½ gill	

2. Measures of—

1 bushel	½ bushel	1 peck

3. Measures of—

4 fluid drachms (½ fl. oz.)	30 minims
2 fluid drachms	10 minims
1 fluid drachm (60 minims)	

Metric system:

4. Measures of—

Any multiple of 10 litres	500 millilitres	20 millilitres
10 litres	250 millilitres	10 millilitres
5 litres	200 millilitres	5 millilitres
2½ litres	100 millilitres	2 millilitres
2 litres	50 millilitres	1 millilitre
1 litre	25 millilitres	

Imperial system:

1. Weights of—

56 pounds (½ cwt.)	1 pound (0.453 592 37 kilo)	½ dram	1 grain
50 pounds (½ cental)	8 ounces	100 grains	0.5 grain
28 pounds (quarter)	4 ounces	50 grains	0.3 grain
20 pounds	2 ounces	30 grains	0.2 grain
14 pounds (stone)	1 ounce	20 grains	0.1 grain
10 pounds	8 drams	10 grains	0.05 grain
7 pounds	4 drams	5 grains	0.03 grain
5 pounds	2 drams	3 grains	0.02 grain
4 pounds	1 dram	2 grains	0.01 grain
2 pounds			

2. Weights of—

500 ounces troy	5 ounces troy	0.04 ounce troy
400 ounces troy	4 ounces troy	0.03 ounce troy
300 ounces troy	3 ounces troy	0.025 ounce troy
200 ounces troy	2 ounces troy	0.02 ounce troy
100 ounces troy	1 ounce troy	0.01 ounce troy
50 ounces troy	0.5 ounce troy	0.005 ounce troy
40 ounces troy	0.4 ounce troy	0.004 ounce troy
30 ounces troy	0.3 ounce troy	0.003 ounce troy
20 ounces troy	0.2 ounce troy	0.002 ounce troy
10 ounces troy	0.1 ounce troy	0.001 ounce troy
	0.05 ounce troy	

3. Weights of—

10 ounces apothecaries	1 ounce apothecaries (480 gr.)	1½ scruples
8 ounces apothecaries	4 drachms	1 scruple
6 ounces apothecaries	2 drachms	½ scruple
4 ounces apothecaries	1 drachm	6 grains
2 ounces apothecaries	2 scruples	4 grains

4. Weights of—

10 pennyweights	2 pennyweights
5 pennyweights	1 pennyweight (24 gr.)
3 pennyweights	

Metric system:

5. Weights of—

20 kilogrammes	50 grammes	100 milligrammes
10 kilogrammes	20 grammes	50 milligrammes
5 kilogrammes	10 grammes	20 milligrammes
2 kilogrammes	5 grammes	10 milligrammes
1 kilogramme	2 grammes	5 milligrammes
500 grammes	1 gramme	2 milligrammes
200 grammes	500 milligrammes	1 milligramme
100 grammes	200 milligrammes	

6. Weights of—

500 carats (metric)	10 carats (metric)	0.2 carat (metric)
200 carats (metric)	5 carats (metric) (1 gramme)	0.1 carat (metric)
100 carats (metric)	2 carats (metric)	0.05 carat (metric)
50 carats (metric)	1 carat (metric)	0.02 carat (metric)
20 carats (metric)	0.5 carat (metric)	0.01 carat (metric)
	0.25 carat (metric)	

APPENDIX B

Some Old English Series

Saxon Lane-Measures Derived from Northern Foot (13.2 in.)

3 barleycorns	= 1 thumb	15 feet	= 1 land-rod (perch)
3 thumbs	= 1 palm	40 land-rods	= 1 furlong (furrow length)
4 palms	= 1 foot		

Edward I Length-Measures—1305

3 grains of barley	= 1 inch	5½ ulne	= 1 rod
12 inches	= 1 foot	40 rods in length and	
3 feet	= 1 ulna	4 rods in breadth	= 1 acre

Henry VII Capacity Standards—1497

2 pints	= 1 quart	2 pottles	= 1 gallon
2 quarts	= 1 pottle	8 gallons	= 1 bushel (800 oz. troy of wheat)

Henry III Weights—1266

32 wheat grains	= 1 pennyround
20 pennies	= 1 ounce
12 ounces	= 1 London pound

The above scale was for spices, confections, apothecaries' goods and coinage.

Henry VII Weights—1497

Troy:	24 grains	= 1 pennyweight
	20 pennyweights	= 1 ounce
	12 ounces	= 1 troy pound = 5,760 gr.

The above scale was for silver, gold, and bread.

Avoirdupois, for commercial use: 16 troy ozs. = 1 Merchants pound avoirdupois = 7,680 gr.

Avoirdupois, for wool weighing:

1 oz. = 437.5 gr. 16 ozs. = 7,000 gr.

APPENDIX C

A Selection of Old English Terms

Schooner: A beer measure of fairly recent use. In 1902 a Schooner of beer cost about 2d., whereas a pint cost 3d. The origin of the name is obscure, but is said to have been first used in Scotland by a Spirit Merchant for seamen who visited the harbour of Glasgow.

Winchester Bushel: This is the earliest British Bushel (a Saxon one) which was ordered by King Edgar towards the middle of the tenth century, to be kept at Winchester.

Stone: The stone of 14 lb. is well known. The butcher used a stone of 8 lb. In Darlington a stone of wool was 18 lb. A stone of flax in Downpatrick was 24 lb. and in Belfast 16¾ lb. In the glass trade a stone is 5 lb.

Melte: Two bushels of coal (Kent).

Tod: 28 lb. of wool (Bradford).

Woffler: The name given to certain individuals of the criminal type who toured the shops of larger towns representing themselves as bona fide scalemakers.

Nail: The discontinued cloth measure of 2¼ inches.

Wick Basket: A variety of quarter-chain measure.

Stillion: Old name for steelyard.

Yard of Ale: A drinking glass, resembling a coaching horn, approximately a yard in length.

Black Jack: The name of a seventeenth century drinking vessel made of leather.

Ale-Conner: An old time officer of the City of London whose duty it was to inspect the measures of public houses.

Ell: The best known of all ancient measures. Believed to have been derived from the word "elbow" and being the distance from the elbow to the end of the middle finger, about 19 inches.

Ullage: The volume of available space in a container unoccupied by contents.

Officer for White Meal: An enforcement officer of about 200 years ago whose duty it was to see that butter weighed 16 ounces to the pound, that milk was sold in a sealed measure, and whose duty concerned the quality, price, and weight of bread.

Weighbaulk: A North of England name given to a weighbridge—probably from baulks of timber.

Mancurs Balance: A form of spring balance—about 1840. Very compact and made from a piece of circular steel.

APPENDIX C

Weights and Measures of the United States of America

United States Yard and Pound

These are the same as the corresponding United Kingdom units and are defined in terms of the metric system.

United States Hundredweight and Ton

When used without qualification, hundredweight and ton commonly mean 100 lb. and 2,000 lb. These may be referred to as short hundredweight and short ton to distinguish them from the long hundredweight of 112 lb. and the long ton of 2,240 lb., the latter being the English versions.

United States Gallon

The prototype of the United States gallon was the Queen Anne wine gallon of 1706. Its volume is 231 cubic inches.

United States Bushel

The prototype of the United States bushel which is used as a dry measure, was the Winchester bushel legalised by William III in 1696. It has a volume of 2,150.42 cubic inches.

THE ART OF MERCHANDISING—YESTERDAY, TODAY, AND TOMORROW

by M. D. SMITH, *Executive Vice President, National Canners Association, Washington, D.C.*

Merchandising is probably as old as man's discovery that each of us has talents of his own and that these talents may have value to others. Before the invention of money, or even an organized barter system, an accomplished maker of stone points or bolas probably found that he could obtain more game by exchanging the fruits of his specialized labor for a fat deer or a share of mammoth meat than he could by becoming a hunter himself. Experimentation produced better products and put greater value on some of these points than others. As evidence, right here in our own country, the grooved "Folsom" arrowheads, produced by neolithic tribes in New Mexico, have been found as far east as Kentucky; and in the cliff dwellings of the Southwest, beads of cowrie shells from Florida waters have been discovered. In those dim days of the past, some enterprising early inhabitants of this land produced a product attractive enough to go beyond the boundaries known to him in return for something of value.

The earliest man who produced something a little bit better in order to trade it for an article he wanted to possess was the world's first merchandising man. Merchandising, by definition, is the promotion of a product by making it more desirable, more attractive, and easier to obtain. Anyone ambitious enough to want to continue his enterprise should also be perceptive enough to make quality the most attractive attribute of his product.

John Ruskin knew this when he pointed out that "Quality is never an accident. It is always the result of intelligent effort. There must be a will to produce a superior thing."

Packaging played its utilitarian role in the days of the ancients just as it does today. When the keels of Phoenician trading vessels grated on the sands of the Lycian shore in Asia Minor, or the mud of caphtor on the Nile Delta, seafaring merchants set up shop at shipside. The graceful amphora, the large jug with a pointed base and handles on either side, was developed specifically for this trade. Easy to lift overside, the pointed amphorae were thrust into the sand or mud shore. This probably constituted one of the world's first point-of-sale displays, as the natives gathered to trade or fight; whichever it was to be, depended upon how effective the merchants were at establishing good customer relations.

In those days, consumer dissatisfaction usually resulted in wholesale butchery at the retail level. It became a matter of some importance, even survival, to display a line which was at least as competitive as some of the cutrate items offered by the Thracians or had more appeal than the olive oil of second-pressing quality packaged in fancy filigreed amphorae by Corinthian merchants who were catering to the women's market in Tyre and Cyrene. It was quite evident that some ground rules were needed. Consumer groups were abroad in the land, and their accusations that conical amphorae were designed to delude the buyer, not as a convenience package, were believed in high places.

Now, I cannot vouch for the complaints of any specific ancient Mediterranean consumer group, but I can say that accurate weights and measures played a vital role in merchandising in Biblical times; so much so, in fact, that weights and measures are mentioned in five books of the Old Testament. Most specific, perhaps, is the thirteenth verse of the twenty-fifth chapter of Deuteronomy. It says, "You shall not have in your house two kinds of weights. You shall not have in your house two kinds of measures. A full and just weight you shall have and a full and just measure you shall have." Throughout history, all cultures have come to this same general conclusion, and merchandising, as an art, has benefitted from this concept, for it requires quality of product and skill in promotion to vie for consumer attention and, more important, repeat sales.

The inclusions of Hebrew Law into the early Christian culture of Europe remained largely a matter between the individual and his church during the Dark Ages, when there was virtually no manufacturing and there were few, if any, standards of either quality or merchandising. But with the rise of the guilds, merchandising became important once more, and pride of craftsmanship and product resulted in trademarks, hallmarks, and brands which could be recognized by consumers everywhere, even in lands far distant from the point of origin. Brands, in those days, literally scored into the containers by hot irons, became tools for merchandising. The name of a product was no longer generic, but began to become proprietary.

Quality of products, standards of quality and merchandising promotion have always gone hand-in-hand, and the same is even more true today than it was in the days of the great guilds. The difference today is in the means of production and distribution and, most important, the market.

Almost concurrent with the rise of the guilds, dedicated to standards of workmanship, was the establishment of mercantilism, a philosophy advocating the desirability of exports exceeding imports for the acquisition of national wealth, vested in the hands of rulers, for the support of armies and fleets to maintain colonialism. The outstanding exception was Spain, which acquired most of her wealth from the gold and silver mines of her colonies and, as a consequence, failed to develop industries of her own.

What all the nations espousing mercantilism utterly failed to recognize is the fact that the principal source of real wealth lay in the productive and consuming powers of their own people and that merchandising, whether practiced by Phoenicians or moderns, can be a key to this wealth.

The year 1965 marks the fiftieth anniversary of the National Conference on Weights and Measures. It is also the 200th anniversary of the birth of free, private, competitive enterprise as we know it today. Years before the American Revolution, Yankee traders had been "merchandising" American products in the pursuit of individual profits, directly in conflict with the English mercantilism's state monopolies and Royal Charters. Two hundred years ago, Adam Smith voiced what most Americans already believed and understood, that "every individual endeavors to employ his capital so that its produce may be of greatest value."

Our nation's history is witness to the industry and vigor which this concept imparted to our people. It gave us the will to compete and the rewards of successful competition. It also spawned the art of American merchandising which has affected the business concepts of the entire world and has conferred on all of us in the United States a standard of living undreamed of by those who have gone before.

The history of the canning industry actually began with an announcement from Napoleon that a prize would be offered to anyone who could devise a method of food preservation which would enable his troops in the field and seamen in the Navy to receive a balanced diet to prevent scurvy. After 14 years, the problem was solved by Nicolas Appert, who found that, if food is sufficiently heated while sealed in a container which excludes air, the food will keep. This is the fundamental principle involved in canning today.

Appert subsequently received the prize from the French, and in 1810 published a book describing the procedures used in canning more than 50 canned foods—probably the industry's first standards.

While Appert knew that his process preserved foods, neither he nor anyone else knew why. It remained for Pasteur to reveal to the world that food spoiled through the process of fermentation because of bacteria.

Two months following the publication of Appert's book in France, an English merchant applied to King George III for a patent with the additional provision that the container be of tin, or iron covered with tin, which a good tinsmith could turn out at the rate of ten cannisters a day. This is probably the first projected production figure on record for canned food containers.

Although canning, as an industry, had its beginning in response to an urgent need by a government, consumers around the world responded to this new and convenient food. They at once recognized it as nutritious, healthful, and easy to store, and that it gave variety at any time of the year—the first time in history that this had ever been possible.

By 1813, canned foods (and by the way, the word "can" was derived from the original term "cannister") were being tried by the British Navy, and by 1818 considerable amounts were being supplied to the Admiralty. Actually, the term "bully beef" is said to come from sailors' efforts to pronounce "soup and bouilli," a popular canned food item of those days.

Because canned foods steadily gained in acceptance among soldiers, sailers, and explorers, thus at government level our product enjoyed a fine reputation at the outset.

In this country, the history of canning dates from 1819, and the first products packed included pickles, fruits, and condiments, which were sold in South America and the Far East. In the same year, another canner produced canned salmon, oysters, and lobsters. Merchandising still was not much of a factor, but canned products did go down the Ohio as provisions on the first river steamer in 1821.

Technological improvements in the young canning industry boosted production during the same era as the great expansion took place in both railroads and river transportation. Merchandising was still in the "cracker barrel" era, and housewives in New York and St. Louis, as well as farmers in Maine or Tennessee, were accustomed to sniffing the coffee beans in the bin, sampling crackers from the barrel after lifting out the cat, feeling the texture of flour in the sack, and generally subjecting the merchandise to exposure of every kind. They were also inclined to haggle. Canning injected quite a new element—the need for trust.

Here was an invisible product sealed up in a can. The drummer who displayed his samples to the store owner said that the can contained a vegetable, fruit, or fish. It said so on the label, too. But the customers could not see it, smell it, nor, as a rule, try a sample without first buying it. The first sale was made on trust, or curiosity, but the second sale had to be on merit. Such merit was achieved and aided in merchandising this new product. Competition, as we know it today, differs from that which existed prior to the Civil War. When that great struggle began, the government commandeered almost all canned food production. By the close of the war, canners had increased their output six-fold and millions of soldiers and sailors had been introduced to the new product. Even so, until 1870, there were fewer than 100 canners in the country.

Between 1870 and 1900, the industry developed the retort, the pressure cooker, which enabled canners to control the cooking temperature of sealed cans; the open-top cylindrical can was invented and many other technological improvements increased production and acceptance. By 1900, the number of canning establishments had multiplied to more than 1,800 and the industry was on a mass-production basis.

During the same period, the Western Frontier, as it had been known, disappeared, mass communications became commonplace, and the consumer began to emerge as a discerning, selective group.

Until around the beginning of this century, the history of merchandising in canning, while different in many respects with merchandising in soft-goods and other products, shared with other industry a somewhat haphazard regard for quality control. Appert's glass bottles and the early handmade tin cannisters were made with little concern for uniform dimensions and capacity. If they were airtight, that was sufficient. The nomenclature of can sizes which grew up in the nineteenth century and continued into this one gave little information concerning volume and weights.

Actually, the developing methods of mass production, coupled with the greater need for advertising to market the volume produced, worked hand-in-hand to produce that which was desirable for the consumer.

When brands became nationally advertised and distributed, this, among many other factors, spurred standards which would enable its various segments to compete, item-for-item and product-for-product, to equate costs, volumes, dimensions, and grades to some established yardstick.

But in merchandising today, all of us are up against a new factor in our products—the psychological ingredient. Its importance has grown rapidly within the last 20 years, and right now we are faced with a population in which 40 percent cannot remember World War II and more than half cannot remember a depression. An entire nation has now reached the point where the majority of its people are more concerned with the kind of a life they live than in simply making a living. This is a profound change, and many of us here may find it contrary to our own experience, background, and social education.

What many of this tremendous group of young adults do not fully understand is that much of the spadework which went into the production of today's bounty, which they seem to take for granted, was done before they were born, or at least when they were children. But lest we take too much credit for that fact, we must remember that a revolutionary force is at work in the marketplace and that it has been brought on by a whole new social and economic class which differs as much from us as we do from the pioneers. If our industry is to continue to be successful at merchandising, it had better learn as much about this buyer group as about the components of the products which it hopes, through sales, to place on the market profitably.

George Bernard Shaw once said: "The fashion in which we think changes like the fashion of our clothes, and it is difficult, if not impossible, for most people to think otherwise than in the fashion of their own period." By the same token, most of today's young adult generation is greatly influenced by the thoughts and actions of others around them.

While these young people are eager to be independent, while they seem sophisticated (even those of today's brides who are most apt to have their first child at age 19), they may not, and often do not, have the maturity needed to make responsible decisions. They are looking for advice. They want to know how to live in this complex new world, but they want to define it for themselves.

Merchandising today must utilize every known tool at its disposal and continue to select new methods to sample consumer attitudes and shape consumer opinion. This burgeoning young society could move quite quickly into unexpected and, at the moment, not fully understood attitudes and catch the merchandisers completely off guard. One unknown and disturbing factor found among this group is the vague suspicion that somehow they have been fooled, on occasion, though by whom and by what are not clear. This is why viewpoint becomes such a vital factor for the merchandising men's consideration. True persuasion depends upon the ability to give oneself an understanding of the viewpoint of the audience and the ability to influence rather than satisfy the persuader of his own product's merit.

While this huge new consumer group, including newlyweds, may appear to have attitudes which are often at variance with our own, it is nonetheless a group seeking identity and stability. It is a group which more often than not insists upon quality which is properly related to price.

As I pointed out a few moments ago, many of these innovations which our young adults enjoy today and accept as products of their own time were actually envisioned decades previously. Our pace today is only an acceleration of the trend we, ourselves, set quite some time ago. We have a responsibility to guide its direction.

Oddly enough, the first institutions to cater to the new "convenience" concept were the nation's banks. About the same time that the supermarket became the Genesis of today's shopping center, banks did away with the austere tellers' cages and iron grillwork, carpeted the cold marble floors, and embarked on a program to merchandise money by making it easier to obtain and more attractive to borrow or save. Merchandising in this new postwar environment resulted in more evening and shopping hours, which reflected the proprietor's desires to accommodate the wants and needs of the consumer. There has been a phenomenal rise in the number of discount houses, which, according to their claim, have lower marketing costs and provide savings to the consumer, who knows his own needs and requires a minimum amount of attention or salesmanship to consummate his purchase.

Occasionally, a consumer charges that a package is deceptive. Because such suspicions are almost completely without foundation, we in the canning industry feel particularly strong about this and are desirous of disseminating the facts regarding proper filling and packaging techniques. We have pioneered in providing a simplification of container program and descriptive labeling standards for containers and labels which go far beyond the statutory requirements. The field of packaging, as related to merchandising, has become a science in itself.

This quiet revolution in the marketplace has brought about a multiplicity of products directly attributable to industry's desire to provide variety of selection through a vast array of consumer articles. It has also confronted the consumer with an equally broad responsibility to know and understand the facts, so that these products may be selected with wisdom. It is definitely in the manufacturer's best interest that the consumer have these facts, and the canning industry, as well as most other industries which produce consumer items, has provided vast amounts of information and material which would give maximum information and protection to the consumer.

In summary flashback, let me remind you that in the early 1900's the canning industry was one of the leading advocates of a Federal food and drug law. Such a policy, as adopted by the National Canners Association, assisted in making the law beneficial to the public and industry alike. As a consequence, good faith was established early, thus permitting the closest cooperation between National Canners Association and regulatory agencies with respect to the formulation of regulations under the law and even for revision and improvement of the law itself.

Over three decades ago, at the request of an association industry committee, a division of the U.S. Department of Commerce, now known as the Office of Commodity Standards, undertook a survey to determine the number of can sizes then in use. From the information collected, this government agency and the industry representatives evaluated the data and presented a list of can sizes to industry for voluntary adherence. The Simplified Practice Recommendation for Cans for Fruits and Vegetables was issued in 1934, subsequent periodic recommendations have been issued, and a present study is underway.

An important factor in this whole consideration of container sizes is the need to give the consumer reasonable choice; also to allow for future marketing innovations, without confusion, while at the same time permitting savings in that the canner would find it expensive to make changes or introduce new sizes without good reason. Through its simplified practice, can-size programs, our industry has successfully met consumer desires for the widest variety of products and most convenient size of container. Most important, the program has been remarkably sensitive and responsive to changes in family size, consumer demand, and the increasing variety of foods available.

The American housewife of today has a choice of some 8,000 items when she visits her large grocery store—the largest selection in history. Even so, food companies are spending about $125 million a year on research to widen the variety of their products by introducing new ones and improving existing ones. According to a recent issue of U.S. News and World Report, by 1975 the big supermarkets will carry 12,000 items, and half of them will be different from those sold today.

Many of these thousands of new products are test-marketed, and virtually all have to be merchandised to be successful. The element of trust by the consumer must prevail, and that trust will still be based in the public's confidence in the products, cooperation, and responsibility of our industry. The latter implies it also involves considerable public education and understanding.

For example, in spite of all the research, surveys, package testing, and advertising which goes into the launching of any new food product, prices today are generally more favorable to the consumer than a casual glance back at the "good old days" might indicate. In the first place, in the "good old days," the new items of today could not be purchased at all. In the realm of convenience foods, U.S. Department of Agriculture figures show that food in partly prepared form actually costs $1.07 less per $100 spent than do fresh foods, without attributing any value to the time required to prepare the fresh food.

Another challenge to canners is to educate consumers regarding fill of containers. Many items packed by our members are subject to Fill of Container Regulations. As you know, this regulation calls for a can to be virtually filled to the top, thus allowing the slight leeway for expansion when the food is heated so that the can does not bulge. You gentlemen are well acquainted with the fact that we in the canning industry have a long history of striving for accuracy in the areas in which you have particular interest. We are making a determined effort to educate the public in this regard. As an association, we do much to inform the general public of the advantages of the products of our industry. This helps the merchandising efforts of canners. Before two separate Senate committees, I have traced the canning industry's interest in protecting consumers from deception. We feel, therefore, that we are sharing with you in fulfilling our mutual basic objectives.

To aid our members in this phase of merchandising by establishing and maintaining trust, since 1952 we have distributed more than 12 million leaflets explaining our Descriptive Labeling Program to housewives, students, teachers, and youth groups, as well as to adult education programs, etc. An additional 21 million leaflets devoted to labeling and other pertinent consumer subjects have been distributed in the past 10 years to these or similar groups. Our members, representing 80 to 85 percent of canning firms packing fruits, vegetables, seafoods, meats, and specialty items, through the National Canners Association, annually spend hundreds of thousands of dollars on continuing consumer and trade-educational programs, and we produce educational publications which include up-to-date information on labeling, can sizes, and other data. These publications are made available to teachers, home economists, youth groups, and others. Actually, statements which we have disseminated concerning these vital consumer-oriented subjects have had a distribution of more than 33 million in the last 10 years, and much of this material has considerable repeat-use.

Turning for a moment from the consumer to the more technical aspects of weights, measures, and standards, there has been a revolution in packaging materials and in technology, as a visit to a modern supermarket will verify. We anticipate that this trend will accelerate.

There is bound to be a vast increase in mechanization of production operations which will increase production rates. You may rest assured that we are aware of the challenges these changes present to the food industry generally as they relate to weights and measures.

In order to further improve filling performance, more and more use is being made of statistical methods. These statistical quality control methods not only help to locate possible sources of error and provide for immediate corrective measures, but also set industry operating goals of uniformity and are being used by regulatory officials in the enforcement of weights and measures laws.

As a matter of fact, you will, I believe, be interested in various quotes from my testimony before the Senate Commerce Committee in May of this year:

> Within this past year a number of states have adopted a type-size scale for the quantity declaration on the labels of consumer commodities, in accordance with the recommendation of the National Conference on Weights and Measures. Canned food labels have no difficulty complying with these type-size requirements. But we see no valid basis for the promulgation of a Federal type-size scale, which at best would do nothing more than duplicate existing requirements already adopted in a great many states, and at worst could impose different and varying size requirements that would lead to untold confusion and needless costs. Here, again, there is no need and obvious duplication.

* * * * * * *

The idea of establishing standard quantities for packing various commodities is not new. The 27th National Conference on Weights and Measures in 1937 recorded an interest in standardization of quantities in which products could be sold. Ten years later, in 1947, the National Conference in their summary of objections to such standardization referred to: "the impossibility of canning fruits, vegetables, meat products, seafoods, etc., having different specific gravities, on a net-content liquid capacity basis without creating a multiplicity of slightly different can sizes or violating slack fill provisions of existing law."

* * * * * * *

Our industry experiences over the past decades have made us cognizant of a great many technological problems which I shall not elaborate. The fill of a canned food container and the specification of net weight for some commodities can most informatively be specified in terms of fluid ounces, or the water capacity of the can. For other commodities, it is best developed against what is called the drained weight. In still others the canning industry, in collaboration with FDA, has developed formulas for relating what is called pressed weight to input. We have done all of this under the provisions of the existing FDA Act. There is no need whatever for additional regulatory authorization.

In closing, I would like to reaffirm my industry's faith in the historic dedication of the staff of the National Bureau of Standards and that of weights and measures officials in our States and Cities. Your 50th anniversary meeting marks a most important half-century of service to the American people. As a segment of that great people, we in the canning industry congratulate you for your contributions and know that you will continue to merit their trust.

AFTERNOON SESSION—THURSDAY, JUNE 24, 1965

(J. H. LEWIS, VICE CHAIRMAN, PRESIDING)

THE NATIONAL SCALE MEN'S ASSOCIATION—DEDICATION TO PROGRESS AND PRECISION

by W. S. FULLER, *Vice President, H. J. Fuller and Sons, Inc., Columbus, Ohio*

It is a sincere pleasure for me to have this opportunity to be a part of this 50th Anniversary Program of the National Conference, and I am honored that my first official act as the new president of the National Scale Men's Association is to bring greetings from NSMA to this very special Conference on Weights and Measures. This Golden Anniversary has double significance for me because the National Scale Men's Association will also be celebrating its 50th Anniversary when it meets in Atlanta this spring for its Annual Technical Conference. So it is with true appreciation that I bring congratulations on your anniversary from the National Scale Men's Association to the National Conference on Weights and Measures.

Your Executive Secretary, Mr. Jensen, has suggested a most provocative title for my address—"The National Scale Men's Association—Dedication to Progress and Precision." A very soul-searching title. I like to think that the National Scale Men's Association has this dedication to progress and precision, always has had this dedication, and always will have this dedication—because, truly, this is the function of any industry's technical society: To keep it abreast of the times and to lead it into the future through education; to protect the standards of the industry, and to constantly try to raise the sights and ethics of the industry.

But this is quite a responsibility–to maintain progress while protecting standards, precision, and accuracy—especially in an industry like ours, where the word precision means so much. For man's economic survival—and even his ethical survival—depends upon the degree to which precision is maintained by the scale industry.

It hasn't been easy. In fact it has been a great temptation in the past to soft peddle the dedication to precision in order to promote progress in a lagging industry. I am quite sure that some of our associated industries have taken over a considerable volume of business from the scale industry with more progressive, but less accurate, measuring systems. But, ladies and gentlemen, I am proud to say that our industry has remained true to its responsibility to society. Not only has your technical society, NSMA, been true to this dedication to progress and precision, but so has our manufacturers association, S.M.A.—and, of course, the work of this National Conference on Weights and

Measures has been most effective. Talk about dedication to progress and precision! We can all be proud of the dedicated men who have worked so hard and so long on a revision for Handbook 44. A revision that would maintain the precise standards of our industry, but do it in a very up-to-date and progressive manner. This responsibility to society has been shared by all facets of our industry.

I would like to give you a little background on the scale industry's technical society: Some history of the National Scale Men's Association, how NSMA has always been dedicated to precision, and what is now being done by NSMA to help the scale industry and weights and measures progress.

The National Scale Men's Association was organized in 1916, almost 50 years ago, to fulfill a very urgent need for a technical society in a very important and highly technical industry. NSMA, however, was slow to grow. In fact, the entire scale industry has been slow to grow because industry in general was becoming mechanized and resented the time required for precision weighing. Even today the membership of NSMA is still under 1,000. But, through the years, NSMA membership has been strong in other ways, if not in numbers. The leadership of the National Scale Men's Association has always been dedicated to maintaining high standards for the scale industry.

One way this has been accomplished is through the NSMA Annual Technical Conference. Each year produces a better and more comprehensive technical program where all progressive ideas on weighing can be presented. But, by NSMA's policy of stressing accuracy, the originators of these progressive innovations, have been forced to further develop their ideas into acceptable precision devices. If these new ideas had not been exposed at these NSMA Technical Conferences, they never could have been refined into some of our modern weighing systems.

Another means of maintaining high standards for the industry has been promoted by paying honor to the men in our industry who have stood for high professional standards, and who have contributed greatly to the Scale Industry. Each year, the National Scale Men's Association, pays tribute to certain deserving men by publicly presenting them with a special award.

In the Division Organization of NSMA there are many opportunities present for scale men to work together for the good of their industry, for scale men to learn more of their technology, and for scale men to develop a professional attitude on a local level where they can recognize the need for precision in our industry.

NSMA has backed and helped promote many projects for the good of the scale industry. To name a few: Contributions were made by NSMA towards the publishing of a book on Scale Terminology and Definitions by the Scale Manufacturers Association; NSMA has always helped in the promotion of Weights and Measures Week; NSMA has been active in encouraging the adoption of Handbook 44 by most of the States in the union; NSMA has compiled a complete and up-to-date library of weights and measures laws; NSMA has advocated the transition to the decimal and metric systems in our country. These are some of the things which the National Scale Men's Association have been doing for years to help the industry maintain its standards of precision, and at the same time to promote its growth.

However, the age of automation has forced a new kind of progress upon us. Industry in general has progressed from the age of mechanization to the age of automation. The scale is now an integral part of the production process; and, at last, the scale industry is growing at a very rapid rate. As you can imagine, the need for education in our industry is critical, and at the same time the need to protect our standard of precision is paramount.

To help satisfy these needs, our industry has helped to establish a Measurement Science Curriculum at the university level, at Alfred Tech, State University of New York. This could well be the most important advancement in all our fifty years. Not only will this technical course help satisfy our educational needs, the outgrowth of this endeavor will create a feedback effect that will make our industry grow even faster.

As you can see, the demands of NSMA to progress with this growth, and to provide the necessary technical society services, are tremendous. But NSMA is taking the necessary steps to meet this challenge. For one thing, NSMA has adopted a new Constitution. A Constitution which will give the Divisions more direction and activity, which means that the Association is organized for growth. Already the National Scale Men's Association has established a Scholarship Fund for sending young men to Alfred Tech where they can study measurement science. And I predict that the National Scale Men's Association will soon have a full-time staff that will put the Society in a position to publish the much needed technical handbook on scales—and to sponsor seminars for upgrading scale men who cannot go back to school.

The membership of the National Scale Men's Association should reach 5,000 members in the next three years. Some of you may ask—just where are all of these members going to come from? The National Scale Men's Association is not made up of a group or several groups; it is not an organization of companies. No, NSMA is an organization of individuals. All persons who are interested in the weighing industry are eligible for membership. This not only includes scale servicemen, but scale salesmen, engineers of weighing systems, users of scale equipment, and by all means, weights and measures men. We are all scale men.

Yes, the purpose of NSMA is just what the title of this talk implies—dedication to progress and precision. To protect the standards, performance, and ethics of our industry—and to promote a professional attitude by all our members; to educate our members in the unique techniques of our industry—and to educate society in the importance of the scale industry, weights and measures, and the scale man; to cooperate with this Conference in every possible way to promote and help with your important work.

If any of you weights and measures men, you scale men, in this room, are not members of NSMA, I want to give you a personal invitation. I want to encourage you and your associates to join NSMA—your technical society. And to dedicate yourselves to maintaining progress and precision in your profession.

THE MEASUREMENT OF LENGTH: YESTERDAY TODAY, AND TOMORROW

by LEWIS BARNARD, JR., *Chairman of the Board, Lufkin Rule Company, Saginaw, Michigan*

Introduction

If man were not a social being, he would have no need for units of measurement, standards of measurement, or measuring devices as we know them today. But, man *is* a social being. He lives among other men and must communicate with them. Systems of measurement are a form of communication.

In all probability, he has always felt some need for measurement. The earliest man, seeking a cave for shelter, tried to find one in which he could stand erect. He was a unit of measure, a standard of measure, and a measuring device, all at the same time. As he began to recognize and satisfy other needs, such as clothing, he pieced together skins and hides to cover him and his mate. Again, however, he had no need for any system of clothing sizes like that required in the garment industry today.

As long as man produced only for his own consumption, he had no need to create names for units of measurement. He had no need for standards of measurement. He required no measuring devices other than the most rudimentary type he might choose to make for himself.

Measurement of Length—Yesterday

However, when human beings began to depend on each other, started working together, and began exchanging goods, a common language of measurement became necessary. As in other forms of communication, a system of names had to be devised—this time for units of measurement. It became necessary to establish standards, so that these units would have the same meaning for every one who used them. It also became necessary to create devices that measured these units and standards.

The Royal Egyptian Cubit

Although there is evidence that many early civilizations devised units of measurement and some tools for measuring, the Royal Egyptian Cubit generally is recognized as the first standard of linear measurement.

It is believed that the Royal Egyptian Cubit came into being about 3,000 B.C., almost 5,000 years ago. It was decreed equal to the length of the forearm plus the width of the palm of the Pharaoh ruling at that time.

The distinctive feature of this system, however, was the formation of a Royal Cubit Master. It was executed in black granite, "to endure for all time." Cubit sticks, made either of wood or ordinary granite, were the tools of measurement used by the thousands of individual workers involved in the construction of tombs, temples, and other royal monuments. It was decreed that each cubit stick should be returned at each full moon to be compared with the Royal Master. Failure to do so was punishable by death. Although such extreme punishment seems incredible today, it does underscore the importance which the Egyptians placed on their standard of measurement.

To recapitulate, we see that the Egyptians, some 5,000 years ago, had a system of measurement. The Royal Cubit was the unit. The Royal Master was the standard. The cubit stick was the measuring device. In addition, they set precedent for government decree in standardizing measurement. This is indicated by the fact that it was the Pharaoh's forearm and palm that provided the basis for the cubit, and by insistence on regular, periodic checking of the cubit stick.

Details of the Royal Cubit.—To achieve some understanding of the versatility of the Royal Cubit and the cubit stick requires no more than a brief review of its divisions and subdivisions. The basic unit in the cubit was the digit. There were 28 digits in a Royal Cubit. Four digits equalled a palm. Five digits equalled a hand. Twelve digits, or three palms, equalled a small span. Fourteen digits (½ cubit) equalled a large span. Sixteen digits, or four palms were one t'ser. Twenty digits, or five palms, were a remen. Twenty-four digits, or six palms, were a small cubit.

A variety of measurements to fractions of a digit was also possible. The 14th digit on a cubit stick, for instance, was divided by scribed lines into 16 equal parts. The next digit was divided into 15 equal parts, and so on, to the 28th digit which was divided into two equal parts. Thus, measurement could be made in digit fractions with any denominator from 2 through 16. The smallest division, $\frac{1}{16}$ of a digit, was equal to $\frac{1}{448}$ of a Royal Cubit.

Accuracy of Measurement.—With the Royal Cubit Master as the standard and periodic checking of cubit sticks against the master, the Egyptians achieved amazing degrees of accuracy. For instance, although thousands of individual workers were involved in building the Great Pyramid of Gizeh, through the use of the cubit stick, the length of the sides of this huge monument vary no more than $\frac{1}{20}$ of one percent from the mean length of 9 069.45 inches. This is only about 4½ inches in 755 feet.

Translating the Royal Cubit—At this point, it is advisable to re-emphasize the communications aspect of measurement. To the Egyptian worker, cubits, palms, digits, hands, spans, and remens were common, everyday terms. To the 20th century worker, they are meaningless until they are translated into present-day units.

Thus, the Royal Cubit takes on familiar proportions when it is described as being equal to about 20.6 inches. A digit was slightly less than ¾ of an inch—.738 of an inch, to be more ex-

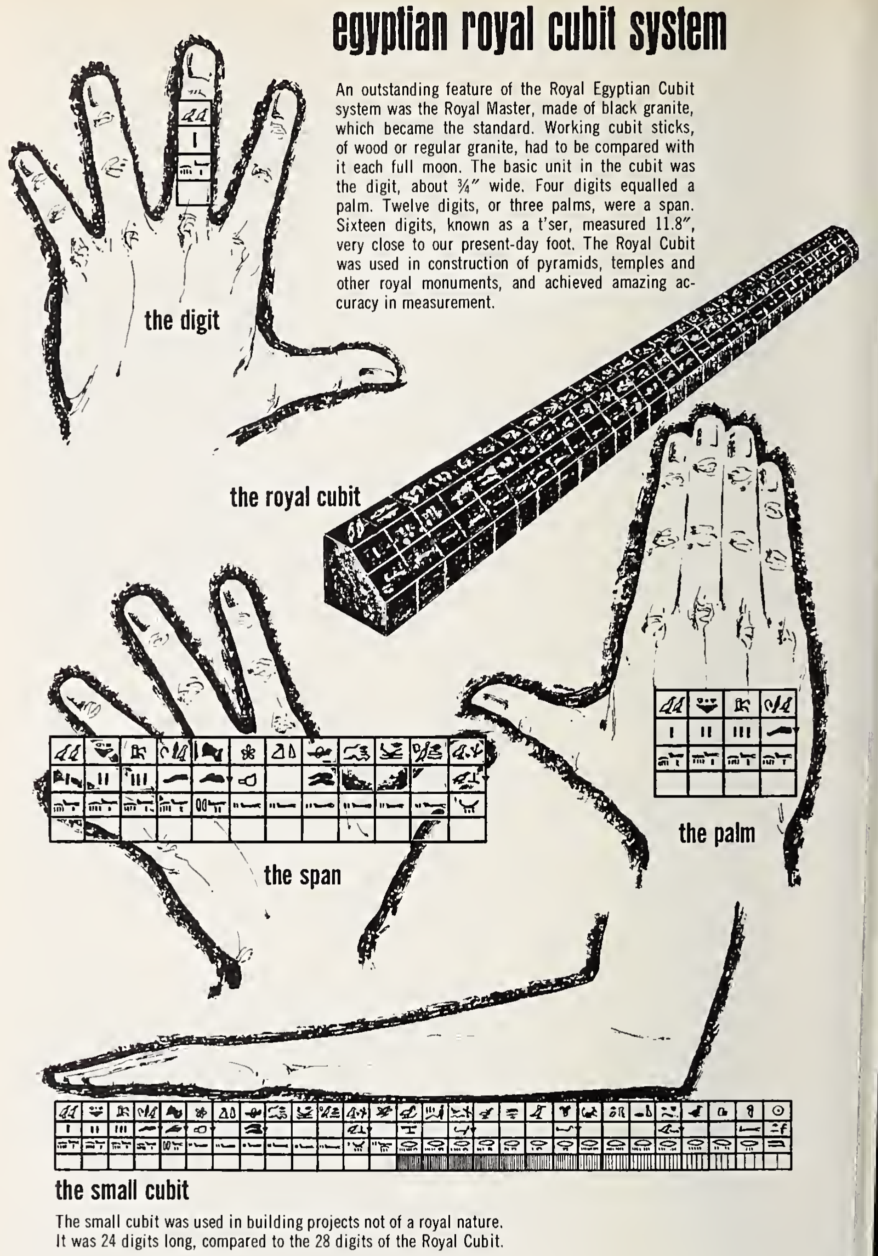


FIGURE 1.

act. The smallest division on a cubit stick, $\frac{1}{16}$ of a digit, trans-lates into .046 of an inch. One t'ser, which was 16 digits, is easier to visualize as 11.80 inches, or close to our 12-inch foot

The similarity that appears in units and standards of measure among civilizations widely separated by both time and geography has been a matter of conjecture. One logical explanation is that trade, commerce, exploration, and military conquest spread certain units from one country to another.

For instance, the Greeks under Alexander the Great, conquered Egypt in 322 B.C. It is entirely possible that the Greeks adopted and adapted Egyptian units of measure. The Greek Olympic cubit contained 24 digits, the same as the small cubit of Egypt. The fact that the Greek digit is .05 of an inch longer than the Egyptian digit presents no real obstacle to believing that the Greek measure was based on the Egyptian.

Another explanation for similarity is that the ancients, whenever and wherever they lived, probably started measuring by using the handiest instruments at their disposal—their hands, their arms, their feet. A finger, or digit, such as the thumb or the middle finger, understandably would be a basic unit.

There is ample evidence throughout history that parts of the human body were used as units and standards. King David I of Scotland, in 1150, ruled that the inch was the mean measure of the thumbs of a large man, a medium-sized man, and a small man. Also, in the 12th century, King Henry I of England decreed the yard to be the distance from the tip of his nose to the end of his thumb. In the 16th century, the rod was established as the sum of the length of the left feet of the first 16 men out of church on a certain Sunday.

In fact, it is not hard to imagine that if we had to start today to create units and standards of measurement, we would use our fingers, hands, arms, and feet. We very conceivably could come up with an American "cubit," divided into digits, palms, and other natural units. And, despite the fact modern man generally is larger than ancient man, a unit such as a finger would not be much different in size from the Egyptian digit.

Land Measurement

Land measurement, too, has its roots in antiquity. The development of surveying instruments appears to have been assisted, at least in part, by development of instruments used in astronomy. The ancients made unusual strides in astronomy through careful observation of the heavens.

About 4,000 B.C., for instance, the Chaldeans used a device known as a "merchet" for measuring time and meridian. It consisted of a slotted palm leaf through which to sight and a bracket from which a plumb bob was suspended. A line was projected by sighting through the slot and past the plumb-bob string.

The Egyptians, too, are known to have developed methods and instruments for measuring land. They had a system of land taxes, and with the Nile annually overflowing its banks, benchmarks and surveying techniques had to be developed, so that property boundaries could be reestablished when the flooding was over.

Knotted ropes are known to have been used in measuring land, and the Egyptians had a knowledge of angles and calculations for determining areas.

Some of our present units of land measurement are related to man and his activities. For instance, the distance a yoke of oxen could plow without stopping was called a "furrow long." This distance was taken as 40 lengths of the pole or goad used in driving the oxen. The "furrow long" eventually was standardized as $\frac{1}{8}$ of a mile. Today, of course, the furlong is $\frac{1}{8}$ of a mile. This is equal to 220 yards. With 40 poles in a "furrow long," the pole, or the rod, is equal to $5\frac{1}{2}$ yards, or $16\frac{1}{2}$ feet.

A strip of land which could be plowed in one day was designated as four ox-goads wide. This would make the area four rods wide and 40 rods long. This amount was legalized under King Edward I of England, in the 13th century, as an acre. It is believed this word derives from the Anglo-Saxon word, "aecer," which meant a plowed or seeded field. Incidentally, the acre in the United States today is the same as that decreed by Edward I some seven centuries ago.

Devices of Measurement

To this point, any measuring device we have considered has been comparable to the ruler or the yardstick—essentially a flat surface, with various divisions and subdivisions marked in some manner.

Refinements began to appear in the 17th century. In 1631, for instance, Pierre Vernier evolved the principle of a sliding scale that made reading of a linear measurement much more accurate than was possible with a scale as ordinarily divided. It makes use of our visual ability to bring two lines accurately into coincidence.

Also, in the 1630's, William Gascoigne devised adjustable indicators to measure stars with the aid of a telescope. Measuring dimensional adjustments to a few thousandths of an inch were possible by mathematical calculation of screw movement. This, in effect, was a forerunner of the micrometer.

In 1772, James Watt invented a micrometer. It had two dials. One was divided into 100's, and made possible reading of the measuring face in .01 of an inch. The second dial permitted readings to $\frac{1}{256}$ of an inch.

In 1789, Eli Whitney started "duplicate part production" of firearms. He devised jigs and fixtures to serve as gages. This was the forerunner of mass production and progressive gaging.

The 19th century witnessed the introduction of devices such as micrometer calipers, micrometer sheet metal gages, vernier calipers, vernier protractors, and a system of gage block sizes based on arithmetical progression.

As the tools of measurement for industry grew in number and application, advances also were made in the development of tools for surveying. Naturally, the number of devices and instruments in industry was much greater because of the variety of manufacturing operations.

In 1620, Sir Edmund Gunter developed an instrument for measuring land that consisted of 100 pieces of steel rod, linked together by small rings. It had a total length of 66 feet and was known as Gunter's chain. The units for recording distances were chains and links. A chain, of course, was 66 feet. A link was .66 of a foot, or 7.92 inches. A mile was 80 chains. An acre was equal to 10 square chains. The 66-foot length of the chain also was equal to four rods. Ten-link intervals on the chain were marked with metal tabs.

Another chain, known as the Ramden or engineer's chain, also had 100 links, but each link was one foot long, and total length of the chain was 100 feet. This, of course, necessitated specifying which chain was used in a surveying project when distances were expressed in links and chains.

Much of the measurement for the subdivision of public lands in the United States was made with the Gunter's chain, and many notes and records are still expressed in chains and links.

When steel-making knowledge and technology advanced to the point where it was possible to make lengths of thin steel ribbon, the Gunter's chain began to be replaced by steel tape measures. They were more compact and easier to handle than the link chain. In addition, the chain with all of its links and rings had so many surfaces subject to wear that it became inaccurate after repeated use.

The steel tape also presented some problems, because it was affected by temperature. Although it was possible, by calculation, to compensate for the expansion or contraction of steel, the search was made for a metal with a smaller coefficient of expansion.

This proved to be a nickel-iron alloy, which is now available under a variety of brand names. Where temperature differences encountered are relatively small, there is no need for correction of readings with this type of tape. The nickel-iron alloy tape became the standard device for taking baseline measurements that serve as the known factor in other survey measurements and computations. Such tapes used in surveying missile tracking sites are now calibrated by the National Bureau of Standards to about a part in a million.

In rough terrain, survey measurements have to be corrected to straight-line distances. Over the years, aids have been developed, such as the transit and the theodolite, to permit reading of angles of slope. Through the use of trigonometry, straight-line distances are then calculated.

Standards of Measurement

Although the genius of individual men produced advances in instruments of measurement at various times and places throughout history, the generally confused political and social state of mankind, in general, militated against orderly development of standards of measurement.

Even the unification of nations was slow in coming, and the existence of many small, autonomous units of government worked against uniform standards of measure. Even the standards that were decreed were not too helpful, because they were not easily reproducible. These would include standards such as "the sum of the length of the left feet of the first 16 men out of church on Sunday," or "the distance from the tip of the nose to the end of the thumb."

Some rulers even capitalized on the lack of standards by using overgenerous measures for the collection of taxes. In fact, this was one of the causes of the French Revolution in 1789.

It was one of the reasons why the French Republican Committee, in 1790, turned its attention to measurement. Their unit of length, adopted in 1790, was the length of the meridian which passes through Paris and extends from the North Pole to the Equator. Divided in 10 million parts, this was the meter.

Experience proved the difficulty of using the earth as a standard of measure. Thus, in 1799, a metal standard, known as the Meter of the Archives, was adopted as the official standard. The metric system met resistance, sometimes stormy, for almost 50 years in France. In 1837, Louis Philippe finally was able to impose the metric system in all measures except time.

Great Britain also was having its problems with standard of measurement in the latter part of the 18th century. For instance, they had at least three different miles and two units for subdivisions. To correct this situation, the British Imperial Yard was agreed upon as the basis for all linear measurements. The one standard that was made was destroyed by fire in 1834. A new standard was constructed and adopted in 1855. Since 1866, it has been in the custody of the British Board of Trade.

In 1870, the first of a series of conferences was held for the purpose of establishing the metric system internationally. Delegates from 15 countries attended. In 1889, the work of this conference was approved. Thirty prototype meters were made from a platinum-iridium alloy. The one most nearly equal to the Meter of the Archives was selected as the International Prototype Meter. The others were distributed to participating countries, including two to the United States. The bar designated as No. 27 has become our National Prototype Meter.

In 1892, using the principles of interferometry, Albert A. Michelson determined the wave-length of the red-cadmium line of the light spectrum, and established measurements by light waves as potential standards. In 1927, an International Conference on Weights and Measures established 1 553 164.13 cadmium-red wavelengths as the length of the International Prototype Meter. In 1960, an international standard of length was adopted which expressed the meter as 1 650 763.73 wave-lengths of krypton 86.

The particular value of using light wavelengths is that they provide a natural, indestructible linear standard, with accuracy to within a millionth of an inch, that can be reproduced anywhere on earth.

An important milestone in measurement, of course, came at the beginning of the 20th century, with establishment in the United States of the National Bureau of Standards in 1901. Subsequent development of mass-production techniques and emergence of the United States as the world's leading industrial power have combined to make measurement standards and refinement of measuring devices of utmost importance in the American scheme of things.

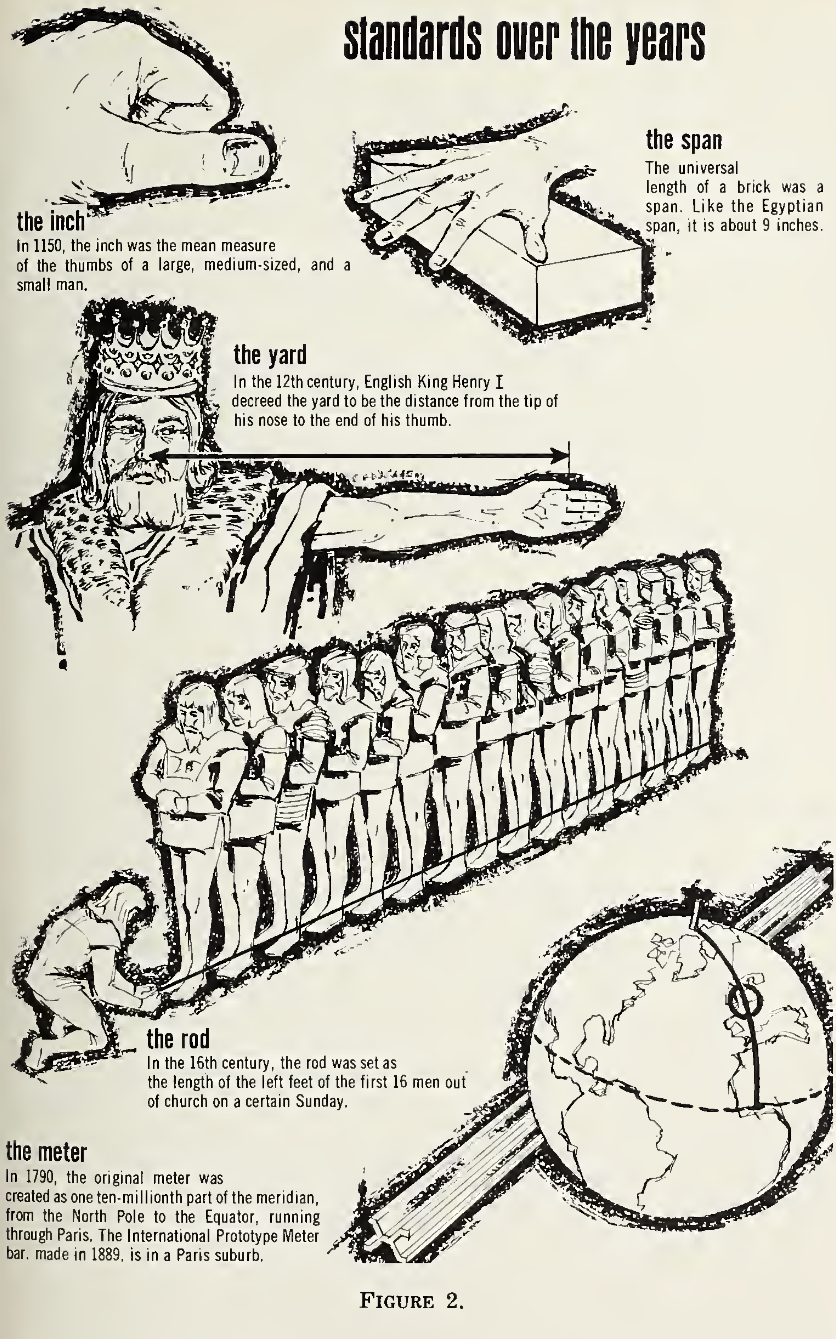

standards over the years
the span
The universal length of a brick was a span. Like the Egyptian span, it is about 9 inches.
the inch
In 1150, the inch was the mean measure of the thumbs of a large, medium-sized, and a small man.
the yard
In the 12th century, English King Henry I decreed the yard to be the distance from the tip of his nose to the end of his thumb.
the rod
In the 16th century, the rod was set as the length of the left feet of the first 16 men out of church on a certain Sunday.
the meter
In 1790, the original meter was created as one ten-millionth part of the meridian, from the North Pole to the Equator, running through Paris. The International Prototype Meter bar, made in 1889, is in a Paris suburb.

FIGURE 2.

Any decision on what constitutes "today" in a discussion of measurement of length must be arbitrary. As in any evolutionary process, it is difficult to keep today from merging with yesterday and tomorrow. But, for our purposes, let us consider as "today" the period from 1940 to the present. The 25 years since 1940 have brought unprecedented growth and advances in science, engineering, and industry. Each advance places new demands on measurement, not only in achieving precision and accuracy, but also a means of communicating new information.

Degrees of Precision

Much has been said and written about the growing emphasis on precision manufacture, shrinking tolerances, and finer finishes. Examples are cited, particularly in spacecraft manufacture, of measurements to a millionth of an inch. Generally speaking, however, tolerances in the one-thousandth inch range are still considered precision in most industrial applications.

One author, Ted Busch, whose *Fundamentals of Dimensional Metrology*, Part I, was published, in 1964, by Delmar Publishers, Inc., Albany, New York, has cautioned: "Don't sneer at thousandths of an inch. . . They do not put space vehicles in orbit, but they do provide the money for all far-out projects. They are the dimensions that keep the modern mass producing economy alive and progressing."

The Role of Magnification

Even taking this seemingly common and undemanding requirement for "precision" manufacturing, how do you measure a thousandth of an inch? About the smallest division on a rule that is discernible to the naked eye is $\frac{1}{100}$ of an inch. This, of course, is 10 thousandths. Thus, you would have to divide the $\frac{1}{100}$ graduation into 10 parts to achieve a graduation of a thousandth of an inch. This discrimination between such small divisions could not be achieved by the human eye.

The answer to reading graduations of a thousandth of an inch or smaller is to find some way to magnify the readings. This can be achieved mechanically by such instruments as a micrometer or dial indicator, optically by comparators, pneumatically by air pressure gages, or electronically by electronic gaging systems.

A micrometer, for instance, achieves magnification through the relationship of radial screw movement to lateral movement of the screw. The screw, or spindle, on a micrometer has 40 threads to the inch. It has a thimble attached and threads into a graduated hub. One revolution of the thimble will move the spindle laterally the distance of one thread. This is $\frac{1}{40}$ of an inch, which is the same as .025 of an inch. Now, let us assume the circumference of the thimble is $1\frac{1}{2}$ inches, which is the same as 1.5 inches. Then, to move the spindle laterally .025 of an inch, we must make one complete revolution of the thimble, which represents a total thimble movement of 1.5 inches. To move the spindle laterally .001 of an inch, we would turn the thimble $\frac{1}{25}$ of a revolution. This represents a thimble movement of $\frac{1}{25}$ of 1.5 inches, or .060 inches. We have thus magnified the .001 inch motion of the spindle into .060 of an inch on the thimble. We have achieved a magnification of 60 times and made it possible to read .001 of an inch quite easily.

Dial indicators use the mechanical principle of gears to magnify distances. A system of racks, pinions, and gears translate the relatively small movement of contact points into readable distances on dial faces. For instance, a dial indicator with a diameter of $2\frac{3}{4}$ inches has a dial circumference of approximately $8\frac{1}{2}$ inches. If it is graduated to .0001 of an inch and has 100 graduations, it achieves a magnification of more than 800 times, because .0001 of an inch movement of the contact point is represented by a graduation on the dial of more than .080 of an inch. Readings to .00005 of an inch are possible with some dial indicators.

As another example of magnification, let us consider electronic systems. Briefly, an electronic instrument changes physical movement of a gaging head into electrical energy, then magnifies the electrical energy and changes it back into mechanical energy, which is reflected by the movement of a needle across a meter face. As an example, let us take an electronic system, which is on the market, that provides a magnification factor of 15,000. It can measure a distance as small as .000002 (2 millionths) of an inch. On the meter face, this is represented by a space of .030 of an inch. An added advantage of electronics is that different magnifications, or ranges, can be built into the system. Changes from one range to another can be made with the simple flick of a switch. This versatility is not possible with mechanical magnification.

Limitations Inherent in Magnification

Despite the great strides made in finer measuring and precision manufacturing, perfection has escaped human beings in the field of measurement as it has in all areas.

Each method of magnification, such as those discussed briefly above, has its inherent limitations. In the micrometer, for instance, any deviation from perfection in the pitch of the screw threads could cause variations at any point within the range of the instrument. Any wear on the spindle or the anvil, which are the micrometer parts that contact the object being measured, also will cause inaccuracies.

In dial indicators, the same problem of correctly-shaped and pitched gear teeth, and wear from metal-to-metal contact, work against perfection. In addition, there is the problem of inertia and balance in the dial hand. In electronic systems, safeguards must be built in against fluctuations in electrical currents, and there are practical limits, such as cost and space, to such safeguards. Accuracy of the readout meter also represents a potential limiting factor.

As a result of these inherent limitations, most manufacturers of measuring devices specify some limitation on the accuracy of the instrument. Obviously, these limitations are not too restrictive, because industry has achieved outstanding success in mass precision manufacture of the many items we all use every day, and also in more sophisticated and smaller volume ventures, such as satellites, rockets, missiles, and spacecraft.

The Rule of Ten

One means of overcoming the limitations of measuring devices is to apply what is known as the "Rule of 10." This means that a measuring device should be selected that can measure to one more decimal place than the established tolerance of the part it is measuring; in other words, the instrument should divide the tolerance into 10 parts.

For example, if the measurement of a part is expressed with a tolerance of plus or minus .001 inch, the instrument selected for measuring should be toleranced to .0001 inch. This still does not eliminate all possibility of error, but it does reduce the possibility substantially. In practice, it is sufficiently accurate.

Compounding this problem, on occasion, is what is known as the "zero of ignorance." Here is how this works. A designer may feel that a given part should have a measurement with a tolerance of plus or minus .001 inch. To be on the safe side, however, he adds another decimal place and specifies the measurement with a tolerance of plus or minus .0001 inch.

As a theoretical venture, let us see what could happen if the "zero of ignorance" were compounded all along the line by the application of the "Rule of 10." This will lead us quickly beyond the realm of the practical, but it will also give us some insight as to why efforts are being made continually to find ways of taking finer and finer measurements with a greater degree of certainty.

This is how it would work. A designer, to be safe, expresses a part measurement with a tolerance of plus or minus .0001 inch. The production worker, applying the "Rule of 10," would then have to have a gage to measure to .00001 inch. The master to set the gage would have a tolerance of plus or minus .000001. The instruments to calibrate the setting master would have to have a tolerance of .0000001 inch.

Thus, we see that the theoretical application of these rules soon takes us beyond the limits of practicality for normal industrial production. However, measurements this fine are being made daily in laboratories all over the world. And, in the light of human progress thus far, who can say that today's laboratory achievement may not be tomorrow's production norm?

Measuring Devices at Work

To go from the theoretical to the practical, let us consider various types of measuring devices, or instruments, and some of the ways in which they are applied today.

Tapes and Rules.—Tapes and rules are available in many different forms, materials, and graduations. All of them, generally speaking, offer a flat measuring surface which is divided and subdivided into recognizable scales. They measure or compare directly, without benefit of magnification.

Let us assume you are going to build a house. The first step is to excavate. In all probability, the excavating contractor will use a woven tape to stake out the measurements of the excavation. He could use a steel tape, but woven tapes, normally available in lengths up to 150 feet, are less expensive, lighter, easier to handle, and sufficiently accurate for the job. The "tolerance" on this job probably would be several inches—even up to a foot.

Next would come the foundation. Again, fairly sizable measuring jobs would be involved. For this work, measurements would be taken with a steel tape, because "tolerance" would become more critical.

As the framework of the house begins to take shape, you probably would see carpenters using folding wood rules, graduated to $\frac{1}{16}$ of an inch; many of these rules would have metal extensions to facilitate inside measurements. Bricklayers, too, might have folding wood rules, graduated to $\frac{1}{16}$ of an inch on one side and marked in brick mason's standard or modular scales on the reverse side. Or, perhaps, the carpenters and brick masons might be using steel tape rules. In fact, the building trades on the West Coast do show a marked preference for steel tapes over wood rules. Even with inside trim and "built-ins," a "tolerance" of $\frac{1}{16}$ of an inch usually is sufficiently precise.

Precision Measurement and Gaging.—When your house is built and you begin installing motors and appliances, or putting your car into the garage, you are dealing with products that were manufactured in plants where tolerances considerably smaller than $\frac{1}{16}$ of an inch are standard.

Metalworking plants, especially those producing moving parts, will certainly be concerned with measurements that have tolerances expressed in thousandths of an inch or smaller. And, as we have discussed previously, this requires instruments that measure to ten-thousandths of an inch.

These precision tools could be micrometers or calipers for measuring inside or outside diameters, or hole depths, or metal thickness. They could also be dial indicators, incorporated into machinery and equipment, to check dimensions at various stages of production. They could be gages for checking thickness, taper, or radius of a part against a known configuration. In addition, they could be any one of several types of instruments used in final inspection, such as electronic systems, air gages, or optical comparators.

Suffice it to say that nothing is designed, developed, or manufactured without being measured. As manufacturers offer longer and stronger warranties on their products, craftsmanship is faced with increasingly severe demands for precision and accuracy. This, in turn, places greater burdens on the instruments of precision measurement, whose manufacturers must work to increasingly tighter standards in producing their equipment.

The fact that longer and stronger warranties are being given on manufactured products is eloquent testimony to the greater precision being offered in this type of measurement.

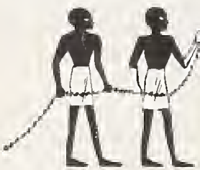
milestones in measuring devices

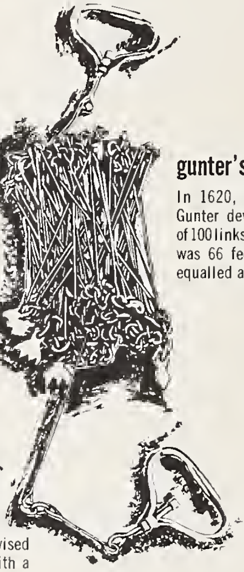
horizontal and vertical levels

As adjuncts to measuring length, the Egyptians used horizontal and vertical levels to achieve trueness. The base of the Great Pyramid of Gizeh, for instance, measures about 755 feet on a side. Linear measurement, without regard for trueness, could produce serious error over these distances.

knotted rope

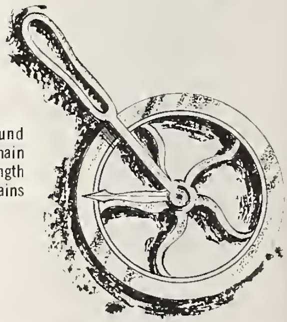
Land measurement was facilitated by the use of knotted rope.





gunter's chain

In 1620, Sir Edmund Gunter devised a chain of 100 links. Chain length was 66 feet; 80 chains equalled a mile.



wheel race

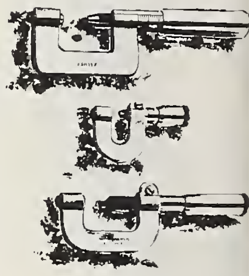
By counting the revolutions of a wheel of known circumference, one man could obtain fairly accurate land measurements quickly.

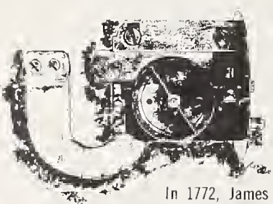
gascoigne indicator

In 1638, William Gascoigne devised adjustable indicators, for use with a microscope, to measure stars.

systeme palmer

Patented in France in 1848, this was a direct forerunner of the present-day micrometer caliper and the micrometer sheet metal gage.





watt's micrometer

In 1772, James Watt made a micrometer with two dials. One read to 1/100 of an inch; the other to 1/256 of an inch.

Figure 3.

Land Measurement

As land values have increased, the need has become greater for land measurements with a high degree of accuracy. Surveyors and engineers have developed and refined techniques for achieving this accuracy.

In recent years, also, new instruments have been developed which take advantage of technological progress in fields such as electronics and optics. Essentially, these instruments provide a source for generating radio or light waves to distant transceivers or reflectors. The time elapsed between projection of the beam or electromagnetic wave and its return, yields distance when the time figure is applied to the known rate of speed of the signal.

With built-in computers, much of the drudgery of computation is removed and in many instances, much time and effort are saved. At present, instruments of this type are being used in helicopters to survey very rugged areas, including some areas previously uncharted.

And now, let us take a quick look into the future.

Measurement of Length—Tomorrow

The future really staggers anyone's imagination. By now, it has become evident that truth is stranger than science fiction.

We are in the midst of a "knowledge explosion." A very significant result of this "explosion" is that it has tended to level many of the "fences" that have separated various fields of human endeavor in the past.

The Laser

A good example is the laser, development and application of which impinges on such traditionally specialized fields as optics, electronics, physical chemistry, and atomic physics. The word "laser" means Light Amplification by Stimulated Emission of Radiation.

Although the laser holds promise for advances in many fields, we are interested in its application to the measurement of length. In this field, it means not only more precise measurement of length, but also more precise measurement over longer distances. In fact, its precision has even led to the suggestion that the laser itself might be used to establish an independent standard of length.

Although light wavelengths have been used for years to define the International Meter, the distance could be measured only over a range of about 10 centimeters. Beyond this distance, fringe patterns of the light become too coarse and not suitable for fringe count. Because of the greater coherency of the laser light, this limitation of distance does not exist. Experiments conducted by the National Bureau of Standards, using a helium-neon gas laser, have been completed over the entire length of a meter bar. The length agreed to within 7 parts in 100 million with the assigned length of the bar. In other experiments, the laser has produced light that has remained coherent over lengths in excess of 100 meters.

In the next five years, the laser could bring more advance in the science of precise length measurement than has been achieved in the last two centuries.

Electronic Measurement

The ability to process dimensions as electronic signals gives us the ability to apply this most powerful tool to the art of measurement. Presently, measurements to millionths of an inch are commonplace in the inspection laboratory.

Extension and refinement of presently known electronic and optical techniques will provide rugged, simple to use, reliable measuring equipment able to measure to millionths of an inch *without* physically contacting the part being measured. This is also a definite possibility with the gas laser mentioned earlier.

The advent of microelectronics and integrated circuitry will make possible the electronic hand gage or micrometer or dial indicator.

This will make it possible to give the worker at his station the ability to measure in tens of millionths rather than in thousandths, as is now the case. As a matter of fact, such devices are already developed, awaiting only market demand. Compared to the present electronic gage, they are like a wrist watch is to a clock you would have on your mantel.

"In-process gaging" will be greatly expanded. The machine that makes the part will also gage the part and correct itself so as to eliminate scrap. The contactless gaging previously mentioned will be extended to machine applications and to automation.

Direct, at-the-machine measurement, using standard light wave lengths as the reference, will become commonplace. The digital output of such instruments lends itself to direct computerization, which, combined with rapidly-evolving data processing techniques, will put quality control on an almost automatic basis.

A completely automatic factory, capable of producing any type of machine part, upon receipt of the desired dimensions and tolerances, certainly is not impossible to imagine.

Land Surveying

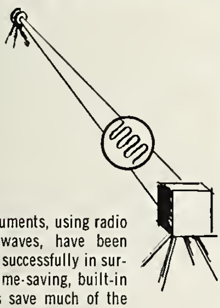
We have been discussing short range measuring techniques. Let us now look at the future for distance measurement, as in land surveying and geophysical studies.

We can predict that experimental work now being accomplished in the laboratory on electronics and optical ranging techniques which convert distance to a digital signal will result in greatly simplified surveying systems. As in the case of short-distance gaging, the ability to process distance as an electronic signal, combined with microelectronics and electronic data processing, will relieve the civil engineer of many of his present routine burdens and will actually revolutionize the art of land surveying. Use of this type of instrument has already yielded accurate measurement over spans of up to 20 miles.

Another revolutionary project in the making is one to map the world, using special cameras and satellites. The NASA and the U.S. Coast and Geodetic Survey are leading this effort. One

electronic surveying

Since man has successfully, and repeatedly, ventured into space, almost anything seems possible for the future. Already satellites have been used in earth-mapping projects. One project revealed that the Bermuda Islands lie 220 feet north and 105 feet west of their previously mapped locations, a difference that helped to explain inconsistencies that had persisted in tracking data produced at Cape Kennedy and Bermuda tracking stations. Experimental work in electronics and optical ranging techniques also promises simplified surveying systems.



New instruments, using radio or light waves, have been employed successfully in surveying. Time-saving, built-in computers save much of the drudgery of computation.

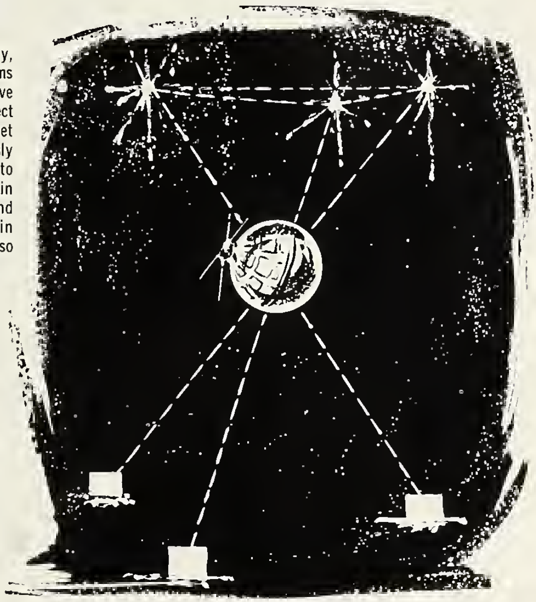


FIGURE 4.

plan calls for cameras positioned at three widely separated points on the earth's surface to photograph simultaneously a satellite passing overhead. Then by complex calculations, relating the location of each ground station to the spacecraft, distances on the ground can be determined in a way somewhat akin to conventional methods of land surveying.

In 1964, Coast and Geodetic Survey experts, working with the satellites, Echo I and II, determined that the Bermuda Islands actually lie 220 feet north and 105 feet west of their previously mapped location. The difference helped clear up inconsistencies that persisted in tracking data produced at NASA's Cape Kennedy and Bermuda sites.

Unquestionably, progress is being made in many other areas, but these few examples serve to indicate that the future may well turn fantasy into fact. Now, let us come back to the present and consider an important problem in the practical application of measurement.

Variety in Units of Measurement

Over the years, there has been much discussion centering on the relative merits and demerits of the inch-pound system versus the metric system. In recent years, a third subject, the decimal-inch, has been added to the discussion because it has attracted growing support from industry.

Discussion in this area, as in the fields of politics and religion, has a tendency to turn into controversy.

Such controversy is not new. In fact, in 1906, a certain Col. Sir Howard Vincent, member of parliament from Sheffield, England, had this to say in defense of the Decimal Association, which then was promoting adoption of the metric system: "It is simply amazing that the campaign of the Decimal Association should meet with any opponent. He should be in the moon!"

The Metric System

Without getting into too much detail, here are the chief arguments put forth by proponents of the metric system:

1. It is a "whole" system, encompassing length, width, volume, area, density, and capacity.
2. It is expressed decimally, and is easier to use than are fractions in making computations. There is no need to convert in and out of fractional quantities. There are no problems of finding common denominators.
3. It is estimated that 90 percent of the world's nations, representing 80 percent of its population and 60 percent of its trade, have adopted the metric system. Among the major nations, only the United States and British Commonwealth countries use the inch-pound system.
4. The metric system is the language of scientists the world over, and science is playing an increasingly important role.

The Inch-Pound System

Supporters of the inch-pound system advance arguments such as these:

1. The inch-pound system is a more natural system, having developed from the requirements of practical men, producing real products.
2. Slightly more than 50 percent of the world's manufactured goods are produced on the inch-pound measurement.
3. Fractional division of the inch is feasible and usable to as fine a division as $\frac{1}{64}$. This is approximately $\frac{15}{1000}$ of an inch. The smallest practical scale division in the metric system is a millimeter. This is about $\frac{40}{1000}$ of an inch. The next metric division would be $\frac{4}{1000}$ of an inch, too small for reading with the naked eye.
4. The number 12 is divisible by 2, 3, 4, and 6; the number 10 is divisible only by 2 and 5.

The Decimal-Inch

Proponents of the decimal-inch, who include many engineers and engineering groups, claim it combines the better features of both the metric and the inch-pound systems. Their arguments run like this:

1. It simplifies arithmetical computation by eliminating fractions.
2. It simplifies conversion of inches to metric where such conversion is required.
3. It is already in use in those instruments graduated to thousandths or ten-thousandths of an inch.
4. It is easier to learn than the fractional progression.
5. Complete decimalization of the inch is compatible with computerization.

Deterrents to International Standardization

Achieving international standardization certainly faces practical difficulties. But, it also involves human factors. Like giving up smoking, or stepping into a cold shower, the first problem is to really make up your mind to do it.

This is not to discount the practical problems. They are formidable. To change to the metric system in the United States would be costly and time-consuming. Estimates range anywhere from $26 billion to $100 billion in cost, and from 5 to 100 years in time.

One real problem would be the conversion of drawings and blueprints from the inch system to the metric. And, a corollary problem would be duplication of prints. For machinery and equipment already in the field, present drawings and prints would have to be retained.

Duplication of parts inventory, by manufacturers and others in the distribution chain, would be required for some time until only metric equipment was in use.

Gages, dials, and other measuring instruments would have to be changed from their present markings and calibrations to become metric.

Industry has become so complex and interdependent that gradual change would be difficult. If a manufacturer decided to employ metric measurement, his suppliers would be obliged to do the same. Training salesmen, dealers, distributors, and consumers to work with metric measurement would be time-consuming and costly. In addition, there would be the expense of new catalogs, sales aids, and other literature necessary to implement the change to the metric system.

On the other hand, proponents of the metric system point out that other nations have made the change at various stages in their development. This began with the Low Countries in 1820 and has continued right up to 1959, when Japan adopted the metric system. They point out that Great Britain is very seriously considering changing to metric, partly to improve its opportunities for trade with Common Market countries. They emphasize that foreign trade, although a relatively small consideration in the American economy now, can grow significantly in the future.

They also point out that the metric system is clearly preferred in science. They argue that it is adaptable to measurements ranging from the tiny particles of nuclear physics to those encountered in the literally astronomical distances of outer space.

They claim that metric measurements can be communicated readily and used in complex calculations with relatively small opportunities for error. They offer the argument that neither the inch-pound system nor the decimal-inch can handle this wide range of measurements so easily or systematically.

Communications Problems

The validity and effectiveness of any form of communication depends to some degree on its audience. A formula is clear to chemists. Morse code is understood by telegraphers and radio operators. Equations make sense to mathematicians. French is the way to communicate in France.

In measurement, modes of communication differ with the audience. Metric is the language of the scientist. In the United States, the inch-pound system has been used by engineers, of whom many are now inclined to support the decimal-inch. Manufacturing, by and large, is on the inch-pound system, with some gravitation toward the decimal-inch. Mr. and Mrs. American Consumer are oriented to the inch-pound system.

In the summer of 1964, for instance, Lt. Billy Mills became the first American ever to win the 10 000 meter race in the Olympic Games. Most Americans had little concept of the length of the race. Had it been called a 10 kilometer race, many of them who have served overseas or traveled abroad might have had a better idea of the length of the contest. The most meaningful description for Americans, of course, would be 6¼ miles. For the ancient Egyptians, it would have been 19 047 Royal Cubits.

Whatever the unit or standard used, the distance would be the same and could be measured accurately. Only the mode of communication and understanding differs.

Thus, if it is proposed to install the metric system at all levels in the United States, perhaps it becomes valid to wonder whether the American consumer would ever settle for a kilogram of ground beef instead of two pounds, or whether he would be satisfied with 118 milliliters of aftershave lotion instead of four fluid ounces.

In any event, it would appear that the need for international uniformity in measurement will increase in the future. With the frontiers of knowledge advancing so rapidly and beginning to overlap in many fields, serious consideration must be given to achieving, rather than talking about, international uniformity. Hopefully, discussion in the future will shed more light and generate less heat than in the past.

Summary

There can be little doubt that our whole economic system of mass production depends on precise and accurate measurement

Neither can there be any doubt that the activities of science engineering, and business and industry are becoming increasingly entwined. The time lag between new scientific theory or discovery is growing shorter all the time.

As the frontiers of knowledge not only move ahead but also overlap, the need for clear communication becomes greater.

As we have seen, measurement is a form of communication.

More than ever, the world needs universal uniformity in units and standards of measurement. Whether the inch-pound system, the metric system or the decimal-inch should prevail is difficult to say. Or, perhaps, there might even be new standards and new units being shaped that will make the inch and the meter as obsolete as the Royal Cubit.

Obviously, mankind has made great strides in the measurement of length despite the multiplicity of units, standards and systems. Progress will not come to a crashing halt if this multiplicity persists. It must be recognized that there are serious obstacles to achievement of worldwide uniformity.

But, there will never be a better time than now to start trying to solve this problem.

MORNING SESSION—FRIDAY, JUNE 25, 1965

(J. E. Bowen, Vice Chairman, Presiding)

(Following the Incoming Executive and Annual Committee Reports, an "Open Forum" was held, led by the Standing Committee Chairmen and Executive Secretary: The session was thrown open to questions from the floor on any weights and measures technical or administrative problem.)

(At the conclusion of the Open Forum, Chairman Campbell presented the gavel to the incoming 51st National Conference Chairman, J. F. True of Kansas. The benediction was then delivered by the Conference Chaplain, Rev. R. W. Searles. Thereupon, at 11:00 a.m., the 50th National Conference on Weights and Measures was adjourned *sine die.*)

REPORTS OF THE CONFERENCE COMMITTEES
REPORT OF THE CONFERENCE EXECUTIVE COMMITTEE

presented by V. D. CAMPBELL, *Chairman, Chief, Division of Weights and Measures, Reynoldsburg, Ohio*

(Thursday, June 24, 1965, 2:15 p.m.)

The Executive Committee of the 50th National Conference on Weights and Measures held the first session on Monday, June 21, 1965, at 8:30 a.m.

Conference activities, program format, social activities, hotel arrangements, and locality for future Conferences were among items reviewed and discussed.

Amendment to Organization and Procedure of the National Conference.—During the past year, the Executive Committee has given serious consideration to the resolution adopted by the 49th National Conference in which the Conference recommended unanimously that a means be found through which the Weights and Measures Advisory Committee might be continued.

The resolution acknowledged that the Advisory Committee as constituted at that time, was to be terminated on June 30, 1964. That Committee had served the National Bureau of Standards since 1954, and its activities and recommendations have been valuable both to the management of the Bureau and to the Conference. Discussion preceding the adoption of the resolution included the thought that an Advisory Committee might be established within the framework of the National Conference. The Executive Committee is of the opinion that this is a sound approach and that it best can be accomplished through an amendment to the Organization and Procedure of the Conference so as to establish an additional standing committee.

Accordingly, the Executive Committee recommends that the Organization and Procedure be amended to provide for a new standing committee to be known as the Committee on Liaison with the National Government. I, therefore, present this proposal in the form of a motion and move its adoption to become effective immediately by unanimous consent of the Conference:

1. Amend paragraph on standing committees of Section 5 on page 6 of the Organization and Procedure to read:

Standing Committees.—The standing committees are the Committee on Specifications and Tolerances, the Committee on Laws and Regulations, the Committee on Education, and the Committee on Liaison with the National Government, each with a normal complement of five members appointed by the President from the active membership (except that the members of the Committee on Liaison with the National Government may be appointed from the active or the associate membership) on a rotating basis for five-year terms . . . (No further change in the paragraph.)

2. Amend Section 7 of the Organization and Procedure by inserting at the end of the section a new paragraph:

Committee on Liaison with the National Government.—The Committee on Liaison with the National Government annually presents a report for Conference action. Its mission is to represent the Conference to the National Government and to consider and make recommendations on matters before the Conference and on matters concerning relationships of Conference members and associate members with the National Government and particularly with the National Bureau of Standards.

* * * * * * *

Location for the 51st National Conference.—Mr. Lawrence Barker of West Virginia, who had been appointed Chairman of a Subcommittee of the Executive Committee to study and advise on the practicability of scheduling the 51st National Conference (1966), in Denver, Colorado, presented his report on the activities of the Subcommittee. This report described a very thorough study of the subject, including a questionnaire to each State requesting their individual views. Based on the results from the questionnaire, the Subcommittee recommended that the 51st National Conference be held in Denver, Colorado.

The Executive Committee as a whole unanimously approved this report and is recommending to the incoming Executive Committee that the 51st National Conference be held in Denver, Colorado. During the open committee meeting no objections were raised to this recommendation.

Attendance at Open Meetings of the Executive Committee.—The Committee feels that attendance at, and participation in, the open meeting of the Executive Committee should be improved. The Committee reminds the delegates that they have a very real responsibility in voicing their views as to Conference plans and affairs.

V. D. Campbell, Chairman
L. Barker
J. E. Bowen
J. H. Lewis
W. I. Thompson
C. C. Morgan
R. W. Searles
N. Berryman
J. M. Boucher
R. J. Fahey
R. H. Fernsten
F. M. Gersz
M. Jennings
D. E. Konsoer
J. F. Lyles
E. A. Vadelund
M. W. Jensen, Secretary
Executive Committee

(On motion of the Committee Chairman, seconded from the floor, the report of the Executive Committee was adopted by voice vote.)

STATEMENT OF THE INCOMING CONFERENCE EXECUTIVE COMMITTEE

presented by J. F. TRUE, *State Sealer, Division of Weights and Measures, State of Kansas*

(Friday, June 25, 1965, 9:35 a.m.)

The Executive Committee for the 51st National Conference met for breakfast at 7:30 a.m. on Friday, June 25, to consider matters falling appropriately within its authority. Decisions were reached as follows:

1. The Conference program should be loosened sufficiently to permit discussions following formal papers.
2. The Executive Committee recommends to the 50th National Conference that the 51st National Conference be held in Denver, Colorado, the week of July 10, 1966. (If it is the decision of the Conference that the 51st be held in Washington, it is to be held the week of June 19).
3. The registration fee for the 51st National Conference will remain at $15.00.
4. The program schedule for the 51st Conference will remain as has been traditional for the past several years—that is, open committee meetings on Monday, and on Tuesday morning if necessary, formal sessions to start either on Tuesday morning or Tuesday afternoon, and to end Friday morning, with Wednesday afternoon open.
5. The Executive Secretary will plan the program.
6. The Executive Secretary is authorized to arrange for an appropriate program for the ladies.
7. An allocation of $400 was authorized for use by the Committee on Education for the promotion of National Weights and Measures Week and to cover other official expenses of the Committee as approved by the Conference Executive Secretary.

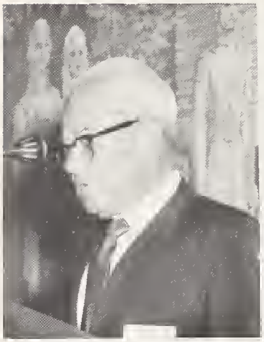
The Executive Committee expresses satisfaction with the arrangements for and conduct of the Golden Anniversary Conference and looks forward to a continuation of progress during the 51st.

REPORT OF THE COMMITTEE ON EDUCATION

presented by J. T. DANIELL, *Chairman, Deputy City Sealer of Weights and Measures, Detroit, Michigan*

(Thursday, June 24, 1965, 10:10 a.m.)

1. Introduction



The Organization and Procedure of the National Conference on Weights and Measures delegates to the Committee on Education consideration of matters embracing the technical training of weights and measures officials, the education along weights and measures lines of the general public and of users of weights and measures equipment, and the public relations programs and procedures for weights and measures organizations.

The Committee on Education has several topics to consider in submitting its report to the 50th National Conference on Weights and Measures.

2. The Measurement Science Course at Alfred Tech—Its First Year

State University of New York, Agricultural and Technical Institute, located at Alfred, New York, and known as Alfred Tech, now has a new curriculum in Measurement Science. The purpose of the curriculum is to offer a terminal program to prepare technicians in the field of Scale and Measurement Technology.

After over a year of planning, the Measurement Science Program began at Alfred Tech in September, 1964, with 16 full-time students. By the beginning of the third quarter, the last of March 1965, forty-five students had enrolled. The increase of 29 students came about through the transfer into the program from other curriculums. It is significant that the program has gained the attention of many students who, before beginning their studies at Alfred Tech, had not heard of Measurement Science. By mid March 1965, twenty-two students already had been accepted for the program for September 1965.

In early September 1964, the entire admissions staff at the College spent a week visiting scale manufacturing plants and allied industries in the New Jersey area. This kind of orientation has done much to inform the admissions staff of the scope of the Measurement Science field.

During the academic year, over $30,000 worth of mechanical scale equipment has been sent to the College by 20 different scale companies. This equipment has represented the major part of the Measurement Science laboratory.

The course during the year has been enriched by speakers from three companies and from the National Bureau of Standards. These representatives have effectively spoken of the scope and opportunities in the field. Next year it is expected that from

15 to 20 specialists will come to the campus and address the students about their special areas.

About one-half of the students during the first year expressed an interest in summer employment in one of the scale manufacturing plants. This number is far less than that requested by the plants. This area holds much promise as the program develops.

Mr. George Whitney, Chairman of the College's Industrial Technologies Division and an enthusiastic supporter of the program spoke at the 46th Annual National Scale Men's Association Technical Conference in Las Vegas, Nevada, on April 20. Mr. Whitney explained the aims and objectives of the Measurement Science Program to the West Coast men.

The College advises that it is pleased with Measurement Science during its first year and hopes that industry will be equally pleased as qualified and well-trained technicians become available.

Your Committee is indebted to Dean Milo Van Hall who was most cooperative in supplying information regarding the first year's progress.

Information regarding the Measurement Science Program may be obtained from Milo Van Hall, Dean of Student Academic Programs, State University of New York, Agricultural and Technical College, Alfred, New York.

3. National Weights and Measures Week

A Subcommittee on National Weights and Measures Week was again appointed this year.

Mr. Lorenzo A. Gredy, Chairman of this Subcommittee, skillfully directed nationwide activity in this area and will present the Report on National Weights and Measures Week.

At the 1964 meeting of the Committee on Education when the "Week" was discussed, it was decided to continue the promotional activities by the Committee on Education as a whole as has been done during the past few years. Each member of the Committee served as regional coordinator with the individual State Chairman responsible for promotional operations within his own State. The Committee feels that this method has proven successful in the various States.

Interest in the "Week," judging from a representative sampling of the reports, indicates that this year's National Weights and Measures Week was a great success. However, again it was evident that in some areas there was no participation while, in other areas, enthusiastic support was overwhelming. From the reports, it was noted that several Governors' proclamations and statements were issued, and governing bodies of counties and municipalities also participated. Excellent use was again made of the newspaper mats (furnished by the NBS Office of Weights and Measures) by advertisers who were desirous of having the public become better acquainted with this very important governmental operation. Many areas throughout the country reported that displays set up in the lobbies of banks, office buildings, and in the windows of stores were viewed with enthusiasm with many questions asked about weights and measures. Lectures and the showing of films were reported by the score. Many of the jurisdictions reported that they have developed their own material to be presented along with talks and exhibits. The Committee is of the opinion that material directed toward students in the lower school levels should be developed. At the present time, the only such materials available are the films produced by the Office of Weights and Measures.

Radio and TV spot announcements and a slide of the weights and measures emblem were used throughout the country during the "Week." Also, prepared radio tapes were used to good advantage.

The Committee on Education is deeply indebted to The Scale Manufacturers Association for its project in providing over 5,000 "Third Man" posters. From the comments received from weights and measures officials, all were highly enthusiastic about the posters. In addition to providing good publicity for weights and measures and for scales, we feel the poster program created goodwill for the scale industry and for weights and measures officials. The Executive Secretary of the Scale Manufacturers Association reported during the open committee meeting that for the coming year they will make available to weights and measures officials at no cost a supply of Weights and Measures Week stickers. However, "Third Man" posters may still be obtained from the printer at nominal cost.

During the year, we were again disappointed in that there was no issuance of a United States commemorative stamp to be timed for our Golden Anniversary National Conference on Weights and Measures. However, the Committee requests your fullest cooperation for National Weights and Measures Week 1966; a request has again been forwarded to the U.S. Postmaster General for issuance of a stamp commemorating the 100th Anniversary of the Congressional action legalizing the use of the metric system in this country. We again urge everyone's support in contacting their legislators in order to obtain additonal consideration for this important project.

It has been the idea of the Conference Committee on Education and a number who attend the National Conference that we conduct year round publicity and not confine our program to a so-called "once a year shot in the arm." We feel that considerable impetus has been given to year around publicity for weights and measures services, as indicated by newspaper articles of weights and measures activities in particular and consumer interest articles in general.

For the 1966 observation, the Committee feels that it may be productive to consider devising a questionnaire to survey for promotional ideas. Should Congress approve the first allotment for State standards in 1966, the Committee will consider attempting to obtain some national publicity, whether it comes during the "Week" or not.

This report cannot be brought to a conclusion without taking the opportunity to thank members of our Conference, both the weights and measures officials and associates, who, through their enthusiastic efforts, are actually responsible for the success of the occasion.

4. New Ideas in Public Education

As a means of getting weights and measures information before the public, a weights and measures official prepared a letter containing tips to housewives and forwarded it to a columnist, who graciously included his letter in her column. This column appeared in about five hundred newspapers throughout the country. This ingenious approach brought the matter of weights and measures information to the attention of many thousands of women and in hundreds of communities.

A particularly fertile field for public education is the elementary school classroom. Not only are the young people themselves presented with weights and measures information, but they take home the ideas, and the parents likewise are educated and become aware of the activities of the weights and measures official.

The need to contact the children and to acquaint them with the functions of weights and measures officials was very evident at this hotel last year when a fine group of young people held their meeting at the same time as the 49th Conference. These students were designated as "Leaders of Tomorrow;" yet, in talking with several in this select group, it was noted that they were unaware of weights and measures activities.

The Committee will undertake as one of its major items for the coming year the development of suggested outlines and other instructional material for use in making presentations to school children starting at the elementary level at a time when basic units and systems of weights and measures are first studied in the classroom and continuing through the high school level. The Committee feels that this is an item of great importance and solicits the cooperation of all weights and measures officials and industry members in the development of such material.

The Committee gratefully acknowledges the many constructive suggestions received relating to the development of material for use at the elementary and high school levels. These suggestions will be given consideration during the coming year.

5. New Training Aids Available for Technical Training of Weights and Measures Officials

A new self-training aid entitled, "Examination of a Single Product Motor Fuel Dispenser" is now available. This aid, together with "Examination of a Computing Scale," presented last year, offer audio and visual instruction in a step-by-step procedure as recommended by the Office of Weights and Measures in the Examination Procedure Outlines for these devices. Loan copies of the presentations are available for short-term loan or the series may be purchased at moderate cost for the permanent use of a jurisdiction. Applications for loan or purchase are available from the Office of Weights and Measures, National Bureau of Standards, Washington, D.C. 20234. Interest in and use of these training aids by weights and measures officials has been quite limited and is disappointing to your Committee. The Committee highly endorses the production of these technical presentations and urges weights and measures officials to take advantage of this training opportunity.

6. Commemorative Stamp—100th Anniversary of the Congress Recognizing the Metric System as Legal in the United States

The Post Office Department issues about fifteen commemorative postage stamps each year. The Department has a backlog of approximately three thousand requests and receives from two hundred and fifty to three hundred new proposals each year. It therefore becomes obvious that to have a postage stamp issued, it must not only comply with the regulations of the Post Office Department, but must have a special appeal to the public.

In 1866, the Congress recognized the metric system as legal in the United States, and it is deemed appropriate to request the issuance of a postage stamp to celebrate the 100th anniversary of this event.

The metric system is a matter of great importance in world economics. Great Britain is preparing to shift its weights and measures to the metric system over the next ten years. The conversion will leave the United States, Canada, Australia, and New Zealand as the only major countries using nonmetric measurements.

So that the request may receive favorable consideration, the cooperation of everyone present is earnestly solicited. It is vitally important that many communications be sent. The Committee strongly urges all delegates to this Conference and others interested in, or affected by, weights and measures control to immediately, upon returning home, prepare and send letters to the Postmaster General and to Senators and Representatives in Washington, so that this request will represent a nationwide project.

7. Summary

The Committee wishes to register its appreciation to all who, by their splendid cooperation, assisted your Committee throughout the year, and to offer them our sincere thanks.

J. T. DANIELL, *Chairman*
S. H. CHRISTIE, Jr.
L. A. GREDY
A. D. ROSE
C. H. STENDER
M. W. JENSEN, *Secretary*
R. N. SMITH, *Staff Assistant*
Education Committee

(On motion of the Committee Chairman, seconded from the floor, the report of the Committee on Education was adopted by voice vote.)

DISCUSSION OF FOREGOING ITEM

J. E. BOWEN: As a past chairman of the Education Committee, I was quite pleased that the Committee stressed the importance of promoting weights and measures education in the schools, both public and private, at the lower grades.

Several of us have appeared before college classes and lectured. The more of that we can do the better. Several of us have also made a point of promoting this at the public school level, sometimes in the primary grades, sometimes at junior high school age.

I would urge everybody here to give that more attention if they can. In another four or five years, these children will be the adults that are doing the purchasing as well as the selling. It is certainly a very worthwhile project for any weights and measures man.

I notice under Item No. 4 that reference is made to a weights and measures official who prepared a letter that ended up in the columns of five hundred newspapers. I think it is a little too bad to say just a weights and measures official. It was Bill Thompson, who is now at the lectern, and I think that is one of the most dramatic promotions that we have had. I think he is to be highly commended, and we could use a lot more promotion of that nature.

REPORT OF THE COMMITTEE ON LAWS AND REGULATIONS

presented by LAWRENCE BARKER, *Acting Chairman, Commissioner, Department of Labor, State of West Virginia*

(Thursday, June 24, 1965, 12:17 p.m.)

The Committee on Laws and Regulations submits its report to the 50th National Conference on Weights and Measures, the report comprising the Tentative Report as amended by this Final Report.

1. ADMINISTRATIVE RULING

Prominence and Placement of Quantity Statements on Package Labels.—The Committee has been encouraged by the almost universal acceptance by the States and by the packaging industry of the Administrative Ruling that was adopted by the 49th National Conference. The Committee is now of the opinion that the provisions of the Administrative Ruling should be made a part of the Model State Regulation Pertaining to Packages.

First, the Committee wishes to acknowledge a proposal to amend the Administrative Ruling that was received from the Glass Container Manufacturers Institute, Inc. Said proposal would permit the net quantity declaration to be blown or molded in the surface of nonreturnable glass containers in the same manner permitted on reusable glass containers. After serious consideration of this proposal, the Committee is in agreement with the proposed amendment and has, accordingly, made the necessary changes in the language of the Administrative Ruling that is recommended for inclusion in an amendment to the Model Package Regulation that follows.

(Item 1 was adopted by voice vote.)

2. MODEL STATE REGULATION PERTAINING TO PACKAGE

SECTION 3.6. REDUCTION OF FRACTIONS.—The Committee has received representations to the effect that the language "only binary-submultiple common fractions" tends to lead to the interpretation that only such fractions with the numerator of 1, such as, ½, ¼, or ⅛, are acceptable. To clarify the intended meaning, the Committee recommends that this section be amended to read as follows:

3.6. *REDUCTION OF FRACTIONS.*—Declarations of quantity may employ common fractions or decimal fractions. A common fraction shall be in terms of halves, quarters, eighths, sixteenths, or thirty-seconds, and shall be reduced to its lowest terms. Except in the case of drugs, a decimal fraction shall not be carried out to more than two places: *Provided*, That, if there exists, with respect to a particular commodity, a firmly established general consumer usage and trade custom contrary to the requirement pertaining to common fractions, as set forth above, for the reduction of a common fraction to its lowest terms, the declaration may be made in accordance with such usage and custom.

(Item 2, Section 3.6., as amended, was adopted by the Conference by voice vote.)

SECTION 3.7. SUPPLEMENTARY DECLARATIONS.—The Model Package Regulation contains no guidelines with respect to the use of supplementary quantity declarations that are, in value of weight, measure, or count, equal to the required declaration. This void has caused a certain amount of confusion among packagers and serious concern to weights and measures officials. In its report to the 49th National Conference, the Committee included an interpretation directed to this point. The Committee now recommends that a new Section 3.7.1. SUPPLEMENTARY QUANTITY DECLARATIONS be added to the Model Regulation and that present Sections 3.7.1., 3.7.2., and 3.7.3. be renumbered to become 3.7.2., 3.7.3., and 3.7.4.

3.7.1. *SUPPLEMENTARY QUANTITY DECLARATIONS.*—The required quantity declaration may be supplemented by one or more declarations of weight, measure, or count: *Provided*, That any such supplementary declaration shall be accurate; any such supplementary declaration shall be neither in larger size type nor more prominently displayed than the required quantity declaration; and any supplementary statement shall not be so located as to detract from, or confuse or mislead as to the precise meaning of, the required quantity declaration.

DISCUSSION OF FOREGOING ITEM

MR. J. F. LYLES (Virginia): Mr. Chairman, it would seem to me that by the adoption of this section it would help lead to the confusion instead of clearing some up, in that more than one supplementary quantity statement may appear on the label. I would propose that this section be amended by changing the first sentence to read as follows:

> The required quantity declaration may be supplemented by not more than one declaration in the same system of weight, measure, or count . . .

and then continuing on with the remainder of this section.

(Mr. Lyles' proposed amendment was defeated by voice vote.)

MR. O. A. OUDAL: Does this mean, for instance, that a package with a quantity declaration of 1 pound 2 ounces, which is correct, could carry a supplementary statement such as, 18 ounces or such as, 510 grams?

MR. BARKER: I would say that your observation is correct, as long as the supplementary statement is not more prominently displayed or apt to mislead or to confuse.

(Item 2, Section 3.7.1., as amended by the Committee, was adopted by a standing vote of the Conference, 93–45).

SECTION 6. PROMINENCE AND PLACEMENT.—The Committee recommends that Section 6 of the Model Regulation be expanded to include the provisions of the Administrative Ruling and that the section thus be amended to read as follows:

6. *PROMINENCE AND PLACEMENT.*

6.1. *GENERAL.*—All information required to appear on a package shall be prominent, definite, and plain, and shall be conspicuous as to size and style of letters and numbers and as to color of letters and numbers in contrast to color of background. The declaration of identity, if required, and the net quantity statement shall appear on the principal display panel of the package. The name and address of the manufacturer, packer, or distributor shall appear either on the principal display panel or on any other appropriate panel. Any required information that is either in hand lettering or hand script shall be entirely clear and equal to printing in legibility.

6.2. *DEFINITIONS.*

6.2.1. *LABEL.*—The term "label" as used in this section shall be construed to mean a display of written, printed, or graphic matter blown into, applied to, or attached to a package for the purposes of branding, identifying, and giving other information on the contents of the package.

6.2.2. *PRINCIPAL DISPLAY PANEL OR PANELS.*—The term "principal display panel or panels" shall be construed to mean that part, or those parts, of a label that is, or are, so designed as to be most likely to be displayed, presented, shown, or examined under normal and customary conditions of display and purchase.

6.2.3. *AREA OF PRINCIPAL DISPLAY PANEL OR PANELS.*—Barring evidence to the contrary, the square inch area of the principal display panel, or of each of the principal display panels if there be more than one, shall be (1) in the case of a rectangular container, one or more entire side or sides of which properly can be considered to be the principal display panel or panels, the product of the height times the width of that side or those sides; (2) in the case of a cylindrical or nearly cylindrical container where the label covers the entire cylindrical or nearly cylindrical surface, 40 percent of the product of the height times the circumference; (3) in the case of a cylindrical or nearly cylindrical container where the label does not cover the entire cylindrical surface, the total actual area of the label or 40 percent of the product of the height times the circumference whichever is less; (4) in the case of a sack or bag, or other flat container, the total printed area or one-third the total flat area whichever is greater; and (5) in the case of a container with a distinctly identifiable label or label area, the total actual area of the label or label space: *Provided,* That this section shall not apply to permanently labeled glass containers, for which see paragraph 6.7.

6.3. *EFFECTIVE DATE.*—This section shall be effective with respect to those labels that are (a) redesigned after July 1, 1965 (b) prepared from plates, dies, cylinders, and the like made after July 1, 1965, and (c) all labels as of July 1, 1966: *Provided* That this section shall not apply to permanently labeled glass containers, for which see paragraph 6.7.

6.4. *QUANTITY DECLARATION.*

6.4.1. *LOCATION.*—The declaration, or declarations, of quantity of the contents of a package shall appear on the principal display panel, or panels if there are more than one, and shall be presented in such a manner as to be generally parallel to the base on which the package rests as it is designed to be displayed.

6.4.2. *STYLE OF TYPE OR LETTERING.*—The declaration, or declarations, of quantity shall be in such a style of type or lettering as to be boldly presented, clearly and conspicuously, with respect to other type or lettering or graphic material on the panel or panels.

6.4.3. *COLOR CONTRAST.*—The declaration, or declarations, of quantity shall be in a color that contrasts definitely with its background: *Provided,* That this section shall not apply to permanently labeled glass containers, for which see paragraph 6.7.

6.5. *MINIMUM HEIGHT OF NUMBERS AND LETTERS.*—The height of any letter or number in the required quantity statement shall be not less than those shown in Table 1, with respect to the square-inch area set forth in paragraph 6.2.3.: *Provided,* That the height of the numbers of a common fraction shall be not less than one-half the dimensions shown: *And Provided further,* That this section shall not apply to permamently labeled glass containers, for which see paragraph 6.7.

TABLE 1.—*Minimum height of numbers and letters*

Square Inch Area of Principal Panel	*Minimum Height of Numbers and Letters*
4 square inches and less	No Minimum
Greater than 4 square inches and not greater than 25 square inches.	1/16 inch
Greater than 25 square inches and not greater than 120 square inches.	1/8 inch
Greater than 120 square inches and not greater than 400 square inches.	1/4 inch
Greater than 400 square inches.	1/2 inch

6.6. *FREE AREA.*—The declaration, or declarations, of quantity shall be presented in an area sufficiently free from other printing, lettering, or marking, to make said declaration, or declarations, stand out definitely with respect to the surrounding printing, lettering, or marking.

6.7. *PERMANENTLY LABELED GLASS CONTAINERS.*

6.7.1. *LABEL INFORMATION BLOWN INTO SURFACE.*—When all label information is blown into the glass surface, the required declaration, or declarations, of quantity may also be blown into the surface: *Provided,* That in such cases said declaration or declarations shall appear in close proximity to the trade or brand name and the height of any letter or number shall be not less than 3/16 inch for containers of one pint or less capacity and not less than 7/32 inch for containers of greater than one pint capacity.

6.7.2. *LABEL INFORMATION APPLIED TO SURFACE OF CONTAINERS.*—When any label information is applied to the surface of a glass container in white or in any color, the required declaration, or declarations, of quantity shall also be applied to the surface and shall be, in size, not less than 1/8 inch for containers of one pint or less capacity and not less than 3/16 inch for containers of greater than one pint capacity.

6.7.3. *LABEL INFORMATION ON CAP OR CROWN OF CONTAINERS.*—When all label information is displayed on the cap or crown of a glass container, the required declaration of quantity may also be displayed on the cap or crown and shall be displayed prominently, conspicuously, and in color contrasting with the background: *Provided,* However, that in the instance of glass containers for soft drinks and fruit juices when the label information is displayed on cap or crown the required quantity declaration may be blown into or permanently applied to that part of the glass container in close proximity to said cap or crown, in sizes as specified in paragraph 6.7.1.

6.7.4. *EFFECTIVE DATE.*—The requirements set forth in paragraphs 6.7., 6.7.1., 6.7.2., and 6.7.3. shall be effective with respect to orders placed after July 1, 1966: *Provided,* That all containers that are manufactured to conform to these requirements shall be permanently marked with the final two digits of the year in which the order was placed: *And Provided further,* That permanently labeled reusable glass containers in service as of July 1, 1966, may remain in service.

6.8. *EXEMPTIONS.*

6.8.1. *INDUSTRIAL-TYPE PACKAGES.*—A so-called "industrial" type or "nonconsumer" type package (one that is not intended to be displayed on a retail shelf or to be sold for home consumption) shall be exempt from the specific type sizes as set forth in Section 6 of this regulation and the conformance or nonconformance of the labeling of such a package shall be determined by the facts of the case.

6.8.2. *CONTAINERS STANDARDIZED BY DEVICE REGULATION.*—Containers, such as milk bottles, lubricating-oil bottles, and measure containers, for which standards are established and specifications are set forth in National Bureau of Standards Handbook 44, *Specifications, Tolerances, and Other Technical Requirements for Commercial Weighing and Measuring Devices,* shall be exempt from the requirements as set forth in Section 6 of this regulation.

6.8.3. *PACKAGES OF ALCOHOLIC BEVERAGES.*—Packages of alcoholic beverages, for which the labeling requirements are specified in Federal law, shall be exempt from the requirements as set forth in Section 6 of this regulation.

(The Ad Hoc Industry Committee on Quantity Declaration, formed before the 49th National Conference to assist the Committee on Laws and Regulations in the development of the Administrative Ruling, has continued as an informal committee to provide additional effort toward nationwide uniformity in this area. Communication has been received from the Industry Committee to the effect that the participating trade organizations and individual business and industrial concerns have been canvassed and have expressed their endorsement of the proposal to incorporate the terms of the Administrative Ruling into the Model Regulation Pertaining to Packages. Similar endorsement was received from the Glass Container Manufacturers Institute.)

(Item 2, Section 6, as amended, was adopted by voice vote.)

3. STANDARDIZATION OF CARDBOARD CONTAINERS

The Committee received a request from Mr. John M. Stackhouse, Director, Department of Agriculture, State of Ohio, for the National Conference to consider the standardization of cardboard containers used in the marketing of apples. It was pointed out that these containers have not been approved as standard containers and, since their use is nationwide, a standard should be established to promote uniformity in interstate commerce.

The Committee is sympathetic to Mr. Stackhouse's request. However, the National Conference has not established standards for any such containers in the past for this is a responsibility that has, by tradition and law, been left up to the Federal Government and the individual States to fulfill.

Although the Committee recommends no action by the Conference, it has asked its Secretary to call this matter to the attention of the proper Federal authorities for their consideration.

(Item 3 was adopted by voice vote.)

4. MODEL STATE WEIGHMASTER LAW

A proposed revision has been developed of the Model State Weighmaster Law so that its format will be similar to that of the Model State Weights and Measures Law. Relatively few minor changes have been made in the revised Model State Weighmaster Law from the Model Weighmaster Law which was last adopted by the Conference in 1951.

It is the desire of the Committee to keep all model laws and regulations up-to-date and, therefore, the Committee recommends the adoption of the revised Model State Weighmaster Law that follows:

MODEL STATE WEIGHMASTER LAW

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF ______________

SECTION 1. MEANING OF TERMS.—When used in this Act:

(1) The term "licensed public weighmaster" shall mean and refer to a natural person licensed under the provisions of this Act.

(2) The term "vehicle" shall mean any device in, upon, or by which any property, produce, commodity, or article is or may be transported or drawn.

(3) The term "director" shall mean and refer to the State director of weights and measures.

SEC. 2. ENFORCING OFFICER; RULES AND REGULATIONS.—The director is authorized to enforce the provisions of this Act and he shall issue from time to time reasonable regulations for the enforcement of this Act, which regulations shall have the force and effect of law.

SEC. 3. QUALIFICATIONS FOR WEIGHMASTER.—A citizen of the United States or a person who has declared his intention of becoming such a citizen, who is a resident of the State of____________, not less than 21 years of age, of good moral character, who has the ability to weigh accurately and to make correct weight certificates, and who has received from the director a license as a licensed public weighmaster, shall be styled and authorized to act as a licensed public weighmaster.

SEC. 4. LICENSE APPLICATION.—An application for a license as a licensed public weighmaster shall be made upon a form provided by the director and the application shall furnish evidence that the applicant has the qualifications required by Section 3 of this Act.

SEC. 5. EVALUATION OF QUALIFICATIONS OF APPLICANTS; RECORDS.—The director may adopt rules for determining the qualifications of the applicant for a license as a licensed public weighmaster. He may pass upon the qualifications of the applicant upon the basis of the information supplied in the application, or he may examine such applicant orally or in writing, or both, for the purpose of determining his qualifications. He shall grant licenses as licensed public weighmasters to such applicants as may be found to possess the qualifications required by Section 3 of this Act. The director shall keep a record of all such applications and of all licenses issued thereon.

SEC. 6. LICENSE FEES.—Before the issuance of any license as a licensed public weighmaster, or any renewal thereof, the applicant shall pay to the director a fee of __________. Such fees shall be deposited with the State Treasurer to be credited to a fund to be used by the director for the administration of this Act.

SEC. 7. LIMITED LICENSES.—The director may, upon request and without charge, issue a limited license as a licensed public weighmaster to any qualified officer or employee of a city or county of this State or of a State commission, board, institution, or agency, authorizing such officer or employee to act as a licensed public weighmaster only within the scope of his official employment in the case of an officer or employee of a city or county or only for and on behalf of the State commission, board, institution, or agency in the case of an officer or employee thereof.

SEC. 8. LICENSES; PERIOD; RENEWAL.—Each license as licensed public weighmaster shall be issued to expire on the thirty-first day of December of the calendar year for which it is issued: *Provided,* That any such license shall be valid through the thirty-first day of January of the next ensuing calendar year or until issuance of the renewal license, whichever event first occurs, if the holder thereof shall have filed a renewal application with the director on or before the fifteenth day of December of the year for which the current license was issued: *And provided further*, That any license issued on or after the effective date of this Act and on or before the thirty-first day of December 19 __ , shall be issued to expire on the thirty-first day of December of the next ensuing calendar year. Renewal applications shall be in such form as the director shall prescribe.

SEC. 9. LICENSED WEIGHMASTER; OATH; SEAL.—Each licensed public weighmaster shall, before entering upon his duties, make oath to execute faithfully his duties. The issuance of a license as licensed public weighmaster shall not obligate the State to pay to the licensee any compensation for his services as a licensed public weighmaster. Each licensed public weighmaster shall, at his own expense, provide himself with an impression seal. His name and the word(s) ______ (insert name of State) ______ shall be inscribed around the outer margin of the seal and the words "licensed public weighmaster" shall appear in the center thereof. The seal shall be impressed upon each weight certificate issued by a licensed public weighmaster.

SEC. 10. WEIGHT CERTIFICATE: REQUIRED ENTRIES.—The director shall prescribe the form of weight certificate to be used by a licensed public weighmaster. The weight certificate shall state the date of issuance, the kind of property, produce, commodity, or article weighed, the name of the declared owner or agent of the owner or of the consignee of the material weighed, the accurate weight of the material weighed, the means by which the material was being transported at the time it was weighed, and such other available information as may be necessary to distinguish or identify the property, produce, commodity, or article from others of like kind. Such weight certificate, when so made and properly signed and sealed, shall be prima facie evidence of the accuracy of the weights shown.

SEC. 11. SAME: EXECUTION; REQUIREMENTS.—A licensed public weighmaster shall not enter on a weight certificate issued by him any weight values but such as he has personally determined, and he shall make no entries on a weight certificate issued by some other person. A weight certificate shall be so prepared as to show clearly that weight or weights were actually determined. If the certificate form provides for the entry of gross, tare, and net weights, in any case in which only the gross, the tare, or the net weight is determined by the weighmaster he shall strike through or otherwise cancel the printed entries for the weights not determined or computed. If gross and tare weights are shown on a weight certificate and both of these were not determined on the same scale and on the day for which the certificate is dated, the weighmaster shall identify on the certificate the scale used for determining each such weight and the date of each such determination.

SEC. 12. SCALE USED: TYPE; TEST.—When making a weight determination as provided for by this Act, a licensed public weighmaster shall use a weighing device that is of a type suitable for the weighing of the amount and kind of material to be weighed and that has been tested and approved for use by a weights and measures officer of this State within a period of 12 months immediately preceding the date of the weighing.

SEC. 13. SAME: CAPACITY; PLATFORM SIZE; ONE-DRAFT WEIGHING.—A licensed public weighmaster shall not use any scale to weigh a load the value of which exceeds the nominal or rated capacity of the scale. When the gross or tare weight of any vehicle or combination of vehicles is to be determined, the weighing shall be performed upon a scale having a platform of sufficient size to accommodate such vehicle or combination of vehicles fully, completely, and as one entire unit. If a combination of vehicles must be broken up into separate units in order to be weighed as prescribed herein, each such separate unit shall be entirely disconnected before weighing and a separate weight certificate shall be issued for each such separate unit.

SEC. 14. COPIES OF WEIGHT CERTIFICATES.—A licensed public weighmaster shall keep and preserve for at least one year, or for such longer period as may be specified in the regulations authorized to be issued for the enforcement of this Act, a legible carbon copy of each weight certificate issued by him, which copies shall be open at all reasonable times for inspection by any weights and measures officer of this State.

SEC. 15. RECIPROCAL ACCEPTANCE OF WEIGHT CERTIFICATES.—Whenever in any other State which licenses public weighmasters, there is statutory authority for the recognition and acceptance of the weight certificates issued by licensed weighmasters of this State, the director of this State is authorized to recognize and accept the weight certificates of such other State.

SEC. 16. OPTIONAL LICENSING.—The following persons shall not be required, but shall be permitted, to obtain licenses as licensed public weighmasters: (1) a weights and measures officer when acting within the scope of his official duties, (2) a person weighing property, produce, commodities, or articles that he or his employer, if any, is either buying or selling, and (3) a person weighing property, produce, commodities, or articles in conformity with the requirements of Federal statutes or the statutes of this State relative to warehousemen or processors.

SEC. 17. PROHIBITED ACTS.—No person shall assume the title licensed public weighmaster, or any title of similar import, perform the duties or acts to be performed by a licensed public weighmaster under this Act, hold himself out as a licensed public weighmaster, issue any weight certificate, ticket, memorandum, or statement for which a fee is charged, or engage in the full-time or part-time business of public weighing, unless he holds a valid license as a licensed public weighmaster. "Public weighing," as used in this section, shall mean the weighing for any person, upon request, of property, produce, commodities, or articles other than those which the weigher or his employer, if any, is either buying or selling.

SEC. 18. SUSPENSION AND REVOCATION OF LICENSE.—The director is authorized to suspend or revoke the license of any licensed public weighmaster (1) when he is satisfied, after a hearing upon 10 days' notice to the licensee, that the said licensee has violated any provision of this Act or of any valid regulation of the director affecting licensed public weighmasters, or (2) when a licensed public weighmaster has been convicted in any court of competent jurisdiction of violating any provision of this Act or of any regulation issued under authority of this Act.

SEC. 19. OFFENSES AND PENALTIES.—Any person who requests a licensed public weighmaster to weigh any property, produce, commodity, or article falsely or incorrectly, or who requests a false or incorrect weight certificate, or any person who issues a weight certificate simulating the weight certificate prescribed in this Act and who is not a licensed public weighmaster, shall be guilty of a misdemeanor and upon conviction for the first offense shall be punished by a fine in any sum not less than twenty-five dollars or more than one hundred dollars; and upon a second or subsequent conviction such person shall be punished by a fine in any sum not less than one hundred dollars or more than five hundred dollars, or by imprisonment for not less than thirty days or more than ninety days, or by both such fine and imprisonment.

SEC. 20. SAME: MALFEASANCE.—Any licensed public weighmaster who falsifies a weight certificate, or who delegates his authority to any person not licensed as a licensed public weighmaster, or who preseals a weight certificate with his official seal before performing the act of weighing, shall be guilty of a misdemeanor and upon conviction shall be punished by a fine in any sum not less than fifty dollars or more than five hundred dollars, or by imprisonment for not less than thirty days or more than ninety days, or by both such fine and imprisonment.

SEC. 21. SAME: GENERAL.—Any person who violates any provision of this Act or any rule or regulation promulgated pursuant thereto for which no specific penalty has been provided shall be guilty of a misdemeanor and upon conviction shall be punished by a fine in any amount not less than twenty-five dollars or more than one hundred dollars.

SEC. 22. VALIDITY OF PROSECUTIONS.—Prosecutions for violation of any provision of this Act are declared to be valid and proper notwithstanding the existence of any other valid general or specific Act of this State dealing with matters that may be the same as or similar to those covered by this Act.

SEC. 23. SEPARABILITY PROVISION.—If any provision of this Act is declared unconstitutional, or the applicability thereof to any person or circumstance is held invalid, the constitutionality of the remainder of the Act and the applicability thereof to other persons and circumstances shall not be affected thereby.

SEC. 24. REPEAL OF CONFLICTING LAWS.—All laws and parts of laws contrary to or inconsistent with the provisions of this Act, and specifically ....

....

....

are repealed insofar as they might operate in the future; but as to offenses committed, liabilities incurred, and claims now existing thereunder, the existing law shall remain in full force and effect.

SEC. 25. CITATION.—This Act may be cited as the "Weighmaster Act of ...."

SEC. 26. EFFECTIVE DATE.—This Act shall become effective on ....

(Item 4 was adopted by voice vote.)

5. GLAZING COMPOUND, CALKING COMPOUND, AND PUTTY

The States of Virginia and Wisconsin have pointed out to the Committee that there exists generally in commerce what appears to be a violation of Section 25 of the Model State Law on Weights and Measures in the method of sale of glazing compound, calking compound, and putty. Section 25 stipulates that commodities not in liquid form shall be sold only by weight. These commodities, which are not in liquid form, are being labeled and sold, in many cases, in terms of liquid measure. It is the view of the Committee that this is a matter that best can be handled by the Office of Weights and Measures in direct negotiation with the industry involved, and recommends that such negotiations be initiated.

(Item 5 was adopted by voice vote.)

6. LABELING OF SOFT DRINKS

A number of States have reported to the Committee frustrating experiences in their attempts to bring about correction in the labeling of soft drinks so as to bring these into conformance with the Model Package Regulation and the Administrative Ruling. The Committee urges that the soft drink industry be more aggressive in its efforts toward the correction of labeling, where necessary, and recommends that all States cooperate in bringing about such correction.

DISCUSSION OF FOREGOING ITEM

R. L. CALLAHAN: Mr. Chairman, I am the legal counsel to the American Bottlers and Carbonated Beverages Association. We of the national association of the soft drink industry, representing about 3900 bottlers throughout the country and the large parent companies which produce the syrups and franchises to bottlers to do operations, are somewhat at a loss to understand this Item 6 in the report of the Committee on Laws and Regulations, especially the reference to the fact that we should be more aggressive in our efforts toward correcting these labeling situations.

We have participated throughout in the drafting of the Administrative Ruling as it applies to our permanently labeled bottles. We have worked with the Committee. We have attended the hearings, and I myself have attended various groups, local and regional groups, of this Association in efforts to find out what the problems might be that the State officials are encountering in dealing with our people, and I have not had any indication of any problems.

With regard to our efforts, we have made very aggressive efforts to try to get the provisions of the Administrative Ruling, which is now to become a regulation, adopted and put into effect. Immediately after the meeting last year, when you first put out the Administrative Ruling, we gave it wide publicity. We sent our special mailings to all of our members, and at our national convention in November in Chicago last year we devoted an entire morning session to discussing the requirements of this regulation and urging our members to comply with it immediately. Last May we had a meeting here of our State Association officials from all 50 States, and at that time again we repeated the importance of compliance with this regulation and the need to cooperate with the State officials in meeting these requirements.

We feel we are doing everything we can and we will continue to make a most aggressive effort to bring our people into compliance. I sincerely ask that this Item No. 6 not be adopted here.

Mr. A. L. Little: Mr. Chairman, the Committee will recall that we recently submitted a sample of a new bottle labeling to the Committee which had been sent to us for our approval by one of the leading bottlers. Although the new design was intended to comply with the Administrative Ruling it failed to meet the requirements and could not be approved. I feel that our action has prompted the Committee's proposal, and I think certainly the Committee is justified in bringing attention to the matter.

The bottling industry as a whole possibly is very aggressive in its efforts to comply. However, in some cases, as we well know, action of the right kind has not been taken.

Mr. Callahan: I do not know the case which Mr. Little is referring to, but I do believe in all honesty that one isolated example is insufficient to warrant casting this sort of aspersion on our industry.

Mr. Barker: I think you misread this as a censure. It is merely a suggestion to States who have not been active in enforcing whatever violation there has been of the law and to please call it to the attention of the Committee and to the Bureau, so that it can be adequately handled and talked out with representatives of the soft drink industry. It certainly is not intended as a censure.

(Item 6 was adopted by voice vote.)

(On motion by Mr. Barker, seconded from the floor, the Conference by voice vote adopted the Report of the Committee on Laws and Regulations.)

(On motion by Mr. Barker, the Conference authorized the Executive Secretary to exercise reasonable editorial freedom in preparing the final report of the Committee and in preparing the documents based on the report.)

MR. BARKER: The Committee desires to record once again its gratitude for the response of weights and measures officials generally and of segments of the packaging industry to the Model Package Regulation and the Administrative Ruling. This response is a unique demonstration of what can be accomplished through Government-Industry cooperation—-accomplishments that in the long run will benefit industry, business, and consumers.

The Committee also desires to express its appreciation to all of those who have responded to its inquiries and to those who presented their views either in writing or orally.

The Committee regrets sincerely that because of travel limitations imposed by his State, the Committee Chairman, Mr. John H. Lewis, could not be present at this Conference. His absence has in no way detracted from his contributions throughout the year.

L. BARKER, *Acting Chairman*
H. L. GOFORTH
M. JENNINGS
J. L. LITTLEFIELD
M. W. JENSEN, *Secretary*
H. F. WOLLIN, *Staff Assistant*

Committee on Laws and Regulations

REPORT OF THE COMMITTEE ON SPECIFICATIONS AND TOLERANCES

presented by R. E. MEEK, *Chairman, Director, Division of Weights and Measures, State Board of Health, State of Indiana*

(Thursday, June 24, 1965, 3:10 p.m.)

The Final Report of the Committee on Specifications and Tolerances comprises a complete revision of National Bureau of Standards Handbook 44, covering technical requirements for all commercial weighing and measuring devices.

The members of the Committee have been in almost constant communication throughout the year and have attempted to provide all who are interested ample time and opportunity to make known their desires with respect to this revision.

The Committee's Tentative Report was distributed several months ago and its Final Report made available on Tuesday of this week. With the assumption that the delegates are prepared now for final discussion and action, I shall call the codes, code by code, as they appear in the proposed revision, and shall call for Conference action on each individual code.

1. GENERAL CODE

MR. GREENSPAN: Why was paragraph G-S.5.5.1. deleted? This paragraph originally read: "Any recorded money-value representation on a computing-type weighing or measuring device used in retail trade shall be in combination with a recorded quantity representation."

MR. MEEK: Since the requirements pertaining to printed tickets now are contained in individual codes, and since in certain instances such requirements are found necessarily to be in conflict with this proposed general requirement, it is the recommendation of the Committee that this general requirement be deleted.

MR. CHRISTIE: We are interested in paragraph G-T.1., ACCEPTANCE TOLERANCES.

We would like to know the reason for the reduction from 90 to 30 days for the application of acceptance tolerances.

MR. MEEK: First, there has been a general reduction in tolerances and a reduction in the minimum tolerance values for scales. Furthermore, it would not appear to me to be practical to extend the time limit, for the reason that some devices when placed into service may be used for thousands and thousands of weighings, whereas other devices may be used vary sparingly. Actually, it would seem most appropriate that acceptance tolerances apply only at the time the device is accepted and placed into service. But, unfortunately, most weights and measures officials are not in a position always to be present to test a device before it is placed in service. Therefore, I think there should be some latitude, but I question the advisability of extending it beyond 30 days.

(Item 1 was adopted by the Conference by voice vote.)

2. SCALE CODE

MR. WILDRICK: Mr. Chairman, I move that paragraph SR.4.1. be amended to read:

"The maximum SR on a livestock scale and on an animal scale shall be the value of the minimum graduated interval on the weighbeam."

In Wisconsin there are $40 million worth of veal calves marketed annually. We feel that a 10-pound SR is too great. We found as a general practice in Wisconsin that in an actual transaction of weighing the animal the livestock dealer believes he is entitled to the "break of the beam."

I have talked to various scale representatives here. None has expressed any concern over the amendment as I have proposed it.

MR. MEEK: It is my understanding that this code has been studied and agreed to by the Packers and Livestock Division, U.S. Department of Agriculture. Would Mr. Thompson like to speak on this proposed amendment?

MR. THOMPSON: We have given this proposal some consideration. We believe that it would result in the rejection of a large number of weighbeam scales. Possibly this is desirable, but we feel that a little more consideration should be given before such a change is made. We would be glad to conduct a study on this and try to determine if it is feasible.

(Mr. Wildrick's proposed amendment of paragraph SR. 4.1. was defeated by a standing vote, 62 to 68.)

(Item 2 was adopted by the Conference by voice vote.)

3. WEIGHTS CODE

(Item 3 was adopted by the Conference by voice vote.)

4. CODE FOR LIQUID-MEASURING DEVICES

MR. MEEK: Before making a motion on the Code for Liquid-Measuring Devices, I would like to read a statement from the Committee:

Subsequent to the preparation of the Committee's Final Report, a number of weights and measures officials and representatives of the petroleum industry urged the Committee to delay any adjustment of tolerances for wholesale liquid-measuring devices and also for vehicle-tank meters for a period of one year, during which time a comprehensive study could be conducted to determine in more specific terms meter performance capability. The Committee accepts this as a reasonable request, and accordingly amends its Final Report by restoring the tolerances for wholesale liquid-measuring devices as these appear in the present Handbook 44.

The Committee feels that the industries involved could have developed meaningful performance data during this past year and probably thus could have avoided this delay. The industries are urged to try and conduct such comprehensive studies as will provide the Committee with performance information on which to base more realistic tolerances.

MR. GREENSPAN: Paragraph S.1.4.4. PRINTED TICKET apparently does not require that the total number of gallons be recorded on a ticket on which the total computed price appears. Is my interpretation correct?

MR. MEEK: The Committee has been made aware of design advances in retail motor-fuel dispensers that provide facilities for printing the total computed price and the price per gallon. Although the Committee still feels that manufacturers should work toward the device that prints also the number of gallons, it feels the Code should not at this time prohibit those advances that presently are available.

MR. LYLES: Are these devices already on the market or are they just on the drawing board? It seems to me this may be a backward step.

MR. SIEBOLD: No, these are in actual use. There are not huge numbers of them installed as yet, but there will be more and more of them, especially on large loading racks in wholesale service.

MR. GREENSPAN: Mr. Chairman, I move that proposed Specification S.1.4.4. be amended so as to require that the total gallons delivered and the price per gallon be printed on a ticket issued by a retail computing device on which is printed the total computed price.

(Mr. Greenspan's motion to amend was seconded from the floor.)

MR. MEEK: The Committee is informed that the manufacturers are not now in a position to manufacture devices that will accomplish what is proposed by Mr. Greenspan's amendment. If they are not, and they are working toward that end, I see no reason for us to retard the progress that is being made.

MR. STASENKO: I am with A. O. Smith Corporation. I am representing the gas-pump industry and possibly can be a spokesman for the meter industry.

The printing output that most manufacturers are looking at is a digital readout. The computing mechanism and some other computers in the industry are analog devices. Now, transferring the information from a mechanical analog mechanism through an electronic black box, which is a digital conversion unit, into a printing output, which would be analog but the output would be digital—you are asking for a digital output from a mechanical analog device. In most instances, you will not get agreement.

(A standing vote on Mr. Greenspan's proposed amendment was requested. By vote of 82 to 51 the amendment was adopted.)

(At this point there was considerable discussion on the words "some reasonable customer position" in Specifications paragraph S.2.5.1., ZERO SET-BACK INTERLOCK. The discussion centered about the interpretation of the language.)

(Item 4 as amended, was adopted by the Conference by voice vote.)

[See end of Report of Committee on Specifications and Tolerances for Statement by Mr. Robert Primley read at this point in the presentation of the Committee Report.]

5. CODE FOR VEHICLE-TANK METERS

MR. MEEK: For the reasons set forth previously with respect to the tolerances for wholesale liquid-measuring devices, the Committee amends its Final Report so as to restore the tolerances for vehicle tank meters as set forth in present Handbook 44.

(Item 5 was adopted by the Conference by voice vote.)

(The following codes were adopted by the Conference by voice vote, without substantive discussion:

LP Gas Liquid-Measuring Devices
Liquid Measures
Vehicle Tanks Used as Measures
Farm Milk Tanks
Measure Containers
Milk Bottles
Lubricating-Oil Bottles
Graduates
Linear Measures
Fabric-Measuring Devices
Cordage-Measuring Devices
Taximeters
Odometers
Dry Measures
Berry Baskets and Boxes)

(Mr. Meek moved for adoption and, after a second from the floor, the Report of the Conference Committee on Specifications and Tolerances, as amended, was adopted by the Conference by voice vote.)

(On motion by Mr. Meek, seconded from the floor, the Conference authorized the Executive Secretary to make necessary editorial alterations in the publication of the revision of National Bureau of Standards Handbook 44–3d Edition, "Specifications, Tolerances, and Other Technical Requirements for Commercial Weighing and Measuring Devices.")

MR. MEEK: The Committee is fully aware that an effort of the magnitude of the complete revision of all technical requirements for devices could not be accomplished successfully without the cooperative assistance of both weights and measures officials and representatives of industry. The Committee is grateful for the willingness of the many individuals who participated in this effort.

It is the sincere hope of the Committee that, with the adoption by the National Conference on Weights and Measures of the revision of the Handbook, the terms thus agreed to will be acceptable to every State and that, in each State where action is necessary for official adoption, such action will be started just as soon as the printed version of the Handbook is available. The finest evidence of sound leadership toward nationwide uniformity on the part of State officials would be a report by the Executive Secretary of this Conference to the 51st National Conference that the third edition of Handbook 44 had been adopted in all 50 States.

On behalf of each and every one of the members of this Committee, I want to thank everyone again for the fine cooperation given us throughout the year and the fine cooperation extended during this Conference, and I do believe and hope that this is an outstanding piece of progress in the way of specifications and tolerances to be adopted by this Conference.

The Committee owes the National Bureau of Standards, Office of Weights and Measures, and these various trade associations and manufacturers a special vote of thanks for their fine cooperation and help.

R. E. MEEK, *Chairman*
H. J. MCDADE
G. L. JOHNSON
J. F. MCCARTHY
H. D. ROBINSON
M. W. JENSEN, *Secretary*
D. R. MACKAY, *Staff Assistant*

Committee on Specifications and Tolerances

Statement by Mr. Robert Primley, Chairman, Subcommittee on Weights and Measures, Operation and Engineering Committee, American Petroleum Institute

Mr. Chairman, this is my first visit to a National Conference on Weights and Measures, and I assure you that it has been a great privilege and a most challenging situation to be a part of this 50th Anniversary. I have looked forward to this for quite some time and with anticipation, but for a time my joy was at a rather low ebb. You see, I come from the midwest. My home is on the shores of beautiful Lake Michigan, and there some of us still look to Washington, D.C., as the greatest center of leadership in the world. But after about five days of being here, sitting in a number of meetings during hours of discussion, I was gravely concerned about the leadership idea.

It is most necessary in our dynamic society, and we realize this, that many changes must constantly be made. Yet, if changes are made without understanding and cooperation, they will surely not be effective. If we are to build a constructive future together democratically, then complete understanding is necessary.

I assure you that after what has been said here in these last few moments it has returned my ideals that I have brought with me to this Conference, and we from the petroleum industry sincerely thank your Committee for giving us the consideration that you have. We stand ready at all times to help you engineers and technical people to consider all of these areas of tolerances, so that we in the future might have perfect understanding, as we all sincerely try to build for the future.

I pledge you our support, and again we thank you very much for these considerations.

REPORT OF THE COMMITTEE ON NOMINATIONS AND ELECTION OF OFFICERS

presented by D. M. TURNBULL, *Chairman, Director, Division of Licenses and Standards, Seattle, Washington*

(Thursday, June 24, 1965, 2:10 p.m.)

The Organization and Procedure of the National Conference on Weights and Measures stipulates that the offices of President and Executive Secretary shall be filled by staff members of the National Bureau of Standards, *ex officio*. All other officers are elected by vote of the Conference.

In the selection of active members to be considered for nomination, consideration was given to attendance record, geographical distribution, Conference participation, and other factors deemed by the Committee to be important.

The Nominating Committee submits the following names in nomination for office, to serve during the ensuing year or until their successors might be elected:

Chairman: J. F. True, Kansas

Vice Chairmen: E. H. Black, California; L. L. Elliott, Massachusetts; M. Jennings, Tennessee; J. L. Littlefield, Michigan.

Treasurer: C. C. Morgan, Indiana

Chaplain: R. W. Searles, Ohio.

Executive Committee: A. J. Albanese, Connecticut; L. A. Gredy, Indiana; J. G. Gustafson, Minnesota; M. L. Kinlaw, North Carolina; R. K. Sharp, Oklahoma; F. F. Thompson, Louisiana; L. W. Vezina, Virginia; A. W. Weidner, New York; W. W. Wells, District of Columbia; E. C. Westwood, Utah.

D. M. TURNBULL, *Chairman*
H. E. CRAWFORD
R. E. MEEK
J. I. MOORE
H. D. ROBINSON
C. H. STENDER
R. WILLIAMS
Nominations Committee

(There being no further nominations from the floor, nominations were declared closed and the officers nominated by the Committee were elected unanimously by voice vote.)

REPORT OF THE COMMITTEE ON RESOLUTIONS

presented by G. L. JOHNSON, *Chairman, Director, Division of Weights and Measures, State of Kentucky*

The Committee on Resolutions, having met and considered resolutions submitted to it by members of this 50th National Conference on Weights and Measures and other resolutions that originated with members of the Committee, now submits to this Conference for its consideration and action the following resolutions that have received the unanimous endorsement of the Committee.

There are included a number of individual resolutions which express appreciation for the arrangements for, conduct of, and participation in the National Conference. In order to expedite the handling of this phase of the Conference program, I request permission of the Chair simply to indicate those to whom appreciation is to be officially expressed:

1. To the Honorable John T. Connor, Secretary of Commerce, for his constructive contribution to the program of the 50th National Conference on Weights and Measures.
2. To Mr. W. J. Owen, Chief Inspector, Weights and Measures Office, City of Bradford, England, for his splendid address and for contributing to the success of committee hearings by participating in the deliberations.
3. To Mr. Bryce Harlow, Director of Governmental Relations, Procter and Gamble Manufacturing Company, for his interesting and enlightening address to the Golden Anniversary Banquet.
4. To all program speakers and Standing Committees.
5. To business and industry for cooperating with the Conference, for attending and participating in the Conference, and for contributing to the success of the Conference through their participation and their gracious hospitality.
6. To all State and local governing agencies that have arranged for or made possible the attendance at this meeting of one or more representatives of their organization to participate in the deliberations directed toward the betterment of weights and measures controls throughout the Nation.
7. To the Director and staff of the National Bureau of Standards for their tireless efforts to insure a successful Conference in planning and administering the program and other details so essential to an interesting educational meeting.
8. To the exhibitors, who devoted so much time and effort to insure the success of the Golden Anniversary Exposition.
9. To the staff of the Sheraton-Park Hotel, who materially assisted in the success of the Conference.

(The following resolution was prepared by the Industry Committee on Weights and Measures and read to the Conference by Mr. F. T. Dierson, Chairman of the Industry Committee.)

Whereas, the Industry Committee on Weights and Measures represents a substantial part of the various industries whose products are subject to regulation under State and Federal weights and measures legislation; and

Whereas, the Industry Committee on Weights and Measures is vitally concerned with uniformity of regulation and has urged the necessity of a model State regulation of quantity declaration for packaged commodities; and

Whereas, the National Conference on Weights and Measures and the National Bureau of Standards have developed a uniform model regulation on prominence and placement of quantity statements on package labels, which the Industry Committee wholeheartedly supports for general adoption by the various State officials: Therefore, be it

Resolved, That the Industry Committee on Weights and Measures at its June 22d meeting in Washington, D.C., does express its thanks and appreciation to the National Conference on Weights and Measures and its delegates for their successful efforts in the development and the sponsoring of a uniform regulation on prominence and placement of quantity declaration, and be it further

Resolved, That the Industry Committee on Weights and Measures extends its appreciation to the National Bureau of Standards of the United States Department of Commerce for its valuable assistance in the development and the sponsorship of a model weights and measures regulation for packaged commodities.

* * * * * * *

G. L. JOHNSON, *Chairman*
H. P. HUTCHINSON
E. W. BALLENTINE
P. DEVRIES

Committee on Resolutions

(On motion of the Committee Chairman, seconded from the floor, the report of the Committee on Resolutions was adopted by voice vote.)

REPORT OF AUDITING COMMITTEE

presented by A. L. LITTLE, *Chairman, Head, Weights and Measures Division, State of Arkansas*

(Friday, June 25, 1965, 9:20 a.m.)

On June 24, your Auditing Committee checked the books of Mr. Morgan, the Conference Treasurer, and found that everything was in order. It is my pleasure to report that we approved the records of the Conference as they have been kept by Mr. Morgan.

A. L. LITTLE, *Chairman*
I. R. FRAZER
N. TILLEMAN
Committee on Auditing

(The report of the Auditing Committee was adopted by voice vote.)

REPORT OF THE TREASURER

presented by C. C. MORGAN, *Treasurer, City Sealer of Weights and Measures, Gary, Indiana*

(Friday, June 25, 1965, 9:25 a.m.)

Balance on hand May 1, 1964		$ 3,712.91
RECEIPTS:		
Registration fees—427 at $15.00	$6,405.00	
Refund from Education Committee	4.68	
Sale of Luncheon Tickets—14 at $4.00	56.00	
Bank Interest Accrued	218.79	
Subtotal	6,684.47	6,684.47
Total		10,397.38
DISBURSEMENTS:		
Franklin Press, Luncheon Tickets, Receipts, I. D. Cards, etc.	$ 54.60	
William Stancliff, Lettering Award Certificate	26.80	
Annual Conference Luncheon—416 at $4.095	1,703.52	
Executive Committee Breakfast—24 at $2.925	70.20	
Ladies Entertainment for Tuesday Afternoon	14.04	
Flowers for Podium	15.45	
Expense of Registration Desk, Press Desk, Headquarters Suite	115.17	
Gratuities for Hotel Personnel contributed to Conference, compliment Dinners for Speakers, tips for porter, maid, messenger, recording, printing, etc.	157.05	
A. B. & W. Transit Co., Sightseeing	129.00	
The Chesapeake & Potomac Telephone Company	21.40	
Investigation Service, 2 Employees	38.25	
The Chesapeake & Potomac Telephone Company	1.32	
J. T. Daniell, Education Committee	25.00	
William Stancliff, Lettering Certificates	19.60	
American Electrotype Co. Inc., 2,000 Mats	72.10	
S & T Committee	1,044.41	
Bank Charge	7.60	
Ladies, Mrs. Virginia Moore, Speaker, Madison Room	36.00	
Deposit on Mr. Gregory's Account	75.00	
Subtotal	3,626.51	3,626.51
Total balance on hand June 1, 1965		6,770.87

DEPOSITORY:

Bank of Indiana, Gary, Indiana
First Federal Savings and Loan Association, Gary, Indiana

(Signed) C. C. MORGAN.

(On motion of the Treasurer, seconded from the floor, the report of the Treasurer was adopted by the Conference.)

PERSONS ATTENDING THE CONFERENCE

Delegates—State, City, and County Officials

ALABAMA

City:

Birmingham	L. T. WILLS, Supervisor, Weights and Measures Department, 406 City Hall.

ARKANSAS

State	A. L. LITTLE, Head, Weights and Measures Division, State Plant Board, 421½ W. Capitol Avenue, P. O. Box 1069, Little Rock 72203.

CALIFORNIA

State	W. A. KERLIN, Chief, Bureau of Weights and Measures, Department of Agriculture, 1220 N Street, Sacramento 95814.

County:

Alameda	R. H. FERNSTEN, County Sealer of Weights and Measures, 333 5th Street, Oakland.
Kern	A. D. ROSE, County Sealer of Weights and Measures, 1116 E. California Avenue, Bakersfield 93307.
Los Angeles	F. M. RAYMUND, Director, Department of Weights and Measures, 3200 N. Main Street, Los Angeles 90031.
San Bernardino	H. E. SANDEL, County Sealer of Weights and Measures, 160 E. 6th Street, San Bernardino 92410.
San Diego	H. J. McDADE, Director, Department of Weights and Measures, 1480 "F" Street, P. O. Box 588, San Diego 92112.
San Mateo	W. H. FREY, County Sealer of Weights and Measures, 702 Chestnut Street, Redwood City 94063.
Ventura	E. H. BLACK, County Director of Weights and Measures, P. O. Box 1610, Ventura 93002.

COLORADO

State	H. N. DUFF, State Supervisor, Weights and Measures Section, Department of Agriculture, State Services Building, 1525 Sherman Street, Denver 80203.
	H. H. HOUSTON, Director, Oil Inspection Department, 1024 Speer Boulevard, Denver 80204.

CONNECTICUT

State	F. M. GERSZ, Deputy Commissioner, Department of Consumer Protection, State Office Building, Room 105, Hartford 06115.
	JOHN BENNETT, Chief, Weights and Measures Division.
	W. B. KELLEY, Senior Inspector.

City:

Hartford	NATHAN KALECHMAN, City Sealer of Weights and Measures, 550 Main Street.
Middletown	PETER GRASSI, City Sealer of Weights and Measures, Box 223, City Hall.
New Britain	A. J. ALBANESE, City Sealer of Weights and Measures, City Hall.

DELAWARE

State	W. H. NAUDAIN, Director, Department of Weights and Measures, State Board of Agriculture, Dover 19901.
	W. C. BAUMGARDT, State Inspector.
	F. C. COLAMAIO, State Inspector.

F. D. DONOVAN, State Inspector.
I. K. GIBBS, State Inspector.
EUGENE KEELEY, State Inspector.
R. R. SMITH, State Inspector.

DISTRICT OF COLUMBIA

Weights, Measures, and Markets Branch, Department of Licenses and Inspections, Room 227 Esso Building, 261 Constitution Ave., N.W., Washington, D.C. 20001.

District	J. T. KENNEDY, Chief. J. M. BOUCHER, Supervisor. K. G. HAYDEN, Supervisor. J. T. BENNICK, Inspector and Investigator. R. E. BRADLEY, Inspector and Investigator. J. M. BURKE, Inspector and Investigator. W. R. CORNELIUS, Inspector and Investigator. F. C. HARBOUR, Inspector and Investigator. H. P. HUTCHINSON, Inspector and Investigator. G. P. KOSMOS, Inspector and Investigator. E. E. MAXWELL, Inspector and Investigator. C. L. MCDONALD, Inspector and Investigator. I. L. WAGNER, Inspector and Investigator. W. W. WELLS, Inspector and Investigator.

FLORIDA

State	NALLS BERRYMAN, Director, Division of Standards, Department of Agriculture, Nathan Mayo Building, Room 107, Tallahassee 32304. W. A. COGBURN, Jr., Metrologist.
City:	
Jacksonville 32202	H. E. CRAWFORD, Inspector of Weights and Measures, City Hall, Room 203.
Miami 33133	H. E. HOWARD, Supervisor, Division of Trade Standards, Coconut Grove Station, P. O. Box 708.

GEORGIA

State	J. B. MCGEE, Director, Weights and Measures Division, Department of Agriculture, Agriculture Building, Capitol Square, Room 330 Atlanta 30303. R. M. BUCHANAN, Field Supervisor. J. W. D. HARVEY, State Oil Chemist, State Oil Lab., Department of Revenue, 264 Capitol Place, Atlanta 30334.

ILLINOIS

State	H. L. GOFORTH, Superintendent, Division of Feeds, Fertilizers, and Standards, Department of Agriculture, 531 E. Sangamon Avenue, Springfield 62706. JOHN STALEY, JR., Assistant Superintendent.
City:	
Chicago 60610	R. J. FAHEY, Acting City Sealer, Department of Weights and Measures, Central Office Building, Room 302, 320 N. Clark Street. LUKE PRENDERGAST, Chief Taximeter Inspector, Public Vehicle License Commission, 1111 S. State Street, Room 105.

INDIANA

State	R. E. MEEK, Director, Division of Weights and Measures, State Board of Health, 1330 W. Michigan Street, Indianapolis, 46207. L. A. GREDY, State Inspector.

County:

Clark	R. W. WALKER, County Inspector of Weights and Measures, Court House Annex, Jeffersonville.
Clinton	W. H. CRUM, County Inspector of Weights and Measures, R. R. #2, Frankfort 46041.
Grant	HARVEY CLINE, County Inspector of Weights and Measures, P. O. Box 421, Marion 46953.
Howard	I. R. FRAZER, County Inspector of Weights and Measures, 113 N. Washington Street, Kokomo 46901.
Lake	NICHOLAS BUCUR, County Inspector of Weights and Measures, 15 W. 4th Avenue, Gary 46408.
LaPorte	EDWIN HANISH, County Inspector of Weights and Measures, Michigan City 46360.
Marion	E. H. MAXWELL, County Inspector of Weights and Measures, Room G-4 City-County Building, Indianapolis. FRANK BRUGH, Deputy County Inspector.
Miami	VICTOR SCOTT, County Inspector of Weights and Measures, R. R. #1, Bunker Hill 46914.
Porter	R. H. CLAUSSEN, County Inspector of Weights and Measures, Room 6, Court House, Valparaiso.
St. Joseph	C. S. ZMUDZINSKI, County Inspector of Weights and Measures, Court House, Room 4, South Bend 46601.
Vigo	R. J. SILCOCK, County Inspector of Weights and Measures, Court House, Room 5, Terre Haute.

City:

Gary 46402	C. C. MORGAN, City Sealer of Weights and Measures, City Hall.
Hammond 46320	DEAN BRAHOS, City Sealer of Weights and Measures, 5925 Calumet Avenue.
Indianapolis 46204	W. R. COPELAND, Director, Department of Weights and Measures, Room G-6, City-County Building.
South Bend	B. S. CICHOWICZ, City Inspector of Weights and Measures, City Hall.
Terre Haute 47801	J. T. HARPER, City Inspector of Weights and Measures, City Hall, Room 205.

KANSAS

State	J. F. TRUE, State Sealer, Division of Weights and Measures, State Board of Agriculture, State Office Building, Topeka 66612. R. N. DAVIS, State Inspector. W. B. SPRANG, State Inspector. RAYMOND VELL, State Inspector.

City:

Kansas City	D. L. LYNCH, Deputy City Sealer of Weights and Measures, City Hall, 6th Ann Ave.
Topeka	D. J. WEICK, City Sealer of Weights and Measures, Room 254, City Hall.

KENTUCKY

State	G. L. JOHNSON, Director, Division of Weights and Measures, Department of Agriculture, Capitol Annex, Frankfort 40601.

LOUISIANA

State	J. H. JOHNSON, Director, Division of Weights and Measures, Department of Agriculture and Immigration, Box 4292, Capitol Station, Baton Rouge 70804. A. J. MAYER, JR., Weights and Measures Inspector, Dept. of Agriculture, 1631 Music Street, New Orleans.

	F. F. THOMPSON, Chief Chemist, Department of Revenue, P. O. Box 18374 University Station, Baton Rouge 70821.

MAINE

State	H. D. ROBINSON, Deputy State Sealer, Bureau of Weights and Measures, Department of Agriculture, Capitol Building, Augusta 04330.
City:	
Portland 04111	C. J. WILLS, JR., City Sealer of Weights and Measures, Room 16, 389 Congress Street.

MARYLAND

State	J. E. MAHONEY, State Superintendent of Weights and Measures, Department of Markets, State Board of Agriculture, University of Maryland, College Park 20742.
	R. L. THOMPSON, Assistant Superintendent.
	E. E. BAUMANN, State Inspector.
	D. E. HELMS, State Inspector.
	R. W. GLENDENNING, State Inspector, P. O. Box 356, Chestertown.
	L. H. DEGRANGE, State Inspector, Route 2, Frederick.
	C. R. STOCKMAN, State Inspector, Route 5, Box 251, Cumberland 21505.
County:	
Prince George's	R. J. CORD, Chief Sealer of Weights and Measures, County Service Building, Room 101, Hyattsville 20780.
	L. S. GRASSO, Deputy County Sealer.
	D. G. TRASK, Deputy County Sealer.
	A. H. GARDNER, Sealer Trainee.
City:	
Baltimore 21207	G. H. LEITHAUSER, Chief Inspector, Division of Weights and Measures, Municipal Building, Room 1106.

MASSACHUSETTS

State	W. C. HUGHES, Head Administrative Assistant, Division of Standards, Department of Labor and Industries, State House, Boston 02133.
City:	
Agawam 01001	L. D. DRAGHETTI, City Sealer of Weights and Measures, 36 Main Street.
Boston 02108	J. F. MCCARTHY, City Sealer of Weights and Measures, Room 105 City Hall Annex.
Cambridge 02139	A. T. ANDERSON, City Sealer of Weights and Measures, City Hall, Room 202.
Everett 02149	L. L. ELLIOTT, City Sealer of Weights and Measures, City Hall, Room 2.
Fitchburg 01422	W. T. DELOGE, City Sealer of Weights and Measures, City Hall Annex, Elm Street.
Holyoke	J. E. RICHARD, Deputy Sealer of Weights and Measures, City Hall.
Newton	J. E. BOWEN, City Sealer of Weights and Measures, City Hall.
Pittsfield	F. J. HUGHES, City Sealer of Weights and Measures, Box 530.
Salem	B. A. KOTULAK, City Sealer of Weights and Measures, 174 Bridge Street.
Somerville	E. L. MALLARD, City Sealer of Weights and Measures, Public Works Building, Franey Road.

West Springfield .... C. A. JACOBSON, City Sealer of Weights and Measures, 61 Morgan Road, Town Hall.

MICHIGAN

State .... J. L. LITTLEFIELD, Chief, Food Inspection Division, Department of Agriculture, Lewis Cass Building, Lansing 48913.
C. O. COTTOM, Supervising Inspector.
JACK HARTZELL, General Supervisor.
MISS MARGARET TREANOR, Secretary, Food Inspection Division (representing Michigan Association of Weights and Measures Officials).
R. J. TUTTLE, State Inspector of Weights and Measures, 321 East Street South, Morenci 49256.

County:
Saginaw .... W. E. HOFFMAN, County Sealer of Weights and Measures, 6358 Mackinaw Road, Saginaw 48604.

City:
Detroit 48216 .... J. T. DANIELL, Deputy Sealer, Bureau of Weights and Measures, 2693 18th Street.
Livonia 48154 .... R. C. BAUMGARTNER, City Sealer of Weights and Measures, 15050 Farmington Road.
Pontiac .... M. J. NOLIN, City Sealer of Weights and Measures, Pontiac Police Department, 110 E. Pike Street.

MINNESOTA

State .... W. E. CZAIA, Supervisor, Department of Weights and Measures, Railroad and Warehouse Commission, One Flour Exchange, Minneapolis 55415.
K. L. LOCKWOOD, Weights and Measures Inspector III, Track and Hopper Scale Department, Railroad and Warehouse Commission, 320 Grain Exchange Building, Minneapolis 55415.

City:
Minneapolis 55415 .. J. G. GUSTAFSON, Chief Inspector, Department of Licenses, Weights and Measures, Room 101A, City Hall.

MISSISSIPPI

State .... P. W. GAITHER, Deputy Director, Weights and Measures Division, Department of Agriculture and Commerce, State Office Building, P. O. Box 1609, Jackson 39205.

MISSOURI

State .... J. P. ARGENBRIGHT, Assistant Commissioner, Department of Agriculture, Jefferson Building, Jefferson City 65102.
J. H. WILSON, Director, Weights and Measures Division.

County:
St. Louis .... L. A. RICK, Supervisor, Division of Weights and Measures, 8008 Carondelet, Clayton 63105.

City:
St. Louis .... D. I. OFFNER, Commissioner of Weights and Measures, City Hall.

MONTANA

State .... C. L. PURDY, Commissioner, Department of Agriculture, Capitol Building, Helena 59601.

NEW HAMPSHIRE

State	G. H. LARAMIE, Director, Division of Markets and Standards, Department of Agriculture, State Office Building, Concord 03301.
	A. H. DITTRICH, Chief Inspector, Bureau of Weights and Measures.

NEW JERSEY

State	MICHAEL GOLD, Deputy Attorney General, State House Annex, Trenton.
	S. H. CHRISTIE, JR., Deputy State Superintendent, Division of Weights and Measures, Department of Law and Public Safety, 187 W. Hanover Street, Trenton 08625.
	J. R. BIRD, Supervisor, Technical Services.
	ANTHONY DEL TUFO, Supervisor of Enforcement.
	A. T. SMITH, Supervisor of Licensing.
	E. N. COLGAN, Regional Supervisor.
County:	
Atlantic	J. E. MYERS, County Superintendent of Weights and Measures, 350 S. Harbor Road, Hammonton.
Bergen	J. A. POLLOCK, County Superintendent of Weights and Measures, 66 Zabriskie Street, Hackensack 07601.
	F. C. HOLLEY, Assistant County Superintendent.
Burlington	D. F. HUMMEL, County Superintendent of Weights and Measures, 49 Water Street, Mt. Holly.
	JAMES CARNIVAL, Assistant County Superintendent.
	E. D. GASKILL, Assistant County Superintendent, Jacksonville Road, Bordentown.
Camden	E. T. CAREY, JR., Director of Weights and Measures, City Hall.
	A. C. BECKER, County Superintendent.
	CARMEN CIRUCCI, Assistant County Superintendent.
	H. J. DAVIDSON, Assistant County Superintendent.
	STEVE FRANCESCONI, Assistant County Superintendent.
Cumberland	G. S. FRANKS, County Superintendent of Weights and Measures, 1142 E. Landis Avenue, Vineland 08251.
	NICHOLAS DIMARCO, Assistant County Superintendent, 305 N. 11th Street, Millville 08332.
Essex	W. H. SCHNEIDEWIND, County Superintendent of Weights and Measures, 278 New Street, Newark 07103.
Mercer	R. M. BODENWEISER, County Superintendent of Weights and Measures, Court House, Trenton 08607.
Monmouth	W. I. THOMPSON, County Superintendent of Weights and Measures, P. O. Box 74, Allenhurst 07711.
	J. A. J. BOVIE, Assistant County Superintendent, 82 W. Wall Street, Neptune City 07753.
	W. G. DOX, Assistant County Superintendent, 40 Waverly Place, Red Bank 07701.
	E. H. CAMOOSA, County Inspector, 1106 Jeffrey Street, Asbury Park 07712.
	J. J. ELKER, County Inspector, 1219 1st Avenue, Asbury Park 07712.
Passaic	WILLIAM MILLER, County Superintendent of Weights and Measures, 317 Pennsylvania Avenue, Patterson 07503.

Salem	R. B. JONES, County Superintendent of Weights and Measures, Box 24, Salem 08079.
Warren	G. E. CONNOLLY, County Superintendent of Weights and Measures, Court House, Belvidere 07823.
	J. P. BURNS, Assistant County Superintendent.

City:

Bayonne	J. J. SHEEHAN, Superintendent of Weights and Measures, City Hall.
Jersey City	P. A. WERMERT, Municipal Superintendent of Weights and Measures, City Hall.
Kearny	JAMES POLLOCK, Superintendent of Weights and Measures, 402 Kearny Avenue, Town Hall.
Passaic 07055	PAUL DEVRIES, Municipal Superintendent of Weights and Measures, City Hall.
	P. J. DOMINO, Assistant Municipal Superintendent.
Trenton 08608	R. J. BONEY, Municipal Superintendent of Weights and Measures, 324 East State Street, City Hall Annex.

NEW MEXICO

State	C. B. WHIGHAM, Chief, Division of Markets, Weights and Measures, Department of Agriculture, Box 457, University Park 88070.

NEW YORK

State	J. F. MADDEN, Director, Bureau of Weights and Measures, Department of Agriculture and Markets, Laboratory Building, 1220 Washington Avenue, Albany 12226.

County:

Monroe	R. J. VENESS, County Sealer of Weights and Measures, 1400 South Avenue, Rochester 14620.
	L. P. ROMANO, Deputy County Sealer.
Nassau	ROBERT WILLIAMS, County Sealer of Weights and Measures, 1035 Stewart Avenue, Garden City 11533.
	A. W. WEIDNER, JR., Assistant County Sealer.
Washington	C. F. FOUNTAINE, County Sealer of Weights and Measures, R. D. #2, Fort Ann 12827.
Wayne	H. H. WRIGHT, County Sealer of Weights and Measures, 30 Catherine Street, Lyons 14489.

City:

Binghamton 13901	E. N. VOLKAY, City Sealer of Weights and Measures, City Hall.
Glen Cove 11542	E. T. HUNTER, City Sealer of Weights and Measures, City Hall.
Ithaca 14850	E. P. NEDROW, City Sealer of Weights and Measures, City Hall.
Lackawanna 14218	J. J. SERES, City Sealer of Weights and Measures, 84 Rosary Avenue.
New York 10013	MOE GREENSPAN, Supervising Inspector, Bureau of Weights and Measures, Department of Markets, 137 Centre Street.
	MARTIN AURIGEMMA, Inspector.
White Plains 10601	T. E. LATIMORE, City Sealer of Weights and Measures, Department of Public Safety, 279 Hamilton Avenue.
Yonkers 10701	S. J. DIMASE, City Sealer of Weights and Measures, City Hall.

NORTH CAROLINA

State	J. I. Moore, Superintendent, Weights and Measures Division, Department of Agriculture, Agriculture Building, Raleigh.
	M. L. Kinlaw, Supervisor.
	D. G. Perry, State Inspector.
	W. D. Taylor, State Inspector.

NORTH DAKOTA

State	Adin Helgeson, Chief Inspector, Department of Weights and Measures, Public Service Commission, Capitol Building, Bismarck 58501.
	John Kaufman, State Inspector.

OHIO

State	V. D. Campbell, Chief, Division of Weights and Measures, Department of Agriculture, Reynoldsburg 43068.
County:	
Auglaize	Ferd Wellman, Deputy County Sealer of Weights and Measures, R. R. #1, New Knoxville 45871.
Fulton	Brice Mann, Deputy County Sealer of Weights and Measures, c/o County Auditor, Court House, Wauseon 43567.
Medina	R. W. Searles, Deputy County Sealer of Weights and Measures, Board of Education Building, 137 W. Friendship Street, Medina 44256.
Ross	G. D. Thacker, Deputy County Sealer of Weights and Measures, Court House, Chillicothe.
Stark	A. L. Deckerd, Deputy County Sealer of Weights and Measures, Court House, Canton.
Summit	W. K. Commerson, Deputy County Sealer of Weights and Measures, Court House, Akron 44308.
Tuscarawas	J. E. Mathews, Deputy County Sealer of Weights and Measures, Court House, New Philadelphia 44663.
Wayne	J. W. Swinehart, Deputy County Sealer of Weights and Measures, County Auditor's Office, Wooster 44691.
City:	
Akron 44304	A. J. Ladd, Acting Superintendent of Weights and Measures, 69 N. Union Street.
Cincinnati 45202	L. B. Frank, Supervising Inspector, Markets, Weights, and Measures, 316 George Street.
Columbus	C. R. Mercurio, City Sealer of Weights and Measures, 200 Greenlawn Avenue.
Springfield	C. A. Turner, City Inspector of Weights and Measures, City Building.

OKLAHOMA

State	H. K. Sharp, Assistant Director, Marketing Division, State Board of Agriculture, 122 Capitol Building, Oklahoma City 73105.
City:	
Tulsa	J. L. Smith, Director, Weights and Measures, Office of Commissioner of Finance and Revenue, City Hall.

PENNSYLVANIA

State	W. A. Polaski, Director, Bureau of Standard Weights and Measures, Department of Internal Affairs, Capitol Building, Harrisburg 17120.

E. A. VADELUND, Assistant Director.
GEORGE MRAZ, State Inspector.
F. E. DYSINGER, Field Supervisor of Weights and Measures, Mifflintown 17059.

County:

Allegheny	E. W. STEC, County Inspector of Weights and Measures, Court House, Grant Street, Pittsburgh.
Delaware	E. B. STORY, JR., Chief, Bureau of Weights and Measures, Court House, Media 19063.
Philadelphia 19107	S. F. VALTRI, Field Inspection Supervisor, Bureau of Weights and Measures, Room 306, City Hall.
Washington	P. J. PAVLAK, Chief County Inspector of Weights and Measures, Box 147, Daisytown.

City:

Philadelphia 19107	J. E. RYAN, Field Inspector II, City Hall, Room 306.
Bethlehem 18018	CASTANZO CASTELLUCCI, City Inspector of Weights and Measures, Department of Public Safety, 623 8th Avenue.
Wilkes-Barre 18701	CHESTER OSTROWSKI, City Sealer of Weights and Measures, City Hall, E. Market Street.
Williamsport	S. J. CILLO, City Inspector of Weights and Measures, City Hall.

PUERTO RICO

Commonwealth	H. L. SCHMIDT, Chief, Division of Weights and Measures, Economic Stabilization Administration, P.O. Box 4183, San Juan 00905.

RHODE ISLAND

State	E. R. FISHER, State Sealer of Weights and Measures, Department of Labor, Veterans Memorial Building, 83 Park Street, Providence 02903.

SOUTH CAROLINA

State	C. H. STENDER, Deputy Commissioner, Department of Agriculture, P.O. Box 1080, Columbia 29202.
	E. W. BALLENTINE, Director, Bureau of Inspection.
	J. V. PUGH, State Inspector of Weights and Measures.
	W. H. RHODES, State Inspector.

SOUTH DAKOTA

State	DONALD SPIEGEL, Director, Division of Inspections, Department of Agriculture, State Office Building, Pierre 57501.
	L. G. BIES, Heavy Scale Inspector, Public Utilities Commission, Salem.
	J. A. ETZKORN, Scale Inspector, State House, Pierre 57501.
	D. C. HANNA, Senior Heavy Scale Inspector, Spencer.
	B. E. HOFER, Scale Inspector, Pierre.

TENNESSEE

State	MATT JENNINGS, Director, Division of Marketing, Department of Agriculture, Melrose Station, P.O. Box 9030, Nashville, 37204.
	J. F. BURTON, Weight Inspector.

TEXAS

State	R. T. WILLIAMS, Chief, Marketing Division, Department of Agriculture, John Reagan Building, Austin 78711.

City:

Dallas 75201	F. G. YARBROUGH, Chief Deputy Sealer, Weights, Measures, and Markets, City Hall.
Fort Worth 76107	R. L. SHARP, City Sealer of Weights and Measures, Department of Public Health and Welfare, Public Health Center, 1800 University Drive.

UTAH

City:

Salt Lake	E. C. WESTWOOD, City Sealer of Weights and Measures, 140 South Third West.

VERMONT

State	T. F. BRINK, Director, Division of Standards, Department of Agriculture, Agriculture Building, Montpelier.

VIRGINIA

Weights and Measures Regulatory Section, Division of Regulatory Services, Department of Agriculture & Immigration, 203 N. Governor St., Richmond 23219.

State — M. B. ROWE, Director, Division of Regulatory Services.
J. F. LYLES, Supervisor, Weights and Measures Regulatory Section.
J. C. STEWART, Assistant Supervisor.
O. T. ALMARODE, Field Supervisor.
B. P. BOWERS, State Inspector.
G. T. COPENHAVER, State Inspector, R. R. #1, Box 318, Rural Retreat.
R. M. COX, State Inspector.
S. L. DUKE, State Inspector.
W. M. DUNN, JR., State Inspector, R. F. D. 3, Box 892, Suffolk.
R. W. ELLIOTT, STATE INSPECTOR.
W. L. GRAY, State Inspector.
W. R. IGO, State Inspector.
J. B. HAUN, State Inspector, 234 W. Frederick Street, P. O. Box 363, Staunton.
E. W. HUDSON, State Inspector.
W. R. JONES, State Inspector.
G. P. LATIMER, State Inspector.
J. E. MICHAUX, State Inspector.
R. OWENS, III, State Inspector.
G. E. PORTER, State Inspector.
J. W. ROGERS, State Inspector.
J. W. SADLER, State Inspector.
J. G. SANDERS, State Inspector.
F. W. SAUNDERS, Field Supervisor.
R. H. SHELTON, State Inspector.
R. V. THOMAS, State Inspector, 1013 11th Street Altavista.
R. N. TRENARY, State Inspector, Box 342, Middleburg.
J. F. WELLS, State Inspector.
R. S. WINFREE, State Inspector.
T. H. WOOD, State Inspector.
C. E. WHITMAN, Field Supervisor, Scale Maintenance, Department of Highways, 1221 E. Broad Street, Richmond.

County:

Arlington	G. D. TAYLOR, County Inspector of Weights and Measures, 1400 N. Court House Road, Arlington.

City:

Alexandria 22313	L. W. VEZINA, City Sealer of Weights and Measures, City Hall.
Danville 24541	C. H. WRENN, City Sealer of Weights and Measures, Curb Market Building, Spring Street.
Lynchburg	C. A. WOOD, City Sealer of Weights and Measures, Lynchburg Health Department, 701 Hollins Street.
Norfolk	W. F. BRADLEY, Chief, Bureau of Weights and Measures, Department of Public Safety, 406 E. Plume Street.
Petersburg 23803	C. R. BRANCH, City Sealer of Weights and Measures, City Hall.
Richmond 23219	W. G. ALVIS, Inspector, Bureau of Weights and Measures, Safety-Health-Welfare Building, 501 N. 9th Street. M. L. RICE, Senior Inspector. M. B. BEAR, Inspector. A. B. MOODY, Inspector. E. C. RAGER, Inspector.
Roanoke	J. M. ALDRICH, JR., City Sealer of Weights and Measures, City Market Building, Campbell Avenue.
Virginia Beach 23456	E. L. WHITEHURST, Supervisor, Division of Weights and Measures, P. O. Box 6175, Prince Anne Station. G. E. FERRELL, Inspector.

WASHINGTON

City:

Seattle 98104	D. M. TURNBULL, Director, Division of Licenses and Standards, Office of the Comptroller, 101 Seattle Municipal Building.

WEST VIRGINIA

Weights and Measures Division, Department of Labor, State Office Building, 1800 E. Washington Street, Charleston 24305.

State	LAWRENCE BARKER, Commissioner, Department of Labor. W. H. HOLT, Administrative Assistant to Commissioner. B. R. HAUGHT, Director, Weights and Measures Division. R. B. COUGHENOUR, Chief Inspector. J. S. FINLEY, State Inspector, Danese. CARL FREELAND, State Inspector, Middlebourne. E. L. HOSKINSON, State Inspector. V. S. MATSON, State Inspector. HASKEL SCHILANSKY, State Inspector. R. E. SHORT, State Inspector. J. C. SPINKS, State Inspector, Craigsville. JOE STRAFACE, State Inspector, Stak City. F. J. THOMAS, Chief Inspector. R. D. WILLIAMS, State Inspector, Prosperity. E. B. WOODFORD, State Inspector.

WISCONSIN

State	D. E. KONSOER, Assistant Chief—Trade, Division of Dairy, Food and Trade, Department of Agriculture, Hill Farms State Office Building, Madison 53702. T. E. WILDRICK, Technical Supervisor.

City:

Green Bay 54301	N. P. TILLEMAN, City Sealer of Weights and Measures, City Hall.
LaCrosse	A. L. KLEIN, City Sealer of Weights and Measures, 416 Jay Street.

Racine 53403 .... R. J. ZIERTEN, City Sealer of Weights and Measures, City Hall.
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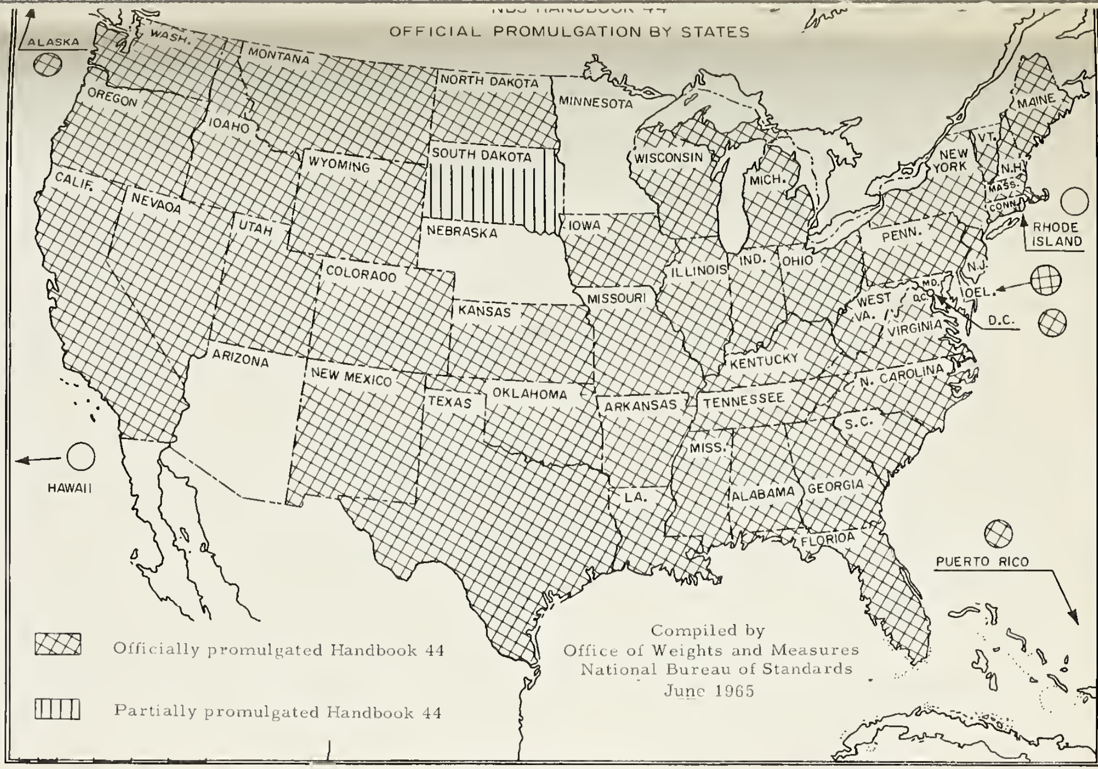

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