

NATIONAL BUREAU OF STANDARDS REPORT

·6627

A SURVEY OF
RECENTLY ACTIVATED OR EXPANDED
STANDARDS AND CALIBRATION PROGRAMS
IN THE ARMED SERVICES

by

Arthur Schach



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

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Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards (\$1.25) and its Supplement (\$1.50), available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

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NBS PROJECT

NBS REPORT

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

FOREWORD

This survey describes briefly some of the systems of standards laboratories that are currently maintained by Federal defense agencies. The information presented has been obtained from a variety of sources, including informal discussions with persons working in the different laboratories. It has not, however, been checked with the laboratories that are listed.

The situation is changing so rapidly that some of the information may already be out of date. The author will be glad to receive additions and corrections so that they can be incorporated in a future edition of this report.

TABLE OF CONTENTS

	<u>Page</u>
Standards and Calibration Programs of the U. S. Army	1
Army Ordnance Program	1
Signal Corps Program	3
Standards and Calibration Programs of the U. S. Navy	8
BuOrd-BuShips Program	8
BuAer Program	11
Standards and Calibration Program of the U. S. Air Force	21
Standards and Calibration Program of the U. S. Atomic Energy Commission	25
Standards and Calibration Requirements Imposed by Defense Agencies on Contractors	29

CHARTS AND TABLES

Chart A-1, Army Ordnance Calibration Structure	6
Chart A-2, Continental U. S. Calibration Facilities (Army Ordnance)	7
Chart N-1, Technical Control of BuOrd-BuShips Calibration Program	13
Chart N-2, Navy BuOrd-BuShips Calibration Program Structure..	14
Table N-1, Navy Standards Laboratories	15
Table N-2, Contractors' Standards Laboratories (BuOrd)	17
Chart AF-1, Air Force Calibration System	24
Chart AEC-1, AEC Calibration Chain	27

STANDARDS AND CALIBRATION PROGRAMS:

U. S. ARMY

REGULAR CALIBRATION PROGRAMS within the Army are carried out by
(1) the Army Ordnance Corps and (2) the Army Signal Corps.

POSSIBLE EXPANSION OF ARMY CALIBRATION ACTIVITY: It is understood that the entire calibration and standards situation within the Army is now being restudied. The indications are that the Army is seriously considering an expansion of its calibration activities on a scale that will match current efforts by the Navy and Air Force.

ARMY ORDNANCE PROGRAM

ADMINISTRATIVE and technical control of the Army Ordnance calibration program is exercised by the Frankford Arsenal in Philadelphia. The Frankford responsibility includes budgeting for, selecting, and procuring standards and distributing them, recommending the installations which will have a calibration facility, preparing administrative and technical directives, furnishing training, establishing control to assure satisfactory operation of the program, effecting coordination within the corps to develop calibration requirements and coverage for all Ordnance Corps materiel, and coordinating with other services to effect equipment standardization, etc.

STRUCTURE of the Army Ordnance calibration program is shown below in Chart A-1. Briefly, there are 3 Primary Reference Laboratories at the top; followed by 11 Secondary Reference Laboratories; followed by 27 Secondary Transfer Sets.

LOCATIONS of Army Ordnance calibration facilities in continental U. S. are shown on the attached Chart A-2.

Primary Reference Laboratories: The 3 top-level labs are at:

Frankford Arsenal, Philadelphia, Pa.
Benicia Arsenal, Calif.
Redstone Arsenal, Alabama

The Primary Reference Laboratories are intended to be the Ordnance Corps activities through which NBS receives all of the routine referral work load. Occasionally it is anticipated that direct contact with the Bureau by one of the lower levels will be required, especially by research activities, when an unusual calibration requirement is generated. In this case, clearance for control purposes is effected through Frankford Arsenal.

Frankford Arsenal services Secondary Reference Laboratories east of the Mississippi, excluding the Redstone Arsenal Area.

Benicia services all Secondary Reference Laboratories west of the Mississippi, excluding the Los Angeles area where, by an arrangement with BuOrd-BuShips, the WPSL at Pomona provides primary calibration services.

The Primary Standards Laboratory at Redstone Arsenal (known as the Army Rocket and Guided Missile Primary Laboratory) is an in-house facility.

Secondary Reference Laboratories: Total number - 8

Five of these are at Ordnance Depots where they serve (1) to calibrate Secondary Transfer Sets and (2) to calibrate instruments located at the depot "rebuild" shops and for production and inspection purposes.

Two Army Ordnance Districts (Boston and New York) have Secondary Reference Laboratories in support of inspection equipment used by contractors and ordnance inspectors within the respective districts.

One Secondary Reference Laboratory is at Picatinny (New Jersey) Arsenal in support of industrial Special Weapons activity.

Secondary Transfer Sets: Total number - 27

These operate with portable equipment to calibrate instruments in the field, contractor's plants, etc., where such service is feasible. They are in the charge of groups of personnel called "calibration teams."

Eighteen Secondary Transfer Sets operate out of depot Secondary Reference Laboratories. Currently these are being transported in 1/2-ton panel trucks. It is understood that consideration is being given to utilizing a large vehicle similar to the 1-1/2-ton multistop commercial delivery vans to accommodate the increased number of standards which will result from Special Weapons integration and planned increased microwave capability at this level.

Nine Ordnance districts are said to have Secondary Transfer capabilities to the extent required in support of their procurement and production programs.

Special Weapons Calibration: Special (nuclear) Weapons have been calibrated at the "primary" level by Sandia Corp. under agreements with all military services. Army calibration of equipment associated with Special Weapons has been a responsibility of the Ordnance Ammunition Command. In December 1958 a letter directive was issued requesting that calibration services of OAC be integrated with those of the Ordnance Corps at the depot and team level, the integration to become effective July 1959.

SIGNAL CORPS PROGRAM

GENERAL FEATURES AND RESPONSIBLE ORGANIZATIONS:

Though it may be a small program when compared with those of Army Ordnance, the Navy or the Air Force, the standards and calibration program of the Signal Corps has been described as "wide ranging" and "decentralized."

Its wide ranging character is shown in the following four general categories of activity:

- (1) During research and development, calibration needs are provided for by the Standards and Engineering Facilities Division of the Army Signal Research and Development Laboratories.
- (2) In the manufacturing stage, the Signal Corps Procurement Agency imposes on contractors strict requirements for calibration of standards and production equipment.
- (3) Signal Corps equipment in use by the Army is supported by Army Signal Field Maintenance shops which, in turn, are kept in calibration by the Signal Corps Field Calibration Service.
- (4) When Signal Corps equipment becomes subject for 5th echelon or depot base maintenance, the Maintenance Division of all Signal Depots or Signal Supply Sections are strictly programmed to avail themselves of the National Standards and thus continue unbroken the chain of National and Signal Corps Standards calibration ... 5th echelon maintenance facilities are programmed for calibration of standards and production by P & D Standards Procedures, and applicable local implementation. These instructions provide for acquisition of Signal Corps Standards, calibration by National Standards, up-keep, and application thereof.

The decentralization of the program is said to avoid the degradation of accuracy associated with a "multilayered centralized calibration organization." Direct contact is thus maintained between the National Standards at NBS and those of Army Signal R & D Labs; Army Signal Supply Agency as aided by Signal Equipment Support Agency; Field Calibration Service; and 5th echelon maintenance facilities.

TYPES OF MEASUREMENT: "GAUGING" PROGRAMS

As might be expected, the bulk of equipment that must be calibrated by the Signal Corps is in the electrical and electronic field. Thus it is "logistically responsible" for over 500 types of general purpose electronic test equipment, as well as for many communication and radar systems, each with its specialized test equipment.

However, attention must also be given to dimensional measurements. In 1953, the Gauge Engineering Division, Signal Equipment Support Agency, was established to deal with problems of physical interchangeability of components; as a result of which the Signal Corps now has mechanical "gauge sets" for more than 300 standard Signal items.

An electrical "gauging program" was begun in 1957. "We have made considerable progress in the electrical gauge area, and standards of many critical items are now available. These standards, when applied by Quality Assurance Division of the U. S. Army Signal Supply Agency to new equipment...supplied by contractors, insures maximum interchangeability, calibration and performance in Signal Corps equipment."

Recently, as in the other Services, increased attention has been given to Radiac equipment. The control point for the most active portion of this calibration program is the Lexington Signal Depot which controls the issuance and use of radioactive field calibration instruments. Nucleonics calibration facilities are in operation at the Lexington and Sacramento Signal Depots. They provide all higher echelon maintenance as well as calibration of radiac equipment for the Signal Corps. Overseas the Signal activity at Saumur General Depot has a similar mission. An additional radiac calibration is now being investigated by the Signal Corps. This will take the form of a mobile facility, such as now exists in the SigC Field Calibration Service and will constitute an extension of that technical assistance. Within this facility it is proposed "to develop a means of radiac calibration by dynamic means rather than by a hazardous radioactive source".

FIELD CALIBRATION SERVICE:

To test the idea of a mobile calibration facility, which (it is said) seemed promising because of the development of more rugged test equipment, a Signal Corps shop truck was converted to this purpose in 1955 at the Sacramento Signal Depot. A Signal Corps pamphlet (see "Reference" below) says: "The need for this service exceeded all expectations. On initial trips it was found that an average of only thirty percent of the equipment in use by the field units was within calibration limits and completely serviceable. On second visits to the same field shops, nine to twelve months later, this percentage rose to approximately fifty-five percent," and there have been steady increases with each successive visit.

The Sacramento Depot was then asked to build six additional vans, one to set up a Field Calibration Service for each Army field maintenance activity in continental U. S. The basic vehicle was a standard Army 32-passenger bus. Delivery of the six calibration vans was completed by August 1957. Since then, another van, fully equipped, was shipped to the Army Command in Europe in June 1958; and recently, additional vehicles were placed in service by the Tobyhanna, Decatur, and Sacramento Signal Depots.

As a result of the field experience gained since 1955, AR 750-615 was published 3 April 1958. This document presents Signal Corps technical and administrative doctrine in regard to calibration of Signal Corps test equipment in the hands of using field personnel. Signal Corps Standard Procedures P & D 750-37 and DEP 750-37 also provide instructive guidance and implementation of the Army Regulation within the Signal Corps Depot System.

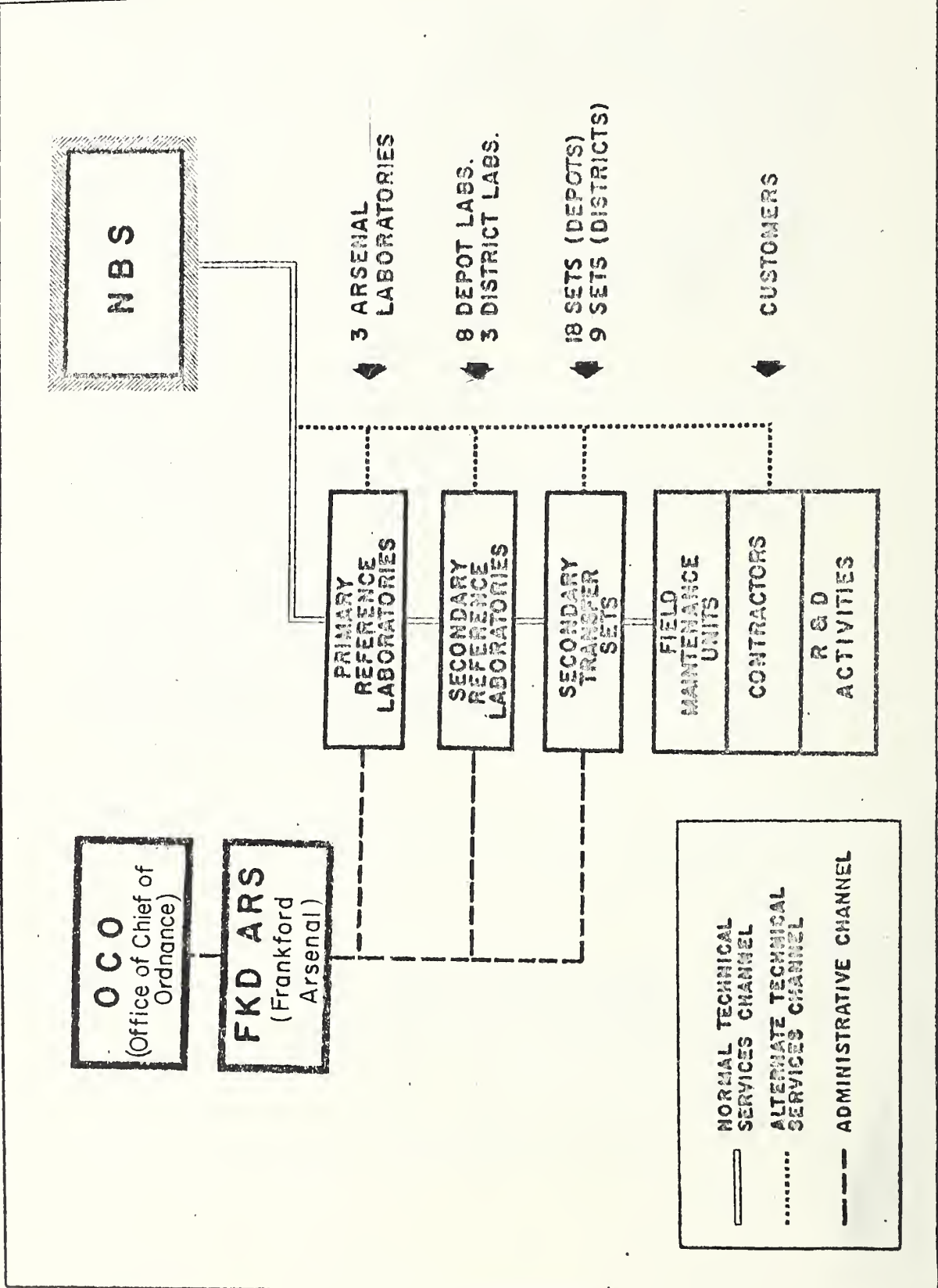
All standards of measurement used by the Signal Corps Field Calibration Service are said to be periodically certified by and at intervals recommended by the National Bureau of Standards.

REFERENCE:

ELECTRONIC COMMUNICATIONS PROCEDURE: FIELD CALIBRATION SERVICE, a pamphlet prepared by the Sacramento Signal Depot for the U. S. Army Signal Corps, dated 20 September 1957.

ARMY ORDNANCE CALIBRATION STRUCTURE

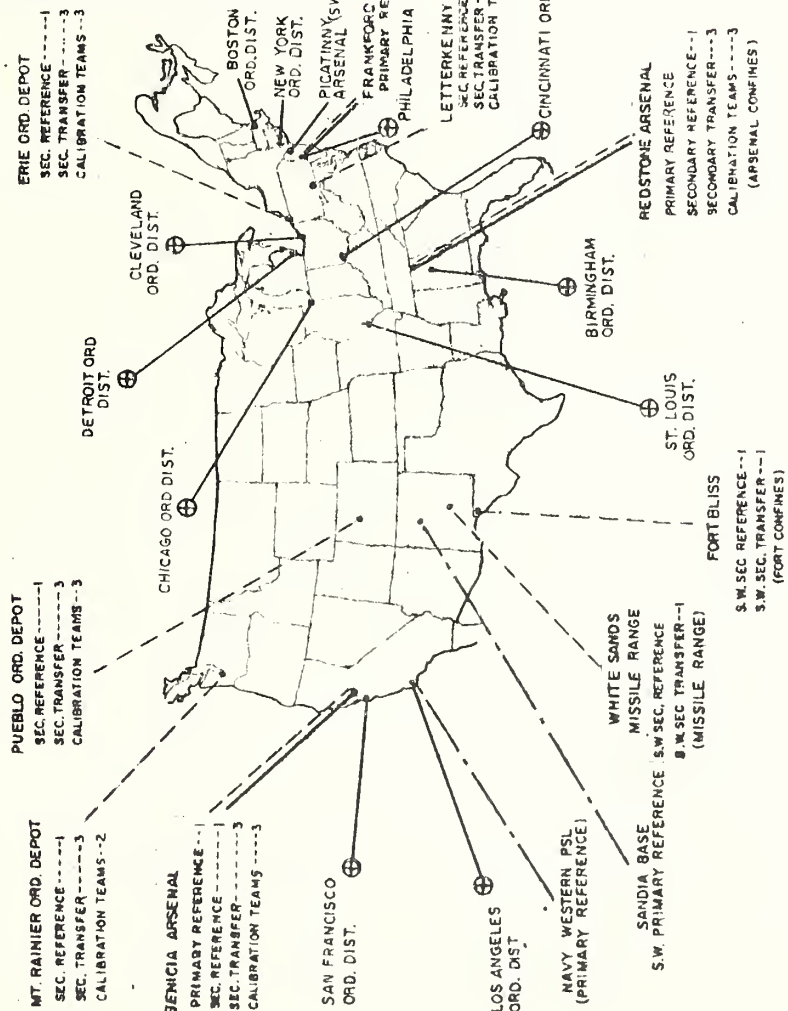
CHART A-1



CONTINENTAL UNITED STATES CALIBRATION FACILITIES

(ARMY ORDNANCE)

LEVELS OF STANDARDS	FIELD SERVICE	INDUSTRIAL
PRIMARY REFERENCE STANDARDS FACILITIES	FRANKFORD ARSENAL BENICIA ARSENAL SANDIA BASE (S.W. ONLY)	FRANKFORD ARSENAL BENICIA ARSENAL REDSTONE ARSENAL NAVY WESTERN PSL SANDIA BASE (S.W. ONLY)
SECONDARY REFERENCE STANDARDS FACILITIES	BENICIA ARSENAL ERIE ORD. DEPT. LETTERKENNY ORD. DEPT. PUERLO ORD. DEPT.	PICATINNY ARSENAL BOSTON ORD. DIST. NEW YORK ORD. DIST.
SECONDARY TRANSFER FACILITIES	3 SETS LETTERKENNY/ORD. DEPT. ERIC ORD. DEPT. 3 SETS PUERLO ORD. DEPT. 3 SETS MT. RAINIER ORD. DEPT. 3 SETS	NOTE ⊕ INDICATES THE ORDNANCE DISTRICTS WHICH HAVE WEAPONS ELECTRICAL STANDARDS NECESSARY TO SUPPORT THEIR PRODUCTION PROGRAMS: BIRMINGHAM, CHICAGO, CINCINNATI, CLEVELAND, DETROIT, LOS ANGELES, PHILADELPHIA, SAN FRANCISCO, AND ST. LOUIS.



LEGEND

--- FIELD SERVICE

— INDUSTRIAL

--- FIELD SERVICE AND INDUSTRIAL FACILITIES

STANDARDS AND CALIBRATION PROGRAMS:

U. S. NAVY

RESPONSIBILITY for calibration activities in the Department of the Navy rests with the cognizant technical bureaus -- the Bureau of Ordnance, the Bureau of Ships, and the Bureau of Aeronautics. BuOrd and BuAer are now combined into the Bureau of Naval Weapons Systems. This is expected to lead eventually to closer coordination of the major calibration programs. There are now two such major calibration programs in the Navy: (1) a combined BuOrd-BuShips program and (2) a BuAer program. Efforts to coordinate calibration activities in the Bureau of Ships, Bureau of Ordnance, and Bureau of Aeronautics have been under the supervision of the Office of Naval Material.

LIST OF NAVY STANDARDS: A list of Navy standards laboratories compiled by the BuOrd March 1959, contains 92 names; a copy is attached as Table N-1.

BUORD-BUSHIPS PROGRAM

NEED: in an informal talk given in late 1959, a representative of the Bureau of Ships noted that a latest model cruiser required ten or more times as much test equipment as did a cruiser before 1950; at the same time the accuracies required have increased a hundredfold or more. "Instruments once used mainly in laboratories are now being procured for field use...thus, we now have, on board ships, large quantities of voltmeters, such as Fluke 801's, precision frequency standards, calorimeters, precision attenuators, and so forth. This equipment is delicate, requires skilled handling and frequent recalibration. Therefore, the development of a comprehensive Navy calibration program became mandatory if these instruments were to be maintained within their designed tolerances."

HISTORY: The BuOrd calibration program began to get under way in 1957, as a result of studies made from 1954 to 1956. About the same time, following on reports of inadequate performance of shipborne electronic equipment, BuShips organized POMSEE (Performance, Operational, and Maintenance Standards of Electronic Equipment), a program to insure periodic measurements of important parameters of electronic equipment. As a result of poor correlation among BuShips test data and the need for increasingly higher accuracies in the newer equipment, a BuOrd-BuShips combined program was inaugurated in 1958; this operates for the most part as a single program under dual administration.

TECHNICAL DIRECTION: While each of the standards laboratories in the program is under military and/or administrative control of the activity in which it is located, all laboratories are under the technical direction of the Metrology Department, Bureau of Naval Weapons Representative (formerly: Naval Inspector of Ordnance), Pomona, California. The purpose of this is "to insure coordination of all necessary technical functions, the use of identical standards, the same calibration procedures, training and inter-bureau use of the calibration facilities." (See Chart N-1 below.)

Chart N-2 below, shows the various echelons of standards laboratories in the BuOrd-BuShips calibration program structures.

Primary Standards Laboratories: There are two such "primary" Laboratories at the top of the BuOrd-BuShips structure. Both are just completing their procurement of apparatus and many staff members are very recent additions. The two laboratories are:

Eastern Primary Stds Lab (EPSL), at Naval Weapons Plant, Washington, D. C. Not counting the large Mechanical Gage Unit, which has been in existence for a number of years, the staff numbers about 12.

Western Primary Stds Lab (WPSL), at Naval Industrial Reserve Ordnance Plant, Pomona, California. Again excepting the gage laboratory, this has a staff of about 45. The gage lab is civil service, Navy operated; the other laboratories are operated by Convair under contract to the Navy.

Secondary Standards Laboratories (BuOrd): The Bureau of Ordnance has ten laboratories at this level. Staff and equipment are expected to be 90 percent complete by the end of 1959 and the labs should be completely operational by the end of 1960. The ten secondary BuOrd labs are:

In the Eastern Area --

Naval Ammunition Depot, Crane, Ind.	Quality Evaluation Centers - R & D Facility
Naval Ordnance Plant, Forest Park, Ill.	
Naval Central Torpedo Office, Newport, R.I.	
Naval Mine Engineering Facility, Yorktown, Va.	
Naval Ordnance Laboratory, Silver Spring, Md.	

In the Western Area --

Naval Torpedo Station, Keyport, Wash. ——— Quality
Naval Ammunition Depot, Concord, Evaluation
Calif. Centers
Naval Ammunition and Net Depot,
Seal Beach, Calif.
Naval Ammunition Depot, Oahu, Hawaii
Naval Ordnance Test Station, China
Lake, Calif. - - R & D Facility

Secondary Standards Laboratories (BuShips): These are on the same level as the preceding, and are usually referred to in BuShips as Reference Laboratories. These laboratories are being located at various Naval shipyards; equipment is now under procurement for 12 such labs.

Secondary Standards Laboratories(Contractor): Also incorporated in the BuOrd-BuShips system at this level are many of the standards labs of contractors. Table N-1 below is a list of 207 BuOrd contractors with standards laboratories, compiled by BuOrd in Feb. 1959. A number of the larger of these contractors, however, are at the level of the BuOrd-BuShips "primary" labs, just below NBS.

Local Standards Laboratories: These are in charge of contractors or of inspectors employed in the calibration of test and inspection equipment at BuOrd or BuShips field activities. Included here are the "floating laboratories" or tenders of BuShips. A total of 27 tenders are now planned. It is expected that 8 tenders will be in operation during the later part of 1959 or early 1960. The remaining activities will get the necessary laboratory instruments, now under procurement, as soon as their facilities are funded and completed. It should be noted that the tenders, although listed as "local" laboratories in the BuOrd-BuShips structure, will be fitted with equipment that is largely on the next higher or "secondary" level.

Also at the local level are the vans fitted out as standards labs which are being planned by the Marine Corps. The Marine Corps and Coast Guard recently agreed with BuOrd-BuShips to coordinate their calibration programs with that of the combined BuOrd-BuShips program in order to insure maximum utilization of existing calibration facilities.

TRAINING: Plans for a training program to handle an anticipated increase in personnel at all levels are currently being drawn up.

REFERENCES: SLIM (i.e., Standards Laboratories Information Manual), prepared by the Metrology Department, is intended to contain "all information pertaining to the establishment, operation, and maintenance of measurements standards laboratories within the framework of the BuOrd-BuShips calibration program."

BuOrd-BuShips Calibration Program, by Lt. Francis L. Roach, IRE Transactions on Instrumentation, Volume 1-7, December 1958, Nos. 3 and 4, P. 357.

The Navy's Test Equipment Calibration Program, by Lt. Cdr. L. O. Whaley, U. S. N., in the Bureau of Ships Journal, January 1959.

BUAER PROGRAM

TECHNICAL DIRECTION of the BuAer calibration program is exercised by BuAer Maintenance Representatives (BAMR's) stationed at the BuAer Primary Laboratories.

PLANS, as of August 1958, called for about 160 items of BuAer primary standards and 270 items for BuAer secondary ("reference") standards per station in use.

Primary Standards Laboratories: These are located at:

Naval Air Station, Alameda, Calif.
Naval Air Station, Norfolk, Va.
Naval Air Station, Pensacola, Fla.
Naval Air Station, North Island, San Diego, Calif.

The first two of these are now fully operational. Equipment and personnel for the others were still being gathered in Sept. 1959.

Reference Standards Laboratories: Nine of these BuAer secondary level labs are or will be established at the following Naval Air Stations:

Pensacola	Lakehurst
Jacksonville	Alameda
Norfolk	North Island (Plant Div. Calibr. Ships)
Quonset Point	North Island (Avionics Div. Calibr. Shops)
Cherry Point	

Calibration facilities at this level are also said to be maintained at Whidley, Washington; Kentron, Hawaii, and Rota, Spain.

Laboratories at this level will bear the brunt of the program; they are responsible for calibration of all production test equipment located at their parent stations and of all fleet "avionics" test equipment located in their particular geographical areas.

Local Standards Laboratories: A block diagram given in an article by M. L. Scroggs of BuAer (See reference below) indicates that these are concerned with production test equipment.

REFERENCE:

Instrument Calibration Program with the Department of the Navy: Bureau of Aeronautics Phase, by M. L. Scroggs, IRE Transactions on Instrumentation, Vol. I-7, Dec. 1958, Nos. 3 & 4, p. 360.

TECHNICAL CONTROL

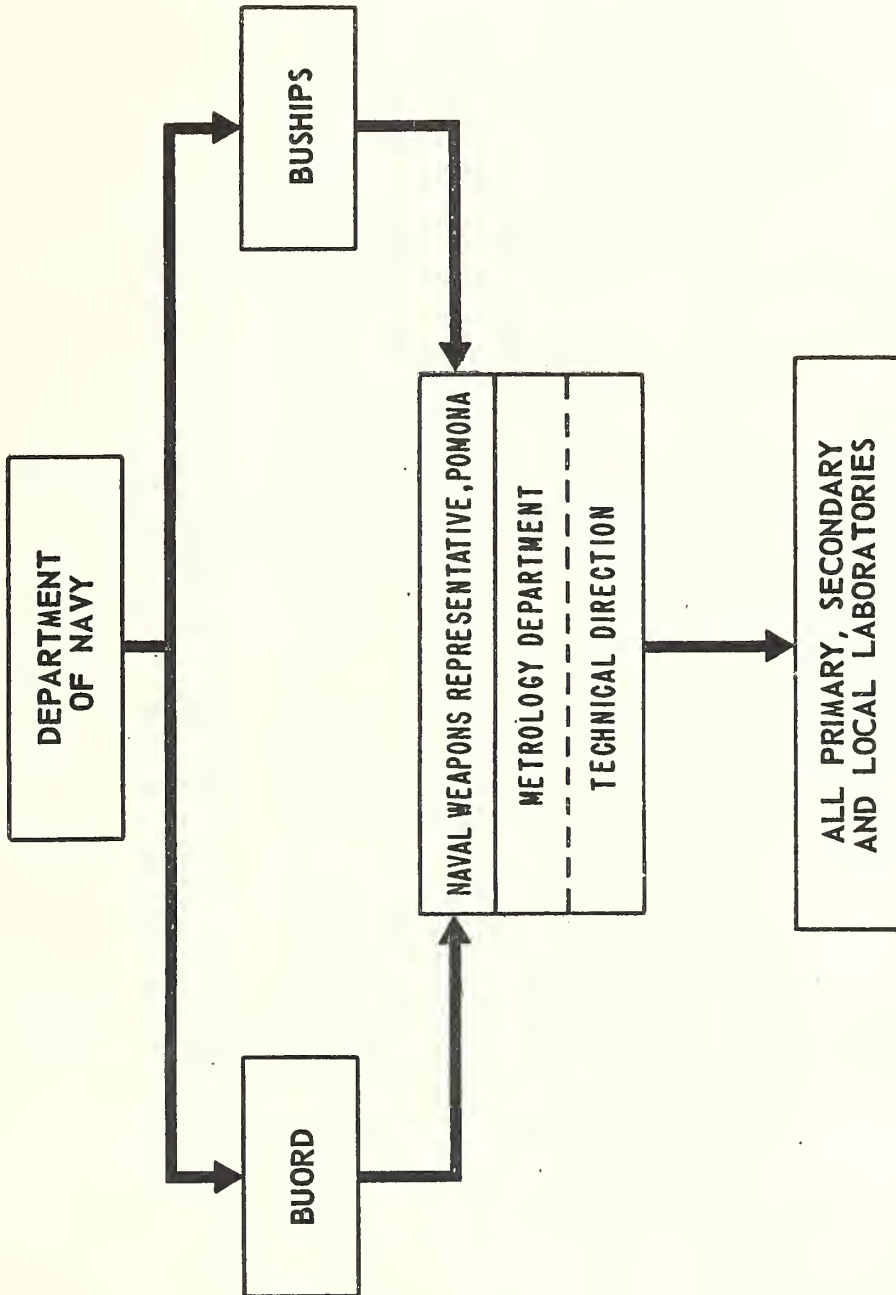
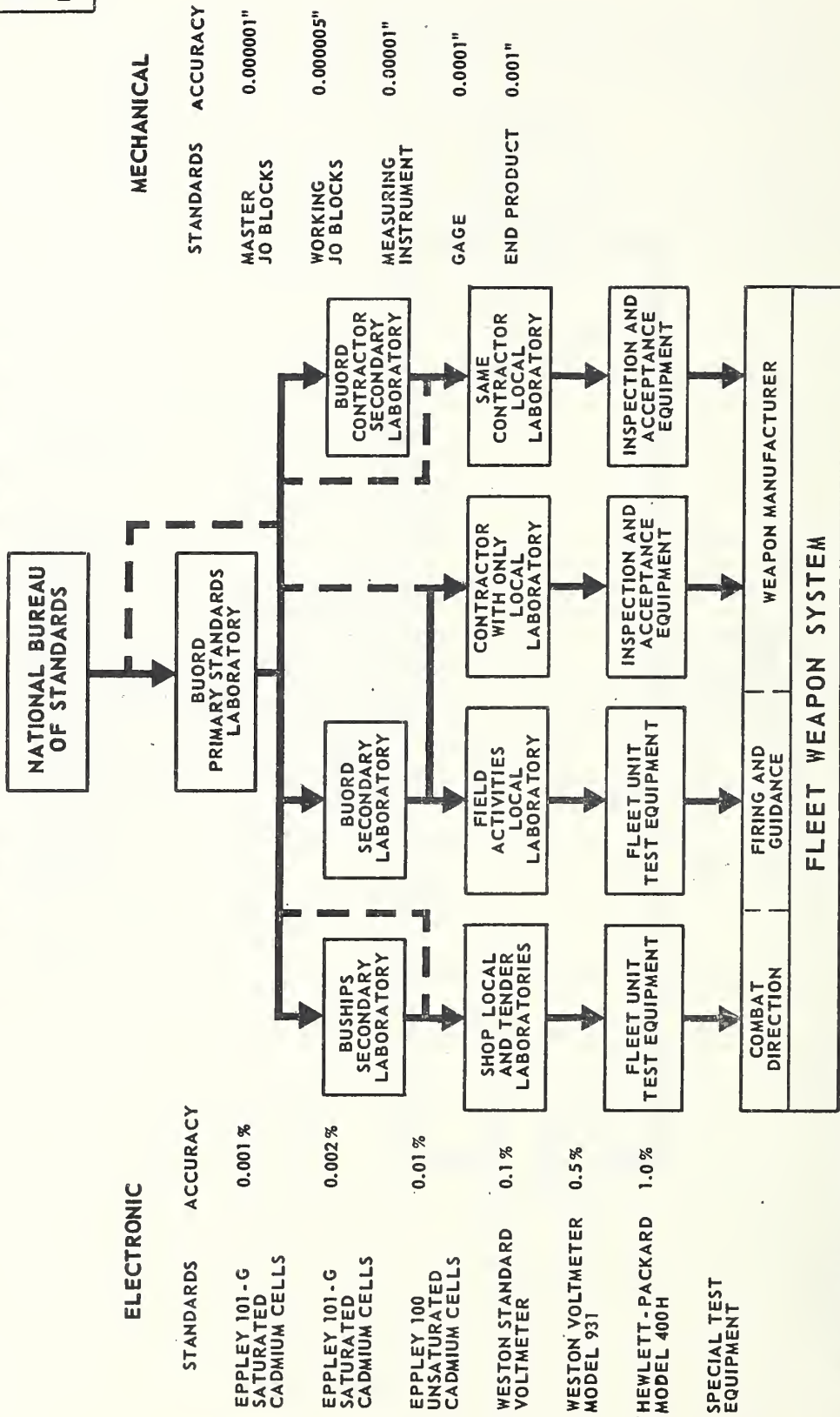


CHART N-2

NAVY BUORD - BUSHIPS CALIBRATION PROGRAM STRUCTURE



— NORMAL CALIBRATION FLOW

- - - ALTERNATE FLOW DICTATED BY ACCURACY REQUIREMENTS

NAVY STANDARDS LABORATORIES

TABLE N-1

ACTIVITY	CODE
CTO NEWPORT, QEL, SECONDARY STANDARDS LAB	NRA
CTO NEWPORT, QEL, CHEMICAL & MATERIALS DIV	NCL
CTO NEWPORT, QEL, ELECTRONIC DIV	NAL
CTO NEWPORT, QEL, MECHANICAL DIV	NBL
CTO NEWPORT, WEAPON SERVICES DEPT	NDL
INSMAT CHICAGO	FBL
INSORD POMONA, WESTERN PRIMARY STANDARDS LAB	WPP
INSORD POMONA, MEASUREMENT STDS DIV, TECH DIRECTION ORG	TDO
MARINE CORPS BASE, TWENTY NINE PALMS	SDS
NAD BANGOR	KCL
NAD CHARLESTON, GMSU 213	YFL
NAD CHARLESTON, STATION	YEL
NAD CONCORD, QEL, SECONDARY STANDARDS LAB	CCA
NAD CONCORD, QEL	CAL
NAD CONCORD, STATION	CBL
NAD CONCORD, MARE ISLAND ANNEX	CDL
NAD CRANE, QEL, SECONDARY STANDARDS LAB	DIA
NAD CRANE, QEL, AMMUNITION & MISSILE BRANCH	DAL
NAD CRANE, QEL, LAUNCHER & GUIDANCE EVALUATION BRANCH	DBL
NAD CRANE, GMSU 219	DCL
NAD CRANE, ORDNANCE DEPT	DDL
NAD CRANE, PYRO RESEARCH & DEVELOPMENT DEPT	DFL
NAD CRANE, PUBLIC WORKS DEPT	DEL
NAD EARLE	NHL
NAD FT MIFFLIN	YHL
NAD HASTINGS	DGL
NAD HAWTHORNE	CCL
NAD HINGHAM, GMSU 215	NEL
NAD MC ALESTER	DHL
NAD OAHU, QEL, SECONDARY STANDARDS LAB	OHA
NAD OAHU, QEL, CHEMICAL BRANCH	OFL
NAD OAHU, QEL	OAL
NAD OAHU, LUALUALEI	OCL
NAD OAHU, WAIKELE	ODL
NAD OAHU, WEST LOCH, ASW SHOP	OIL
NAD OAHU, WEST LOCH, MINE SHOP	OBL
NAD SHUMAKER	DIL
NAD ST JULIENS CREEK	YGL
NAND SEAL BEACH, QEL, SECONDARY STANDARDS LAB	SBA
NAND SEAL BEACH, QEL	SAL
NAND SEAL BEACH, GMSU 217	SDL
NAND SEAL BEACH, ORDNANCE DEPT	SBL
NAND SEAL BEACH, PUBLIC WORKS DEPT	SCL
NAOTS CHINCOTEAGUE, GMU 3 & GMU 11	YNL
NAS ATSUGI	OAS
NAS BARBERS POINT	OBS

ACTIVITY	CODE
NAVDEGSTA KINGSTON	KAS
NAVDEGSTA NORFOLK	YAS
NAVAL RADIOLOGICAL DEFENSE LAB, SAN FRANCISCO	CBS
NAVAL SHIPYARDS	
BOSTON NAVAL SHIPYARD	NDS
CHARLESTON NAVAL SHIPYARD	YCS
LONG BEACH NAVAL SHIPYARD	SAS
MARE ISLAND NAVAL SHIPYARD	CAS
NEW YORK NAVAL SHIPYARD	NES
NORFOLK NAVAL SHIPYARD	YBS
PEARL HARBOR NAVAL SHIPYARD	ODS
PHILADELPHIA NAVAL SHIPYARD	YDS
PORTSMOUTH NAVAL SHIPYARD	NCS
PUGET SOUND NAVAL SHIPYARD	KBS
US NAVY, 9TH NAVAL DIST, ELECTRONIC ORD DEPT, GREAT LAKES	FAS
NCEL PORT HUENEME	SCS
NGF WASHINGTON, EASTERN PRIMARY STANDARDS LAB	EPP
NM GUAM	OHL
NM SUBIC BAY	OGL
NMEF YORKTOWN, QEL, SECONDARY STANDARDS LAB	YVA
NMEF YORKTOWN, STATION	YBL
NOF SASEBO	OJL
NOF YOKOSUKA	OEL
NOL CORONA	SFL
NOL WHITE OAK	WOB
NOLTF FT MONROE	YPL
NOP FOREST PARK, GAGE LAB, SECONDARY STANDARDS LAB	FPA
NOP FOREST PARK, STATION	FAL
NOP LOUISVILLE	YJL
NOP MACON	YML
NOP POCATELLO	KBL
NOP SOUTH CHARLESTON	YKL
NOP YORK	YIL
NOTS CHINA LAKE	CLB
NOTS PASADENA	SEL
NPG DAHLGREN	YQL
NPP INDIAN HEAD	YOL
NRF SAN DIEGO	SBS
NRL WASHINGTON	YES
NSRF GUAM	OCS
NUOS NEWPORT, INSTRUMENTATION BRANCH, APPLIED SCIENCE DEPT	NFL
NWS YORKTOWN, GMSU 211	YCL
NWS YORKTOWN, GMU 51	YDL
NWS YORKTOWN, STATION	YAL
SWSA NORFOLK	YRL
SWSA SAN DIEGO	SGL
US NAVAL WAR COLLEGE, NEWPORT	NAS

TOTAL NO. : 92

APPENDIX I
CONTRACTOR'S STANDARDS LABORATORIES

(SLIM)

TABLE N-2

EASTERN AREA

CODE	CONTRACTOR	LOCATION
APC	ACF INDUSTRIES, INC	ST CHARLES, MO
AEC	AERONAUTICAL RADIO, INC	WASHINGTON, DC
ACC	AIRCRAFT ARMAMENTS, INC	COCKEYSVILLE, MD
AJC	ALLEGANY BALLISTICS LAB, HERCULES PWDR CO	CUMBERLAND, MD
ARC	ALLOYD RESEARCH	WATERTOWN, MASS
ANC	AMPHENOL ELECTRONICS CORP	CHICAGO, ILL
ABC	APPLIED PHYSICS LAB, JOHN HOPKINS UNIV	SILVER SPRING, MD
ADC	ARMOUR RESEARCH FOUND, ILL INST OF TECH	CHICAGO, ILL
AIC	ATLANTIC RESEARCH CORP	ALEXANDRIA, VA
AGC	AVCO MFG CO, CROSLLEY DIV	CINCINNATI, OHIO
BXC	BALDWIN PIANO CO	CINCINNATI, OHIO
BNC	BALLANTINE LAB, INC	BOONTON, NJ
BQC	BARNES ENGRG CO	STAMFORD, CONN
BHC	BAUSCH LOMB OPTICAL CO	ROCHESTER, NY
BJC	BELOCK INSTRUMENT CORP	COLLEGE POINT, NY
BDC	BENDIX AVIATION CORP, BENDIX PROD DIV	MISHAWAKA, IND
BFC	BENDIX AVIATION CORP, BENDIX RADIO DIV	TOWSON, MD
BCC	BENDIX AVIATION CORP, FRIEZ INST DIV	BALTIMORE, MD
BSC	BENDIX AVIATION CORP, MONTROSE DIV	S MONTROSE, PA
BGC	BENDIX AVIATION CORP, RESEARCH LAB	DETROIT, MICH
BYC	BENDIX AVIATION CORP, YORK DIV	YORK, PA
BAC	BORG CORP, GEORGE W, EQUIPMENT DIV	JANESVILLE, WIS
BBC	BRUSH BERYLLIUM CO	CLEVELAND, OHIO
BKC	BULOVA WATCH CO	FLUSHING, NY
CWC	CHICAGO MINIATURE LAMP WORKS	CHICAGO, ILL
CAC	COLUMBIA UNIV, LAMONT GEOLOGICAL LAB	NEW YORK, NY
CTC	CONTINENTAL ELECTRIC CO	GENEVA, ILL
CBC	COOK RESEARCH LAB	CHICAGO, ILL
CLC	CORNELL AERONAUTICAL LAB	BUFFALO, NY
DDC	DEARBORN ELECTRONIC LABS	CHOCAGO, ILL
DEC	DETROIT CONTROLS CORP	NORWOOD, MASS
DAC	DUNLAP ASSOCIATES	STAMFORD, CONN
EEC	EASTMAN KODAK CO, NAVY ORDNANCE DIV	ROCHESTER, NY
EAC	EDO CORP	COLLEGE POINT, NY
EMC	ELECTRAN MFG CO	CHICAGO, ILL
ENC	ELGIN NATIONAL WATCH CO	LINCOLN, NEBR
ERC	EMERSON RESEARCH LAB	SILVER SPRING, MD
EFC	ESSO RESEARCH ENGRG, PROCESS RESEARCH DIV	LINDEN, NJ
EBC	EUREKA WILLIAMS CORP	BLOOMINGTON, ILL
ECC	EWEN KNIGHT CORP	NEEDHAM HEIGHTS, MASS
EDC	EXCELCO DEVELOPMENTS, INC	SILVER CREEK, NY
FDC	FAIRCHILD ENG AIRPLANE, GUIDED MISSILE DIV	WYANDANCH, NY
FBC	FARNSWORTH ELECTRONICS CO	FORT WAYNE, IND
FAC	FARRAND OPTICAL CO, INC	NEW YORK, NY
FEC	FEDERAL TELECOMMUNICATIONS LAB, INC	NUTLEY, NJ
GMC	GENERAL DYNAMICS CORP, ELECTRIC BOAT DIV	GROTON, CONN
GJC	GENERAL ELECTRIC CO, ELECTRONIC COMPTS DIV	OWENSBORO, KY
GHC	GENERAL ELECTRIC CO, GENERAL ENGRG LAB	SCHENECTADY, NY
GKC	GENERAL ELECTRIC CO, MIL ELECTRONIC EQUIP	UTICA, NY
GAC	GENERAL ELECTRIC CO, MISSILE ORD SYS DEPT	PITTSFIELD, MASS
GIC	GENERAL ELECTRIC CO, SEMICONDUCTOR PROD DEPT	SYRACUSE, NY
GLC	GENERAL MOTORS CORP	SAGINAW, MICH
GPC	GENERAL RADIO CO	OAK PARK, ILL
GFC	GEORGIA INST OF TECH	ATLANTA, GA
GOC	GOOD ALL ELEC MFG CO	OGALLALA, NEBR
GCC	GOODYEAR AIRCRAFT CORP	AKRON, OHIO
GGC	GRUEN APPLIED SCIENCE LAB, INC	HEMPSTEAD, NY
GBC	GULTON INDUSTRIES, INC	METUCHEN, NJ

CONTRACTOR'S STANDARDS LABORATORIES (SLIM)

EASTERN AREA

CODE	CONTRACTOR	LOCATION
HAC	HAMILTON WATCH CO	LANCASTER, PA
HCC	HYCON EASTER, INC	CAMBRIDGE, MASS
HBC	HYTRON RADIO ELECTRONIC CO	DANVERS, MASS
ICC	INDUSTRIAL RADIO CORP	CHICAGO, ILL
IDC	INTERNATIONAL ELECTRONICS	WASHINGTON, DC
IBC	INTERNATIONAL TELEPHONE TELEGRAPH	CLIFTON, NJ
KBC	KELLOGG CO, M W	JERSEY CITY, NJ
KCC	KIP ELECTRONICS CORP	STAMFORD, CONN
KAC	KOLLMORGEN OPTICAL CORP	NORTHAMPTON, MASS
KDC	KOLLSMAN INSTRUMENT CORP	ELMHURST, LI, NY
MAC	MASS INST OF TECH, DIV OF DEFENSE LAB	CAMBRIDGE, MASS
MEC	MASS INST OF TECH, DIV OF SPONSORED RESEARCH	CAMBRIDGE, MASS
MFC	MASS INST OF TECH, GUIDED MISSILES COMM	CAMBRIDGE, MASS
MCC	MAXSON CORP, W L	NEW YORK, NY
MIC	MCDONNELL AIRCRAFT CORP	ST LOUIS, MO
MHC	MINNEAPOLIS HONEYWELL REG CO	MINNEAPOLIS, MINN
NKC	NRK MFG ENGRG CO	CHICAGO, ILL
NDC	NATIONAL BERYLLIA CORP	NORTH BERGEN, NJ
NRC	NEW YORK UNIV, ENGRG RESEARCH DIV	NEW YORK, NY
NBC	NORDEN KETAY CORP, NORDEN LAB DIV	WHITE PLAINS, NY
PFC	PARAPLEGICS MFG CO	FRANKLIN PARK, ILL
PCC	PHILCO CORP	PHILADELPHIA, PA
PAC	PHOTOGRAMMETRY, INC	SILVER SPRING, MD
PKC	PICKARD BURNS	NEEDHAM, MASS
PEC	POWER INDUSTRIES, INC	CHICAGO, ILL
PDC	PREMIER INSTRUMENTS CORP	NEW YORK, NY
RIC	RADIO CORP OF AMERICA	HARRISON, NJ
RBC	RADIO CORP OF AMERICA, VICTOR DIV	CAMDEN, NJ
RJC	RAYTHEON MFG CO	NEWTON, MASS
RDC	RAYTHEON MFG CO, MISSILE SYSTEMS DIV	BEDFORD, MASS
RAC	REEVES INSTRUMENT CORP	NEW YORK, NY
RCC	ROSEN ENGRG PROD, INC, RAYMOND	PHILADELPHIA, PA
SDC	SEEBURG CORP, J P	CHICAGO, ILL
SCC	SERVONICS, INC	ALEXANDRIA, VA
SEC	SONATONE CORP	ELMSFORD, NY
SBC	SPERRY GYROSCOPE CO, AIR ARMAMENT DIV	GREAT NECK, NY
SAC	SPERRY GYROSCOPE CO, MARINE DIV	GARDEN CITY, NY
SKC	SPERRY GYROSCOPE CO, MARINE DIV	MINEOLA, NY
SJC	SPERRY RAND CORP	CHARLOTTESVILLE, VA
SFC	STAVID ENGRG CORP	PLAINFIELD, NJ
SXC	STEMM CO R EDWARD	CHICAGO, ILL
SGC	SYLVANIA ELECTRIC PROD INC	EMPORIUM, PA
TCC	TEAGUE, W D	NEW YORK, NY
TFC	TECHNICRAFT LAB, INC	THOMASTON, CONN
TDC	TESLA ELEC CO	CHICAGO, ILL
TEC	THIOKOL CHEMICAL CORP	ELKTON, MD
TGC	THOMPSON, JOHN I	WASHINGTON, DC
TBC	TUNG SOL ELECTRIC, INC	NEWARK, NJ
VDC	VICTOR DESIGN CORP	NEWARK, NJ
VCC	VICTOREEN INSTRUMENT CO	CLEVELAND, OHIO
VBC	VIRGINIA, UNIV OF, PHYSICS DEPT	CHARLOTTESVILLE, VA
VFC	VITRO CORP OF AMERICA, VITRO LAB DIV	SILVER SPRING, MD
VEC	VITRO CORP OF AMERICA, VITRO LAB DIV	WEST ORANGE, NJ
WBC	WESTINGHOUSE ELECTRIC CO, TUBE DIV	ELMIRA, NY

CONTRACTOR'S STANDARDS LABS (SLIM)

WESTERN AREA

CODE	CONTRACTOR	LOCATION
AKC	AEROJET GENERAL CORP	AZUSA, CALIF
ALC	AEROJET GENERAL CORP	SACRAMENTO, CALIF
AOC	AERO NUTRONIC SYSTEMS, INC	GLENDALE, CALIF
AFC	AMERICAN ELECTRIC MOTORS	LOS ANGELES, CALIF
AHC	AMERICAN ELECTRONICS, INC	EL MONTE, CALIF
AAC	ASSOCIATED MISSILE PROD CORP	DENVER, COLO
AMC	ASSOCIATED MISSILE PROD CORP	POMONA, CALIF
BLC	BABCOCK RADIO ENGRG CORP	COSTA MESA, CALIF
BIC	BECKMAN INSTRUMENTS	FULLERTON, CALIF
BEC	BENDIX AVIATION CORP, PACIFIC DIV	N HOLLYWOOD, CALIF
BMC	BERMITE POWDER CO	SAUGUS, CALIF
BPC	BOURNS LAB, INC	RIVERSIDE, CALIF
BRC	BRUBAKER ELECTRONICS, INC	CULVER CITY, CALIF
CCC	CALIFORNIA INST OF TECH, JET PROPULSION LAB	PASADENA, CALIF
CGC	CALIFORNIA, UNIV OF, RADIATION LAB	LIVERMORE, CALIF
CEC	CENTURY ENGINEERS, INC	BURBANK, CALIF
CSC	CLARY CORP	SAN GABRIEL, CALIF
CDC	CONSOLIDATED ELECTRODYNAMICS CORP	PASADENA, CALIF
CXC	CONVAIR, ASTRONAUTICS	SAN DIEGO, CALIF
CNC	CONVAIR, ORDNANCE AEROPHYSICS LAB	DAINGERFIELD, TEXAS
COC	CONVAIR, POMONA, ENGRG	POMONA, CALIF
CMC	CONVAIR, POMONA, MFG	POMONA, CALIF
DSC	DAYSTROM PACIFIC CORP	SANTA MONICA, CALIF
DPC	DEMORNAY BONARDI	PASADENA, CALIF
DNC	DONNER SCIENTIFIC CO	CONCORD, CALIF
DBC	DOUGLAS AIRCRAFT CORP	EL SEGUNDO, CALIF
DCC	DOUGLAS AIRCRAFT CORP	SANTA MONICA, CALIF
FCC	FARNSWORTH ELECTRONICS CO, PACIFIC DIV	PALO ALTO, CALIF
FGC	FENSKE, FREDERICK MILLER, INC	LOS ANGELES, CALIF
FFC	FIRESTONE TIRE RUBBER CO	LOS ANGELES, CALIF
GQC	GENERAL ELECTRIC CORP	ONTARIO, CALIF
GEC	GILFILLAN BROS, INC	LOS ANGELES, CALIF
GRC	GRAND CENTRAL ROCKET CO	REDLANDS, CALIF
GDC	GUDEMAN ELECTRONICS, DIELECTRON DIV	MONROVIA, CALIF
HEC	HALLAMORE ELECTRONICS, INC	ANAHEIM, CALIF
HOC	HOFFMAN LABORATORIES, INC	LOS ANGELES, CALIF
HDC	HUNTER DOUGLAS ALUMINUM CORP	RIVERSIDE, CALIF
HYC	HYCON ELECTRONICS, INC	PASADENA, CALIF
HRC	HYDRAULIC RESEARCH MFG CO	BURBANK, CALIF
HSC	HYCOR CO, INC	SYLMAR, CALIF
IEC	INTERSTATE ELECTRONICS CORP	ANAHEIM, CALIF
IAC	INTERSTATE ENGRG CORP	EL SEGUNDO, CALIF
LAC	LANSDALE TUBE CO, DIV OF PHILCO CORP	LANSDALE, CALIF
LIC	LIBRASCOPE INC	GLENDALE, CALIF
LHC	LITTON INDUSTRIES	BEVERLY HILLS, CALIF
LSC	LOCKHEED AIRCRAFT CORP, MISSILE SYSTEMS DIV	SUNNYVALE, CALIF
LVC	LOCKHEED AIRCRAFT CORP, MISSILE SYSTEMS DIV	VAN NUYS, CALIF
LBC	LOCKHEED AIRCRAFT CORP, SANTA CRUZ TEST BASE	SUNNYVALE, CALIF
LZC	LOCKHEED AIRCRAFT CORP, TERMINAL ISLAND	LONG BEACH, CALIF
LMC	LUTHER MFG CO	HOLLYWOOD, CALIF

WESTERN AREA CONTRACTOR'S STANDARDS LABS (SLIM)

CODE	CONTRACTOR	LOCATION
MDC	MARTIN COMPANY, GLENN L	DENVER, COLO
MBC	MINNEAPOLIS HONEYWELL REGULATOR CO	MONROVIA, CALIF
MOC	MOTOROLA, INC, PHOENIX RESEARCH LAB	PHOENIX, ARIZ
NAC	NADER MFG CO	MONROVIA, CALIF
NFC	NEW MEXICO COLLEGE OF AGRIC MECH ARTS	STATE COLLEGE, NM
NCC	NORTH AMERICAN AVIATION INC, AUTONETICS DIV	BELLFLOWER, CALIF
NEC	NORTH AMERICAN AVIATION INC, ROCKETDYNE DIV	CANOGA PARK, CALIF
OPC	OWEN LAB	PASADENA, CALIF
PBC	PRECISION TECHNOLOGY, INC	LIVERMORE, CALIF
POC	POMONA ELECTRONIC CO	POMONA, CALIF
RMC	RADIAPHONE CO	MONROVIA, CALIF
RVC	RADIOPLANE	VAN NUYS, CALIF
REC	REINHOLD ENGRG PLASTICS CO	NORWALK, CALIF
RGC	RHEEM MFG CO	RIVERA, CALIF
RFC	ROBERTSHAW FULTON CONTROLS CO	ANAHEIM, CALIF
RKC	ROYAL INDUSTRIES	ALHAMBRA, CALIF
RHC	ROYAL INDUSTRIES, INC	BURBANK, CALIF
SIC	SANDIA CORP	LIVERMORE, CALIF
SHC	SANDIA CORP, SANDIA BASE	ALBUQUERQUE, NM
SZC	STELLARDYNE LAB	EL CAJON, CALIF
STC	STODDART AIRCRAFT RADIO CORP	HOLLYWOOD, CALIF
SSC	SPECTROL CORP	SAN GABRIEL, CALIF
SPC	SUNDSTRAND TURBO	PACOIMA, CALIF
THC	TELECOMPUTING CORP	N HOLLYWOOD, CALIF
TAC	TEXAS, UNIV OF, DEFENSE RESEARCH LAB	AUSTIN, TEXAS
USC	US ENGRG CO	LOS ANGELES, CALIF
VAC	VARIAN ASSOCIATES	PALO ALTO, CALIF
WAC	WAHLGREN ELECTRICAL MFG CO	PASADENA, CALIF
WSC	WASHINGTON, UNIV OF, APPLIED PHYSICS LAB	SEATTLE, WASH
WKC	WASTE KING CORP	LOS ANGELES, CALIF
WEC	WESTERN DESIGN MFG CO	GOLETA, CALIF
WDC	WESTINGHOUSE ELECTRIC CO	SUNNYVALE, CALIF
WCC	WIANCKO ENGRG CO	PASADENA, CALIF
WZC	WESTINGHOUSE, TERMINAL ISLAND	LONG BEACH, CALIF
WLC	WHITAKER CO, WM R	LOS ANGELES, CALIF

TOTAL NO. : 207

STANDARDS AND CALIBRATION PROGRAMS

U. S. AIR FORCE

RESPONSIBILITY for calibration of precision equipment used by Air Force activities rests with the Air Materiel Command (AMC), which in turn has designated the Gentile Air Force Station, Dayton AF Depot, as the Air Force central control agency for certification of all standards utilized in all Air Materiel Areas (AMA's) and AF Depots.

(The AMA is a field agency of the AMC in a specified geographical area -- with the exception of the Rome (N.Y.) AMA, which is concerned with the procurement and storage of larger items of electronic ground equipment (radar, communication systems, etc.). There are nine AMA's in continental U. S. and six overseas. An AF Depot is an establishment within the confines of an AMA and includes a landing field, base facilities, and facilities for the wholesale receipt, storage, and distribution of AF supplies and for performing depot maintenance.

BUDGET: The capital equipment devoted to the AMC calibration program is about \$18 millions and the annual cost to AMC is about \$9.5 millions. Also, there are about 2,170 AF personnel concerned with calibration activities; this includes about 1,200 persons at AF Base facilities who are occupied mostly with maintenance and repair.

TRAINING: The extent to which the AF is expanding its calibration activities is indicated by its training program in the maintenance and calibration of precision measuring equipment. The training is concentrated at Lowry Technical Training Center, Lowry AF Base, Denver, where courses were started in April 1959. So far about 140 have been graduated, about 100 are now in training, and about 18 are added per week. Several sections run simultaneously, with about six trainees per section. The course lasts 18 weeks. Trainees are Airmen 1st class or civilians with two or more years experience with electronic equipment; they are selected by competitive examination.

AIR FORCE STANDARDS: These are the highest echelon AF standards in the dimensional and electromechanical areas. They are kept in the AF Standards Laboratory at Dayton AF Depot, and are used to calibrate transfer standards which are then hand-carried to lower echelon standards labs at various AMA's and Depots.

There are no corresponding AF Standards in the electrical and electronic areas. Instead, there is a Dayton AF Depot Detachment at NBS Boulder Laboratories which maintains a pool of standards of the kind used at the next lower AF echelon. Standards in the pool are calibrated by NBS Boulder and are then exchanged, on a regular schedule, for standards in use at the AMA-level labs.

The AF is currently planning to move its top standards lab from Dayton to a location near Heath, Ohio. It is converting to this purpose a "surplus" plant (built by Kaiser for a large-scale forging operation which was made obsolescent before it could be put to use) consisting principally of a very large pit with unusually thick concrete walls. The AF expects to expand the measurement facilities at this new location to include means for handling the ultra-precise inertial guidance accelerometers which no existing standards laboratory is presently equipped to calibrate.

AMA-LEVEL STANDARDS LABORATORIES: Just below NBS, for electrical-electronic measurements, and just below the AF Standards Laboratory at Dayton, for dimensional and electromechanical measurements, are the "AMA-level" laboratories maintained presently at 16 locations throughout the world, namely at:

Sacramento AMA	Mobile AMA
San Bernardino AMA	Rome AMA
Ogden AMA	Warner Robbins AMA
San Antonio AMA	Middletown AMA
Oklahoma City AMA	

Patrick AF Base: RCA is in the process of being supplied with AMA-level electrical and electronic standards. Under consideration is a plan to supply a set of AMA-level dimensional and electromechanical standards to the Pan American Airways plant at Patrick.

Central AMA, Europe (Chateauroux, France; operated by RCA). Spain AMA (Madrid; operated by General Electric). Northern AMA, Pacific (Tachikama, Japan).

Elmendorf AF Base, Alaska, has been authorized certain standards at this level, and is in the course of getting them.

Canada: In connection with the maintenance of radar outposts, limited numbers of AMA-level standards are being provided to two firms that have contracted to handle maintenance operations for the AF.

The principal function of the AMA-level standards laboratories is to calibrate the standards of the next lower echelon of AF standards -- those maintained usually at AF Bases.

BASE STANDARDS LABORATORIES: The AF "Base" Standards Laboratories will ordinarily be located at AF Base Calibration and maintenance shops. About 160 such Base Standards Laboratories are now planned. About 40 are now operational, and the remainder are expected to have their complement of Base standards in six to twelve months. The main obstacle to the setting up of such labs has not been that of procuring equipment, but of getting laboratory buildings and competent staff. Equipment for all planned Base standards facilities is now being delivered to Dayton, where the "packages" of standards are put together for shipment to the Base locations. In FY 1959, the AF spent \$6 millions for such equipment; in FY 1960 it will spend closer to \$5 millions.

The number of Base standards facilities planned for each of the AMA's is indicated in the following by the numeral in parentheses after the name of the AMA:

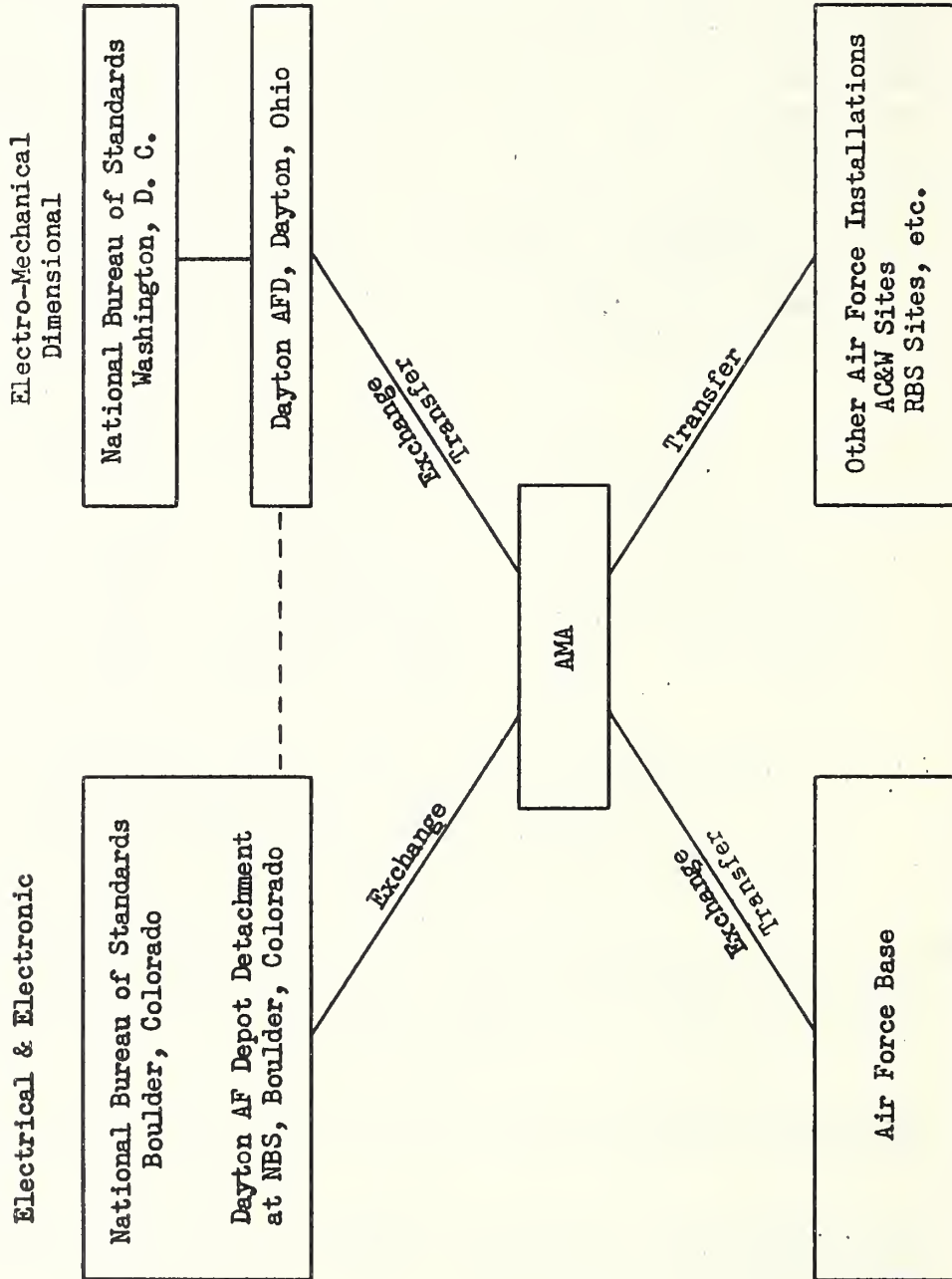
Sacramento	(10)	Warner Robbins	(13)
San Bernardino	(9)	Middletown	(19)
Ogden	(15)	Northern Pacific	(8)
San Antonio	(21)	Northern Europe	(23)
Mobile	(18)	Spain	(7)

At about this same level are the calibration vans that are used to service the Thor squadrons in the U. K.; also the test facilities at other AF installations such as the Aircraft Control and Warning (AC & W) or Radar Bomb Scoring (RBS) sites.

REFERENCES: AF Regulation 74-2, 17 Jan 1958, with SUPPLEMENT 1, 19 Mar 1958, "establishes basic requirements and assigns responsibilities for the repair, calibration, and certification of precision measurement equipment."

AF Technical Order, TO: 33-1-14, 21 Feb 1958, outlines the structure of the AF calibration program and gives lists of standards and accessories at the AMA and AF Base levels.

USAF Program for Calibration and Repair of Precision Measurement Equipment, by Major K. M. Johnston, U. S. Air Force Aircraft Accident and Maintenance Review, 14, 2 (October 1959).



USAF Calibration System

STANDARDS AND CALIBRATION PROGRAMS

ATOMIC ENERGY COMMISSION

(All quotations are from the IRE article by H. C. Biggs referred to below)

NEED FOR AEC SYSTEM TO MONITOR PRECISION MEASUREMENTS: "The basic problem is to establish and maintain standards in a system marked by great decentralization with many participating agencies and wide geographic dispersion."

AEC-related "research, development, and manufacturing, and use of atomic weapons constitute an involved set of interlocking operations. Non-nuclear development work is the responsibility of Sandia Corporation. Components and sub-assemblies are manufactured throughout the country by companies carefully chosen for their ability to do precision work. Weapon components are inspected either at Sandia or at widely separated manufacturing plants. The AEC also operates a quality assurance program to confirm that weapon systems, as produced, meet the design intent outlined by the design engineers. Finally, additional tests are made by military agencies at storage locations or in the field."

As for the weapons themselves, their complexity makes many different kinds of measurement necessary. "Every weapon is enclosed in a case of some sort, contains nuclear fuel, and has a fuzing and firing system. For testing purposes, it consists basically of mechanical, electrical and electromechanical parts, all of which must be measured during manufacturing. After a weapon has been assembled, measurements are confined mainly to electrical and electromechanical tests. For field tests, only electrical and pressure measurements are needed."

STRUCTURE: The structural outline of the AEC calibration system is shown in the attached Chart AEC-1.

To meet the problem indicated above and "to secure compatible measuring results throughout the complex of development, manufacturing, and testing agencies, a Physical and Electrical Standards Department was formed at Sandia Corporation," with the responsibility of monitoring the measuring equipment of all other special weapons agencies.

SANDIA ("PRIMARY") STANDARDS LABORATORY: This is the top standards laboratory in the AEC structure. Operated by the Sandia Physical and Electrical Standards Dept., its principal function is to certify reference standards used by the "Secondary Reference Laboratories" at the next lower step in the calibration chain.

The Sandia Standards Laboratory has rather strict technical surveillance over the Secondary Labs. According to Biggs: "If methodology is to be standard, one agency must be paramount. This is especially important because the trend in AEC manufacturing is toward ever tighter tolerances, which carry in their wake the demand for tighter standards and more sensitive equipment. To meet these demands, the AEC has asked the primary laboratory (at Sandia) to report on the quality of work done at the secondary laboratories. These determinations of quality are made through technical audits. Samples -- barometers, voltmeters, gauge blocks, resistors -- are rotated continually among the secondary laboratories, each of which is asked to measure or calibrate the samples to the limit of its ability. The results of these measurements are sent to the laboratories as an indication of their competence."

The "Primary" lab at Sandia has two parts: "Physical" and "Electrical." The first is concerned with standards for dimensional measurements, for calibration of weighing equipment, humidity measurements, pressure, and temperature. The other handles electrical standards -- voltage, current, impedance, power, pulse, and radiation -- in the range from DC to tens of kilomegacycles.

Coordination of the standards at Sandia with those at NBS on the one hand and with those of the "Secondary" labs on the other is effected largely by means of "closed calibration loops." For example: "In establishing secondary electrical references, four unsaturated-type standard cells are first certified against a bank of saturated cells at the primary (Sandia) standards laboratory and then sent to a secondary laboratory. There they are intercompared by a precision potentiometer. After three months, one standard cell is compared with the other three cells and sent to the primary laboratory for a new certification. After the cell is returned to the secondary laboratory its value is again intercompared with the other three cells to make sure that it has suffered no damage in transit. Many calibration loops, similar to this in essence but varying in detail, insure the validity of all calibrations."

SECONDARY STANDARDS LABORATORIES: These are established at various inspection locations -- at Sandia itself, manufacturing suppliers of the AEC, and at military installations. Their task is to provide calibration service for measuring equipment.

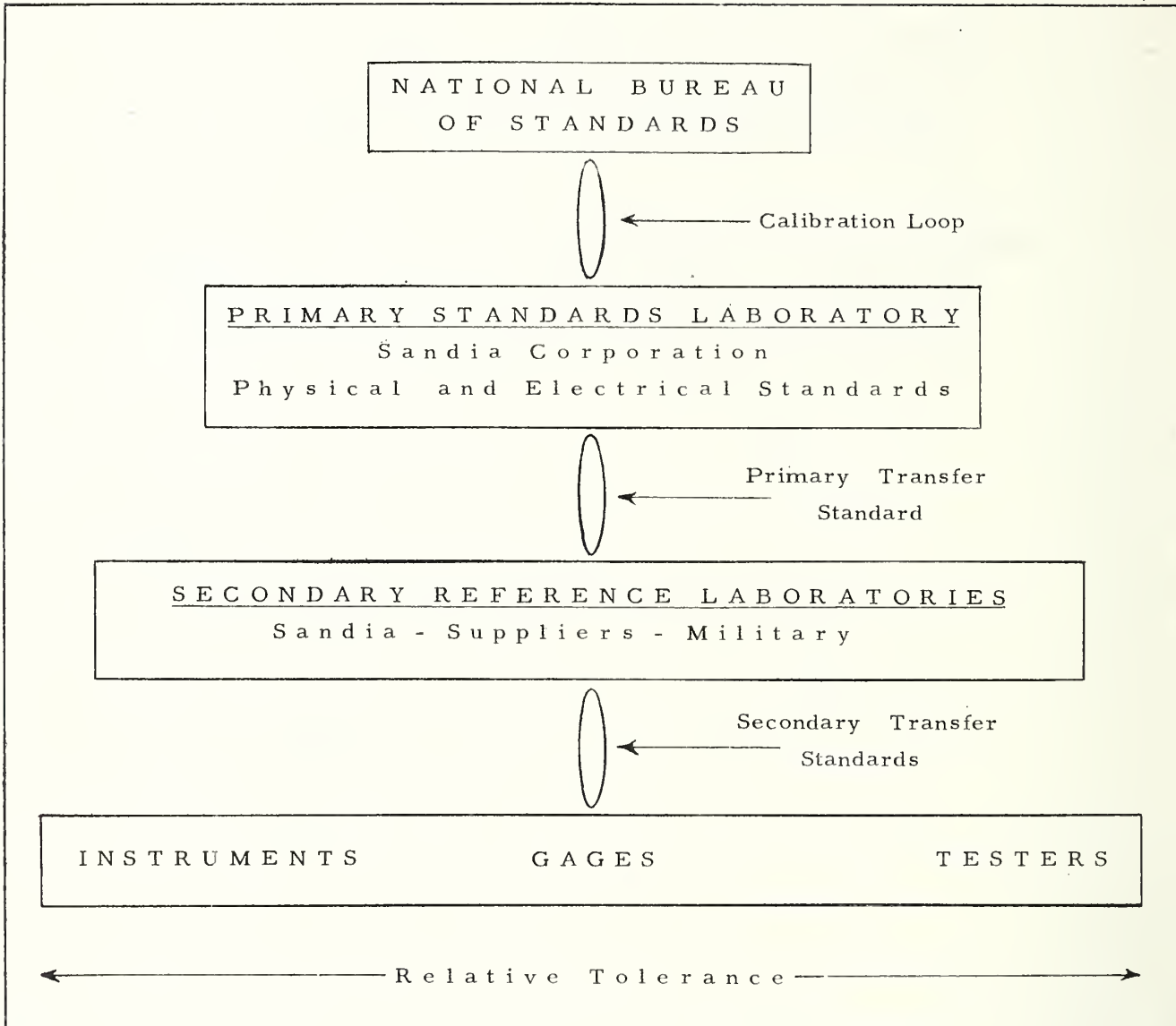
"...the term secondary is used in a relative sense... The quality of the standards at secondary laboratories is similar

to that of the primary standards of many industrial organizations. In fact, the primary standards of a supplier automatically becomes secondary standards when the supplier enters the AEC system."

As the last sentence may suggest, although the secondary lab may belong to a private company, or be part of a military installation, the AEC (through Sandia) will provide it with calibration services without charge -- at least to the extent that the secondary lab's work relates to a special weapons project.

REFERENCE: Physical and Electrical Standardization Program for the AEC, by H. C. Biggs, IRE Transaction on Instrumentation, Vol. I-7, Nos. 3 and 4, December 1958, page 364. This is accompanied by four and a half pages of tabulations showing the principal standards and equipment, and their accuracies, in use at the various levels of the AEC calibration system.

CHART AEC-1



AEC CALIBRATION CHAIN

(Based on diagram accompanying H. C. Biggs' IRE article-- see "Source of Information.")

STANDARDS AND CALIBRATION REQUIREMENTS
IMPOSED BY DEFENSE AGENCIES ON CONTRACTORS

Army Ordnance Corps: The Army Ordnance Corps requires its contractors to have complete calibration systems, including the necessary standards. In their acceptance testing work, Army Ordnance inspectors need not rely entirely on contractor test equipment but can call on the Army Ordnance standards laboratories for assistance. Occasionally, but not very often, the provision of services by Army Ordnance standards laboratories to contractors is written into the contract.

Air Force. As a matter of general policy, the AF expects its contractors to provide for their own calibration needs, either through a company standards laboratory or through an outside commercial laboratory. The only case in which the AF provides regular calibration service is when the contractor, as part of his contractual obligation, performs maintenance and repair work with AF equipment at AF installations. AF standards labs will also perform "referee" calibrations.

All AF contracts have a clause that requires the contractor to "provide and maintain gages and other measuring and testing devices necessary to assure that supplies conform to contract requirements. Such devices shall be checked with suitable measurement equipment at established periods to assure continued accuracy...and (the contractor) shall maintain records or other conclusive evidence that proper control is being provided." (Quotation from MIL-Q-5923C(USAF), paragraph 3.3, 8 Jan. 1956). A more detailed clause is now being drafted which will call specifically for traceability to NBS." The "traceability" requirement has already been put into effect as an interpretation of the existing clause, starting early in 1959 and is probably a major factor in the current expansion of standardization activities in private industry.

Navy BuOrd-BuShips. BuOrd and BuShips make it mandatory for contractors to maintain test equipment in calibration and to keep records of calibration dates. For contractors without the needed calibration facilities, the Metrology Department of the BuOrd-BuShips calibration system will undertake to perform a "measurement requirements analysis" for them. Then, on an interim basis, until the contractor can set up his own standards lab, BuOrd-BuShips standards labs will service his instruments.

Navy BuAer. BuAer takes pretty much the same position as BuOrd and BuShips. The aim of the BuAer standards labs is to provide assistance to BuAer inspectors, not to the contractors (who must provide their own calibration services).

Atomic Energy Commission. The "Primary" Standards Laboratory established at Sandia Corporation in Albuquerque, N. M., supplies calibration services to AEC contractors without charge. Calibrations are mostly in the areas of microwave quantities and acceleration. A preferred way of providing this service is by preparing special kits of standards and calibrated instruments that are sent to the contractors on loan.

U.S. DEPARTMENT OF COMMERCE

Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*



THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enamelled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.

