NBS TECHNICAL NOTE

437

DISCLOSURES ON:

Autosort - An Automatic Collating and Sorting Machine,
Optical Heterodyne Refractometer,
Liquid Metering Pump,
Stable Wideband Relaxation Oscillator Using Three Inverting Amplifiers, and
Seat Belt Webbing Abrasion Resistance Testing Machine

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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UNITED STATES DEPARTMENT OF COMMERCE
Alexander B. Trowbridge, Secretary
NATIONAL BUREAU OF STANDARDS • A. V. Astin, Director

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Editors: David Robbins and Alvin J. Englert

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ABSTRACT

This booklet presents descriptions and drawings of five devices that embody interesting and unusual solutions to problems frequently encountered in their respective fields. The devices are:

Autosort - An Automatic Collating and Sorting Machine

Optical Heterodyne Refractometer

Liquid Metering Pump

Stable Wideband Relaxation Oscillator Using Three Inverting Amplifiers

Seat Belt Webbing Abrasion Resistance Testing Machine.

Key Words:

automatic document distribution, programmed document distribution, rotatable document bin array, optical refractive index, laser beam phase shift, laser heterodyning, flexible tubing pump, liquid metering pump, relaxation oscillator, inverting amplifiers, seat belt webbing abrasion, abrasion resistance testing.

AUTOSORT - AN AUTOMATIC COLLATING AND SORTING MACHINE

Ballard Jamieson
Donald O. Lambert
Lynn L. Huffman

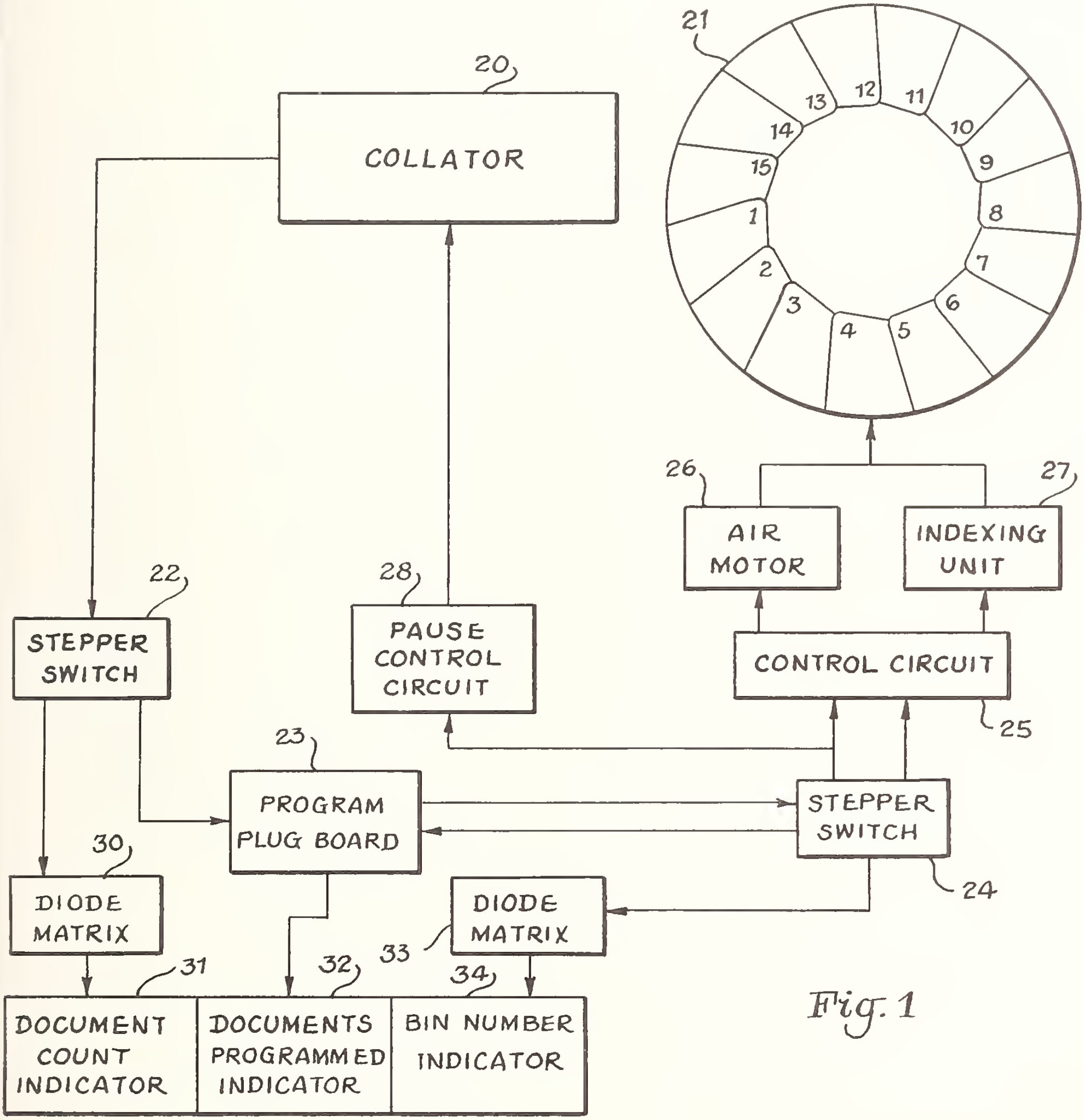

Fig. 1

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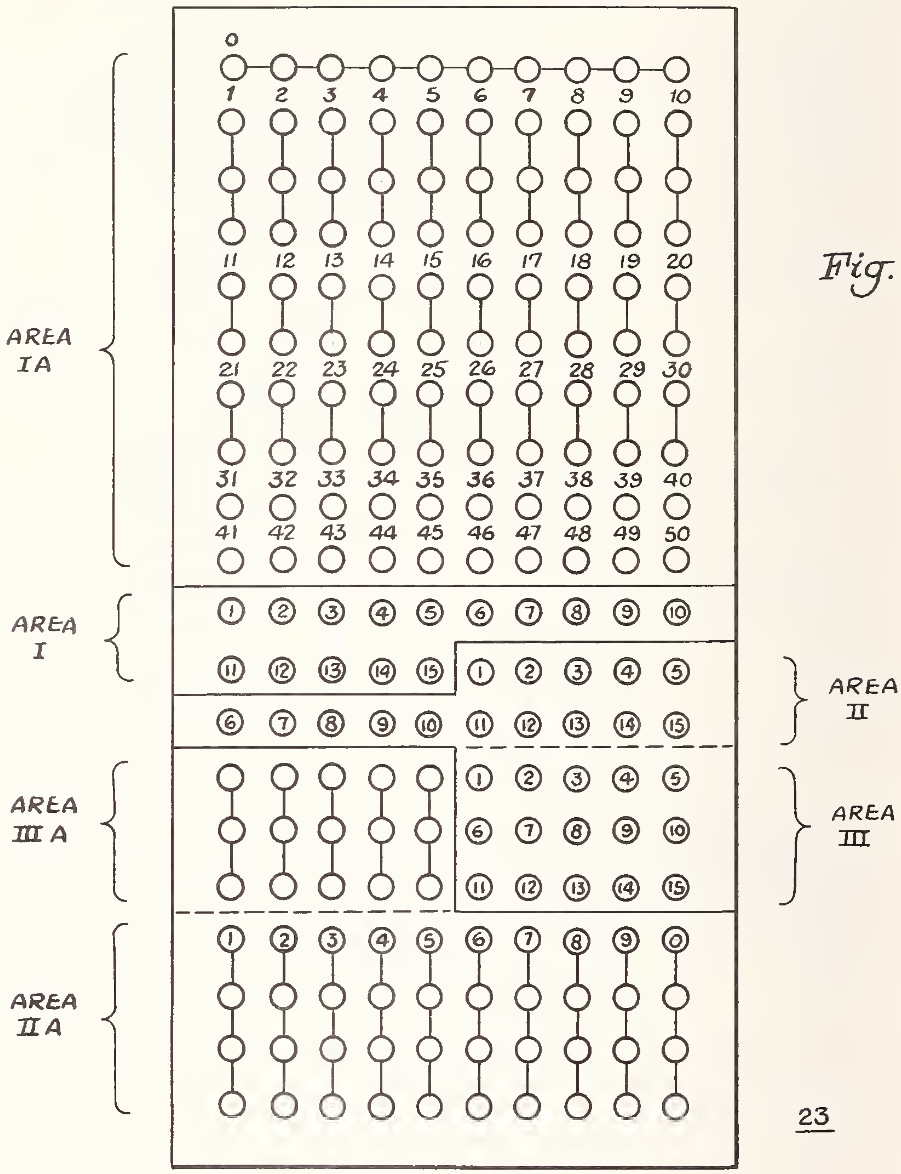

Fig. 2

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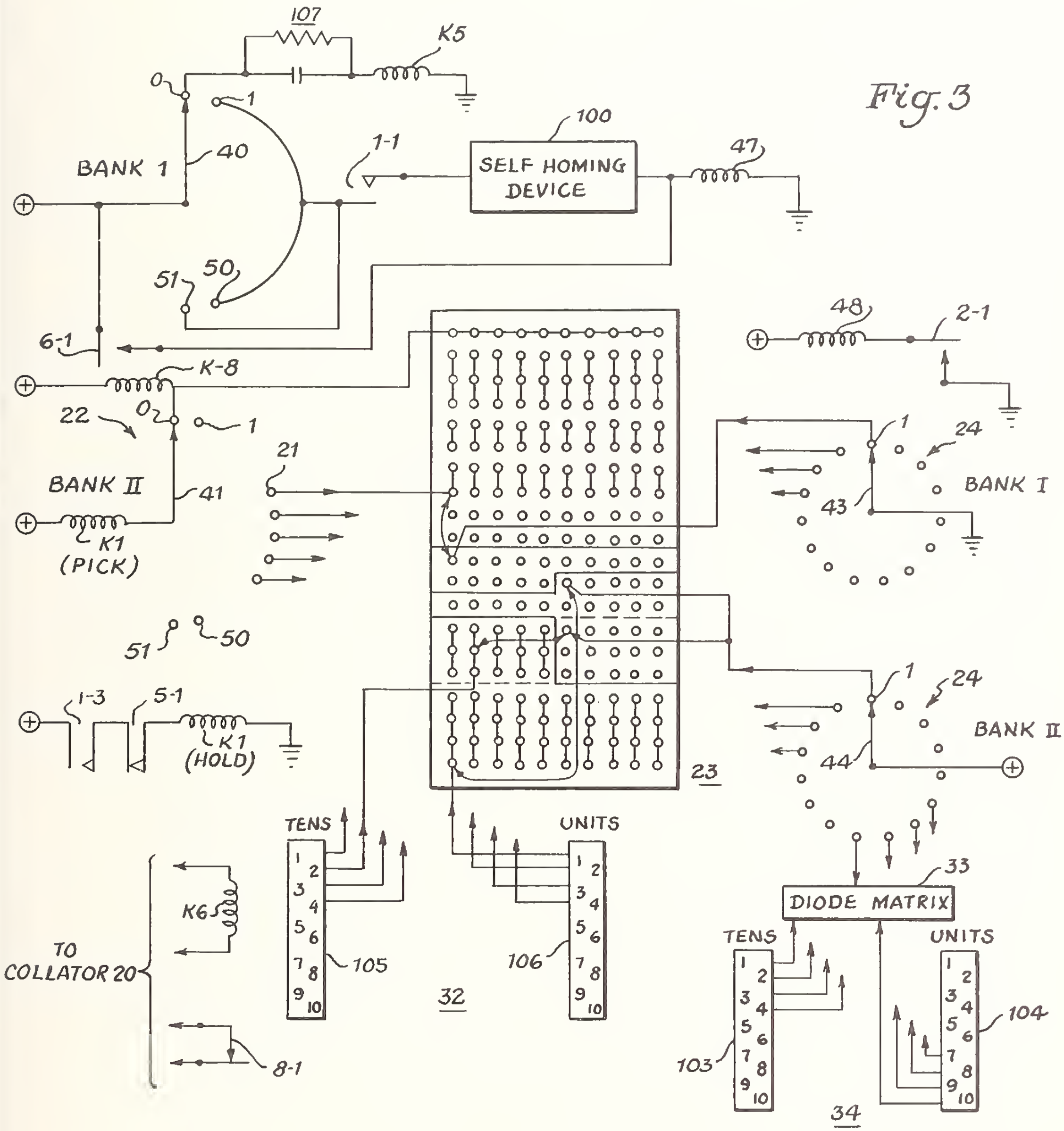

Fig. 3

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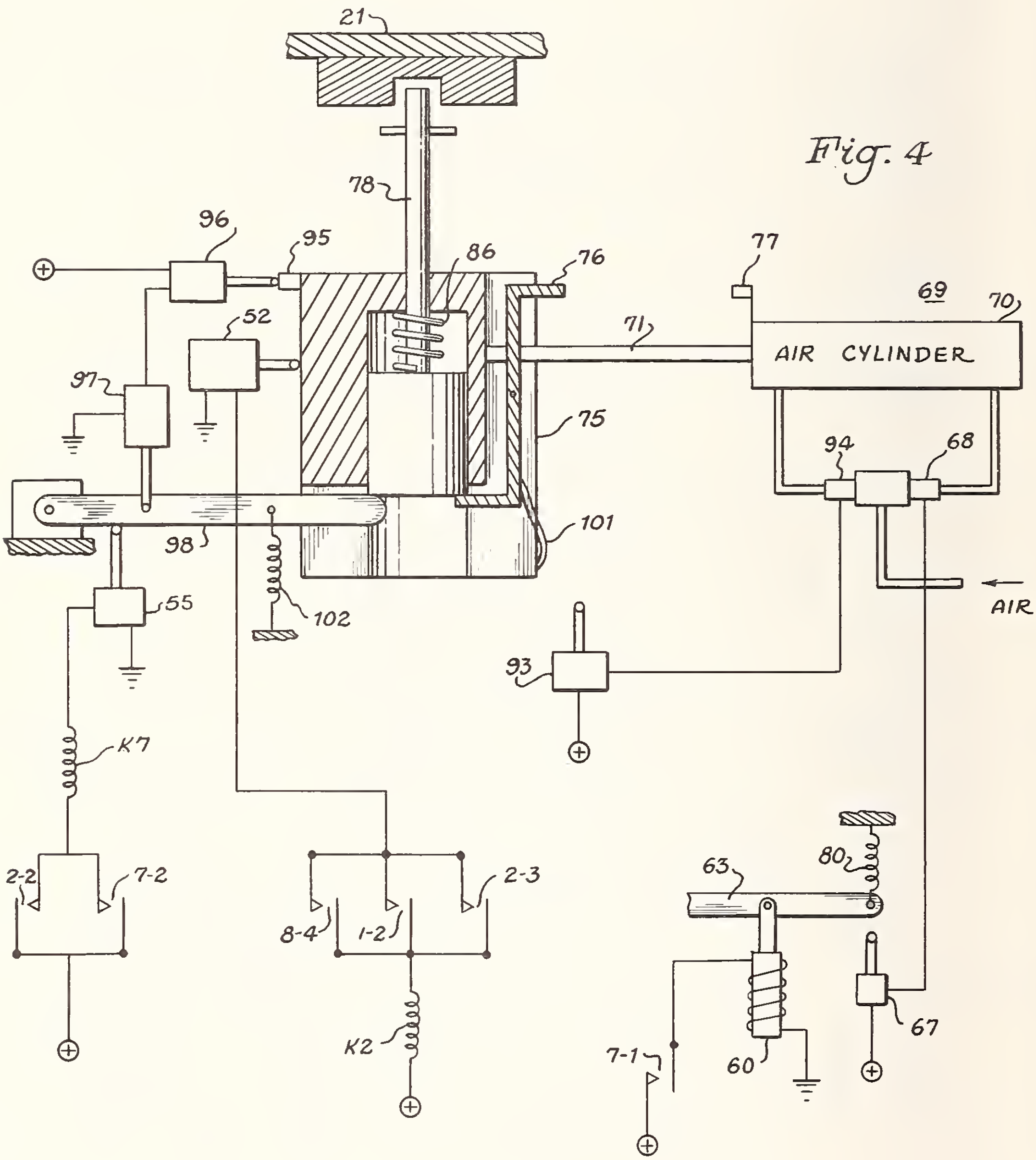

AUTOSORT - AN AUTOMATIC COLLATING AND SORTING MACHINE

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This publication describes a device which was designed to save manpower and reduce throughput time for distribution of multipage reports. The counting and sorting of reports in accordance with a wide variety of distribution lists had been previously performed as a separate manual operation. It is now accomplished automatically and simultaneously with collating and stapling in a continuous operation.

Each type of report has an entirely different distribution list in which (a) the number of copies required varies from one subscriber to the next (b) not all of the list of subscribers receive all types of reports.

Each distribution bin is permanently assigned to a subscriber and thus receives a variety of reports each with a different quantity but all for the same destination.

To achieve this flexibility interchangeable plug boards are used as programming elements, each board controlling the distribution of a certain type of report. The device comprises a commercially available collator coupled to a newly developed rotatable table with a circular array of bins.

In the figures, each relay is designated by K and a number, e.g., K1, and the contacts related to the relay are designated by the relay number together with an additional numeral, e.g., 1-1, 1-2, and 1-3. When one component is connected to another, a few leads are drawn between the components and the remaining leads are illustrated by a few arrows directed between the components.

In Fig. 1, collator 20 collates and staples together sheets of printed material to form documents which are deposited in bins 1 to 15 on table 21. Whenever a document is stapled a pulse, transmitted from the collator, advances stepper switch 22 until the count programmed for the bin is achieved. Current then flows through stepper switch 22, program plug board 23 and stepper switch 24. This current activates control circuit 25 to operate air motor 26 and indexing unit 27 until the table is advanced to the point where collator 20 may deposit documents into the next bin. When no documents are to be deposited in a bin, a pulse is transmitted through switch 22, plug board 23 and switch 24 to operate pause control circuit 28 which inactivates the collator until the table has been advanced to the following bin.

Signals are sent through diode matrix 30 to provide a visual display on indicator 31 of the count of a document deposited in a bin. Likewise, signals are fed from stepper switch 24 through plug board 23 to indicator 32 to display the number of documents programmed for a bin, and signals are fed through diode matrix 33 to indicator 34 which displays the number of the bin in which the documents are deposited.

Plug board 23 is shown in detail in Fig. 2. Each terminal in area IA represents the number of documents to be deposited in a bin, and each terminal in areas IIA and IIIA represents the units and tens digit, respectively, of such a number. The terminals in areas I, II, and III designate bin numbers.

A program is wired into the plug board by connecting each terminal in I to a respective terminal in IA, depending upon the number of documents to be deposited in each bin. The terminals in area II are each wired to a terminal in area IIA, while the terminals in area III are each wired to a terminal in area IIIA, depending upon the units and tens digits, respectively, in the number programmed for the related bin.

As an example, assume that bin 1 is positioned to receive documents from collator 20 and that 21 documents are to be deposited in this bin. Then terminal 21 in area IA is wired to terminal 1 in area I in the plug board, as shown in Fig. 3, and the terminals 1 in areas II and III are wired to terminals 1 and 2 in IIA and IIIA, respectively. In this way 21 documents are programmed in the plug board for bin 1.

Before the start of operation, arms 40 and 41 in banks I and II on stepper switch 22 are resting on terminal 0 in their respective banks. At the same time, arms 43 and 44 in banks I and II of stepper switch 24 are on terminal 1 of their respective banks. When collator 20 staples the first document relay K6, located in parallel with the stapler coil (not shown) in the collator, is energized to close contacts 6-1. A circuit is then completed through stepper coil 47, advancing arm 41 on switch 22 to terminal 1. This process is continued until arm 41 engages terminal 21 when a circuit is established through the pick coil of relay K1, plug board 23 and arm 43 of stepper switch 24 to ground. Relay K1 is picked up and contacts 1-2 make (Fig. 4) to complete a circuit through microswitch 52 to ground. Relay K2 is then energized and a holding circuit for this relay is established through contacts 2-3. Contacts 2-1 (Fig. 3) make to energize stepper coil 48 and advance switch 24. Contacts 2-2 (Fig. 4) close, setting up a circuit through microswitch 55 to ground. Relay K7 is then activated and contacts 7-2 close, completing a hold circuit for the latter relay.

Contacts 7-1 close to complete a path that energizes solenoid 60, and detent arm 63 is disengaged from a block (not shown) on the bottom of table 21. There are fifteen detent blocks located around the bottom of the table, one for each bin. As the detent arm moves out of the engaged position, it closes microswitch 67, which completes a circuit that energizes the pull solenoid valve 68 in air motor 69.

Air is admitted into cylinder 70 which pulls rod 71 and sliding block 75 to the right in Fig. 4. As 75 moves to the right, spring 102 moves arm 98 downward and microswitch 55 is opened which breaks the circuit through relay K7. Contacts 7-1 open and solenoid 60 is released. Spring 80 then causes detent arm 63 to engage the block on the bottom of table 21 associated with the next bin.

The rod pulls the sliding block to the right until the trigger pad on latch 76 engages projection 77. When 77 is engaged the latch can not move any further but the sliding block continues to move a short distance, pivoting the latch so that pin 78 is disengaged. Spring 86 then forces the pin down, which trips microswitch 93. The pin is now in the released position and 93 completes a circuit that energizes solenoid 94. Air is now admitted into cylinder 70 in such a way that rod 71 is pushed to the left in Fig. 4.

When pad 95 engages the plunger of microswitch 96, the microswitch completes a circuit that energizes solenoid 97. Arm 98 is then pivoted upward, moving pin 78 into the recess in the block, associated with the next bin, on the bottom of table 21. As the pin moves upward the lower lip on latch 76 is pushed under the pin by leafspring 101.

Before the start of the example above, arms 40 and 41 (Fig. 3) are in their initial positions on terminals 0 on banks I and II, respectively, of stepper switch 22. As the collator 20 staples its first document relay K6, connected in parallel with the stapler coil, is energized to close contacts 6-1 and thus complete a circuit through stepper coil 47. Arms 40 and 41 are then advanced to terminal 1 on their related banks. This process is continued until arm 41 engages terminal 21 when the circuit described in the paragraphs above is activated and relay K1 is picked up. Contacts 1-3 then close to establish a circuit through contacts 5-1 to energize the hold coil of relay K1. Since terminals 1 to 50 of bank I, switch 22 are connected together a circuit is creatd through contacts 1-1, self-homing device 100 and a stepper coil 47. Arm 40 is then advanced until it engages terminal 51 when a circuit is completed through the self-homing device to advance the arm to terminal 0. A circuit is then established momentarily through timing network 107 and relay K5 to pulse-open contacts 5-1, opening the holding circuit for relay K1. Contacts 1-1 break and the arms of switch 22 remain at rest on terminal 0 of their respective banks.

If the number of documents required for a particular bin is zero, a patchcord is connected between the bin's terminal in area I and terminal 0 in area IA of plug board 23 (Figs. 2 and 3). When arm 43 on stepper switch 24 is advanced to the terminal representing the bin, a circuit is completed to pick relays K1 and K8. Contacts 8-1 break and since these contacts are connected in series with the drive motor of collator 20 the motor is inactivated. Contacts 8-4 (Fig. 4) close, picking up relay K2; contacts 2-1 make to complete a circuit through coil 48 (Fig. 3) to advance the arms of stepper switch 24 to terminal 2. Contacts 2-2 close to energize relay K7, which in turn closes contacts 7-1 and starts the table advancing cycle described above. In this way the table is advanced but no documents are deposited in the bin.

Each of the terminals in bank III (not shown) of stepper switch 22 are connected to diode matrix 30 (Fig. 1) which contains output circuits connected to the respective terminals of a tens and units Nixie tube in indicator 31. Thus when the arm of this bank is advanced in unison with arm 41 on bank II, the selected tube elements are ignited to indicate the count of the documents being deposited in a certain bin.

The terminals on bank II (Fig. 3) of stepper switch 24 are connected to diode matrix 33 which in turn has output leads connected to each of the tens and units Nixie tubes 103 and 104 in indicator 34. As the bins on table 21 are advanced to receive documents, arm 44 is advanced around the terminals of bank II and the Nixie tubes are energized to display the number of the bin receiving documents.

Plug board 23 is wired to program the number of documents required for each bin, and in the example above bin 1 is programmed for 21 documents. When arm 44 is on terminal 1, bank II in switch 24 a circuit is established through the plug board to Nixie tube 105 to display a "2" for the tens digit, while another circuit is completed through the plug board to Nixie tube 106 to display a "1" for the units digit. In this way "21" is displayed on the Nixie tubes in indicator 32.

OPTICAL HETERODYNE REFRACTOMETER

Lockett E. Wood
Moody C. Thompson, Jr.

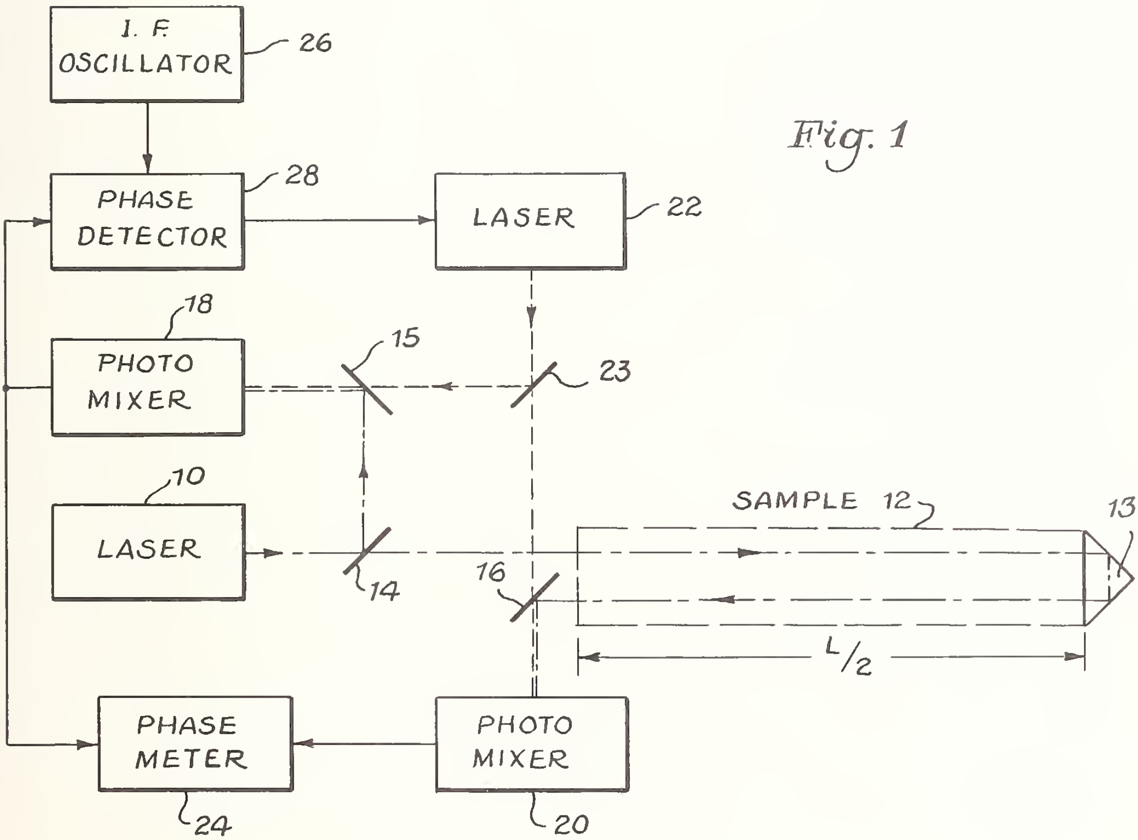

Fig. 1

OPTICAL HETERODYNE REFRACTOMETER

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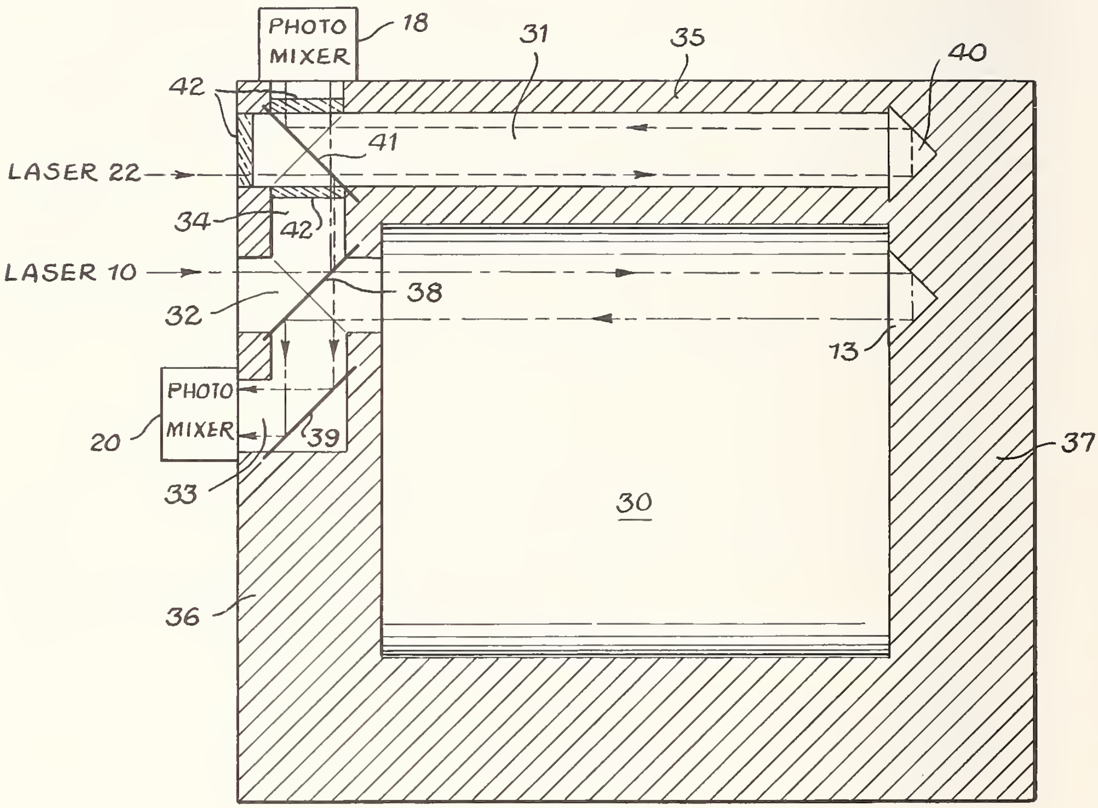

Fig. 2

OPTICAL HETERODYNE REFRACTOMETER

Lockett E. Wood
Moody C. Thompson, Jr.

This refractometer measures the optical refractive index of a thin (1 cm) sample by projecting a laser beam through the sample and measuring the phase shift between the incident and emergent beams. The measurement is facilitated by heterodyning the beams with laser light of another wavelength. The light reflecting components of the refractometer are small and may be incorporated into a microwave cavity, for example, to provide an optical-microwave dispersion measuring system.

As shown in Fig. 1, the refractometer comprises a laser 10 arranged to project a light beam through a sample 12 whose refractive index is to be measured. A retro-reflector 13 is positioned to return the light through the sample 12, and beam splitters 14-15 and 16 are aligned to direct portions of the incident and emergent beams, respectively, to a pair of photomixers (photodetectors) 18 and 20. A second laser 22 and a beam splitter 23 are arranged to project additional laser light to the photomixers 18 and 20. The laser lights heterodyne and the difference frequency components actuate the photomixers 18, 20. The outputs of the photomixers 18, 20 are applied to a phasemeter 24; the meter reading is the phase shift of the laser light traversing the sample 12.

The phase shift φ indicated on phasemeter 24 is related to the refractive index n of sample 12 by

$$\varphi = \frac{nf}{c} L,$$

where f is the frequency of the light from the first laser 10, L is the total length of the light path through the sample 12, and c is the velocity of light in vacuum. Hence, if laser 10 is a helium-neon laser emitting light at 0.6328 microns ($f = 4.76 \cdot 10^{14}$ Hz), and the sample 12 is 1 cm thick (L = 2 cm), a change in the refractive index n of one part per million results in a phase change

$$\Delta \varphi = \frac{fL}{c} \Delta n \times 360° = 11.4°.$$

The refractometer thus can easily measure the refractive indexes of 1 cm samples to better than 1 ppm.

In Fig. 1, the photomixer 18 and a stable intermediate-frequency oscillator 26 are connected to a phase detector 28. The oscillator frequency is equal to the nominal difference in the frequencies of lasers 10 and 22. Thus, if the frequency of laser 22 drifts because of thermal or other changes, the phase detector 28 produces an output proportional to the drift. The output is applied to a piezoelectric or magnetostrictive mirror mount (not shown) in the laser 22; the mount adjusts the laser resonant cavity in the direction to oppose the detected frequency drift. In this manner, laser 22 is phase locked the intermediate frequency away from laser 10, and the phasemeter 24 may be sharply tuned to increase its sensitivity and simplify the measurement.

The sample 12 may comprise a gas flowing through a (transparent) conduit, a liquid in a conduit or a container, or a solid in the form of a disc or plate.

If the accuracy of the phase shift measurement is to be high, the laser path through the sample 12, the mountings of the four beam splitters 14, 15, 16, and 23, and the frequency of laser 10 should be stable during the measurement.

Fig. 2 shows the refractometer incorporated into a microwave cavity 30. The cavity has three parallel, axially extending bores 31, 32 and 33, which are jointly intersected by a transverse bore 34. The bore 31 extends into a side wall 35 of the cavity, bore 32 extends through end wall 36, and bore 33 extends partly into the end wall 36.

The light from laser 10 is projected through bore 32, through the gas in the microwave cavity 30, and is retro-reflected by prism 13 fitted into the far end wall 37. A beam splitter 38 disposed diagonally across bore 32 directs a portion of the incident laser light up to photomixer 18, and a portion of the emergent light down to photomixer 20, via a flat mirror 39. The light from laser 22 is projected into bore 31, passes through the gas therein, and is returned by retro-reflector 40. A beam splitter 41 directs part of the incident light down to photomixer 20, and part of the emergent light up to photomixer 18. The bore 31 is hermetically sealed by three windows 42, and is evacuated or filled with a dry reference gas.

The photomixers 18, 20 are connected to a phasemeter 24 as in Fig. 1; the lasers 10 and 22 may be phase locked with the intermediate-frequency oscillator 26 and phase detector.

In the operation of the optical-microwave refractometer of Fig. 2, the beams from lasers 10 and 22 are projected over identical paths through the sample gas in the microwave cavity 30, and the vacuum or reference gas in bore 31, respectively. Portions of the incident and emergent beams are paired, heterodyned, and applied to the photomixers 18 and 20; the phase difference of the photomixer outputs is a measure of the refractive index of the sample gas in cavity 30, relative to the refractive index of the vacuum or reference gas in bore 31.

Simultaneously, the cavity 30 is supplied with variable frequency microwave energy in the well-known manner, and the resonant frequency of the cavity is determined and related to the microwave refractive index of the sample gas in the cavity. From the resultant optical and microwave refractive indexes, the dispersion of the sample gas at the frequencies of laser 10 and the microwave resonance may be determined, as known in the art.

The dispersion measurement provided by the refractometer of Fig. 2 provides a convenient, precise method of determining the water vapor content of an atmospheric sample in the cavity 30. It is well known that the difference between the optical and microwave refractive indexes of moist air is in the order of 100 ppm. Since the refractometer resolves these indexes to better than 1 ppm, the water vapor can be determined easily and directly within a few percent.

In Fig. 2, the optical components (beam splitters 38, 41, mirror 39, prisms 13, 40, and windows 42) are arranged symmetrically in the walls of the microwave cavity. This makes many of the dimensional changes in the spacings of the components, due to temperature or other changes, balance or cancel each other. In addition, the usual temperature compensations employed in the microwave cavity tend also to compensate the optical system.

LIQUID METERING PUMP

Walter D. Komhyr

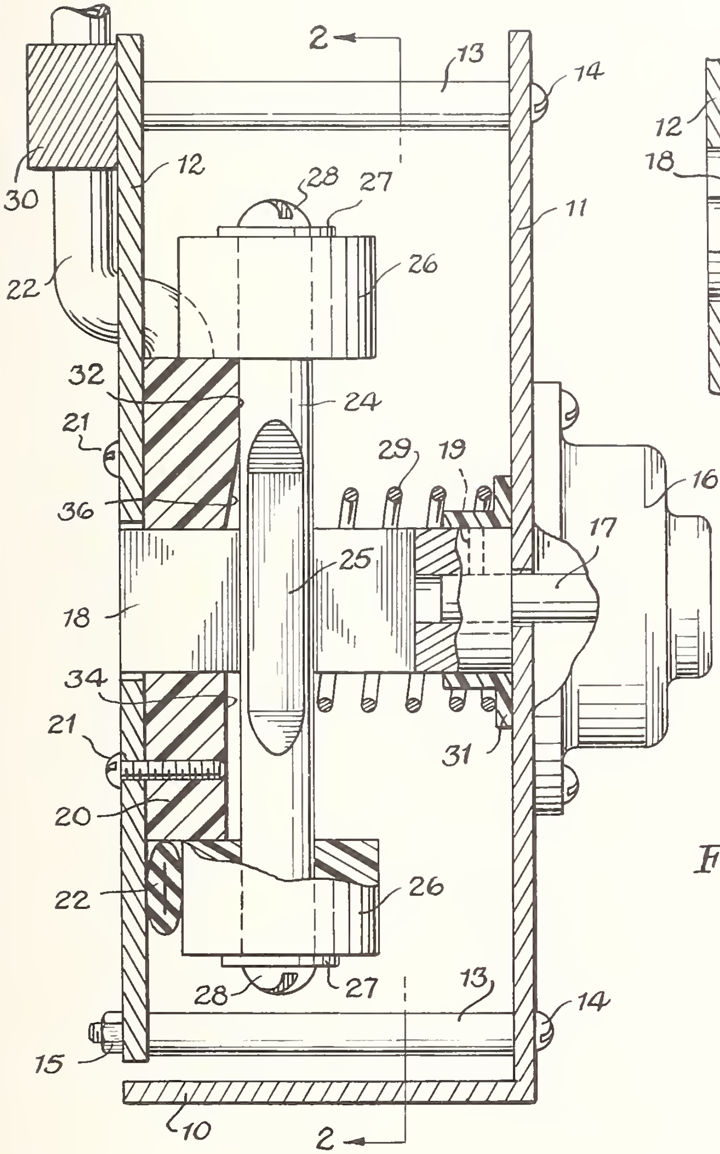

Fig. 1

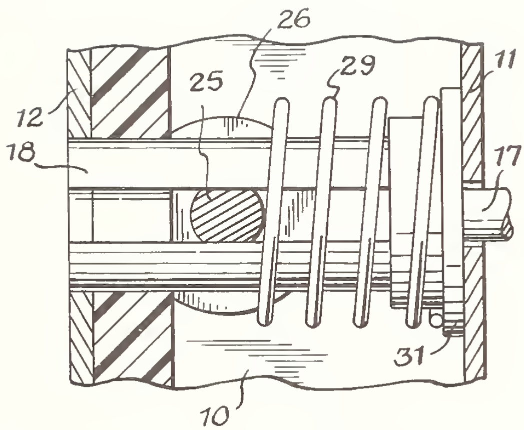

Fig. 3

LIQUID METERING PUMP

Walter D. Komhyr

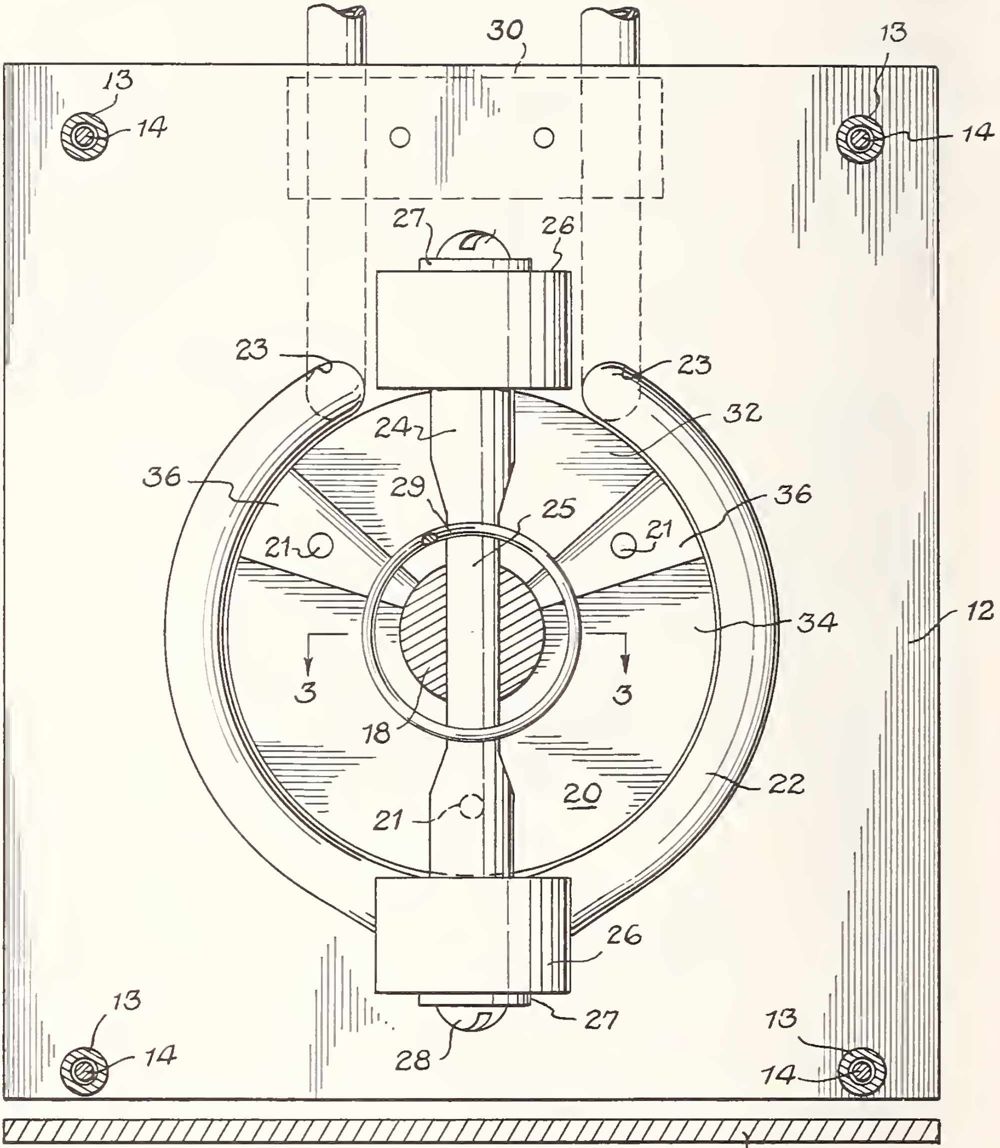

Fig. 2

LIQUID METERING PUMP

Walter D. Komhyr

This pump relates to the class of pumps utilizing a rolling compression along a flexible tube. It eliminates leakage usually associated with such pumps, and in addition is self-adjusting, trouble-free, and economical.

As shown in Figs. 1 and 2, the pump housing comprises a base plate 10, an integrally-formed back plate 11, and a front plate 12 that is spaced from and secured to the back plate 11 by cylindrical, threaded-through spacers 13, screws 14, and nuts 15. The back plate 11 mounts a small geared motor 16, the shaft 17 of which is connected to a pump shaft 18 by a recessed set screw 19. The pump shaft 18 is journalled in an annular bushing 20, preferably of Teflon, that is attached to the front plate 12 by screws 21. A section of flexible tubing 22 of silicone rubber or the like is wrapped around the bushing 20 and suitably cemented to the front plate 12. The ends of the tubing 22 extend through holes 23 provided in plate 12, and are anchored in a clamp 30. The ends provide the inlet and outlet of the pump.

The pump shaft 18 is slotted, as shown best in Fig. 3, to slidably receive an axle 24 having a flattened midportion 25. The axle 24 slidably and rotatably carries a pair of rollers 26, preferably Teflon, which are retained on the axle by washers 27 and screws 28. The axle 24 is slightly longer than the diameter of the bushing 20 plus the lengths of the rollers 26, so that the rollers 26 are freely guided by the cylindrical surface of the bushing 20 to overlay the tubing 22. The rollers 26 compress the tubing 22 against the front plate 12 by virtue of a helical spring 29 disposed about the pump shaft 18 between the axle 24 and back plate 11. A Teflon washer 31 is provided between the spring 29 and plate 11 to reduce the friction therebetween as spring 29 rotates with the pump shaft 18 and axle 24.

As shown in Fig. 2, the surface of the bushing 20 adjacent the axle 24 comprises upper and lower parallel planar portions 32 and 34, and a pair of interconnecting ramps 36. The upper or raised portion 32 extends over an arc that includes the ends of the tubing 22 (apertures 23), and provides a support for the axle 24 when the associated roller 26 traverses the end portions. This supporting action is clearly shown in Fig. 1. The ramps 36 smoothly guide the axle 24 onto and off the raised portion 32 so that the associated roller 26 effects a correspondingly smooth release and compression of the tubing 20. In this manner, the rotation of the axle 24 by motor 16 is free from the vibration that would otherwise ensue from the transfer of the rollers 26 across the ends of the tubing 22; and the flow of liquid effected by the rolling compressions of the rollers 26 on the tubing 22 is smooth and free of pulsations that cause back-leakage of the pumped fluid. This latter feature is especially important when the pump is used to precisely meter liquids in medical instruments, chemical analyzing apparatus, and the like. Furthermore, it will be apparent that the construction of the bushing 20, slidable axle 24 and slotted pump shaft 18 is rugged, reliable, self-adjusting, and economical to fabricate and assemble. The inexpensive, lightweight, but rugged characteristics of the pump are especially adapted to portable and airborne chemical analyzer instrumentation requiring continuous metering or replenishment of reagent solution.

STABLE WIDEBAND RELAXATION OSCILLATOR USING THREE INVERTING AMPLIFIERS

Rufus E. Gordon

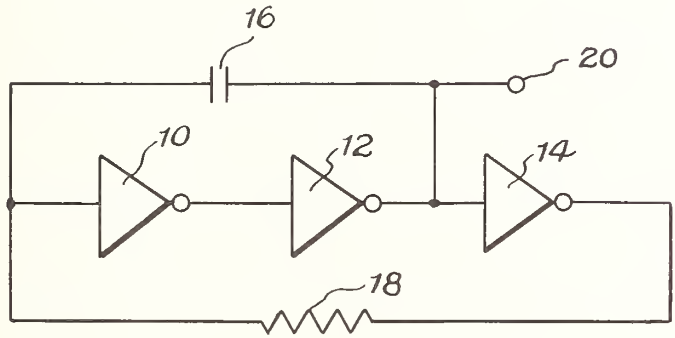

Fig. 1

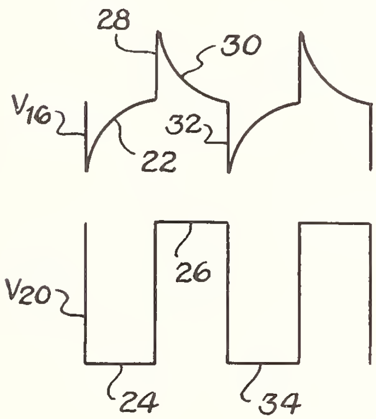

Fig. 2

STABLE WIDEBAND RELAXATION OSCILLATOR USING THREE INVERTING AMPLIFIERS

Rufus E. Gordon

This relaxation circuit oscillates over a range extending from less than one Hz to several MHz, and is relatively insensitive to temperature changes.

As shown in Fig. 1, the oscillator comprises three cascaded inverting amplifiers 10, 12, and 14. A capacitor 16 is connected around amplifiers 10 and 12, and a resistor 18 is connected around all three amplifiers 10, 12, and 14. The oscillator output 20 is taken from the output of amplifier 12.

In the operation of the oscillator, when the input to amplifier 10 is low, its output is high, the output of amplifier 12 is low, and the output of amplifier 14 is high. In this condition, capacitor 16 charges through resistor 18, as illustrated by the charging curve 22 of the voltage curve V_{16}, Fig. 2, which represents the voltage across capacitor 16. The voltage V_{16} raises the input to amplifier 10, and eventually reaches the amplifier turn-on point, causing the output of amplifier 10 to go low, and the outputs of amplifiers 12 and 14 to change state. As the output of amplifier 12 changes state from the low value 24 to the high value 26 (see V_{20} in Fig. 2), capacitor 16 provides regenerative feedback to the input to amplifier 10, causing the input to rise sharply as shown at 28 of V_{16} in Fig. 2. After the amplifiers change state, capacitor 16 discharges through resistor 18, as illustrated at 30 in Fig. 2. This continues until the turn-off point of amplifier 10 is reached, and all of the amplifiers again change state, as indicated at 32 and 34 in Fig. 2. Thus the output voltage V_{20} taken from amplifier 12 provides a very clean rectangular wave having a frequency approximately equal to $\frac{1}{2R_{18} C_{16}}$. The frequency may be varied by varying resistor 18 or capacitor 16, or both. If presently-available digital integrated circuit inverting amplifiers (NOR gates, etc.) are used at 10, 12, and 14, the circuit will oscillate from less than one Hz to six MHz or better.

The frequency stability of the present oscillator is very good because the period is determined by the sum of the times 22 and 30 of V_{16}. As the turn-on and turn-off points, which are essentially the same, vary with temperature, time 22 will increase while time 30 decreases or vice versa. Since the slope of one curve increases as the other decreases the compensation is not perfect, but nearly so if times 22 and 30 are nearly equal. This inherent characteristic of the circuit achieves high frequency stability without the use of conventional, expensive compensating means. The symmetry of the rectangular wave is disturbed slightly but the period and frequency remain nearly constant over a wide temperature range.

SEAT BELT WEBBING ABRASION RESISTANCE TESTING MACHINE

Alfred B. Castle, Sr.

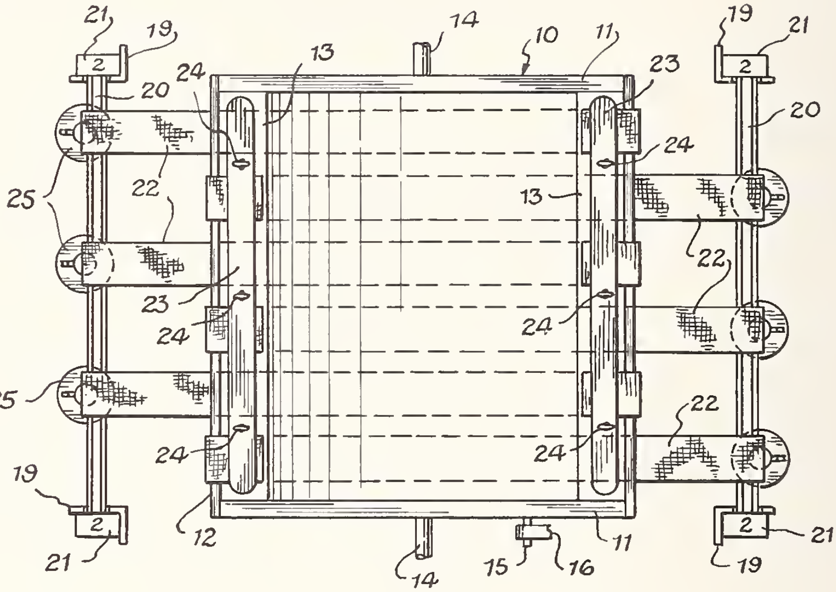

Fig. 1

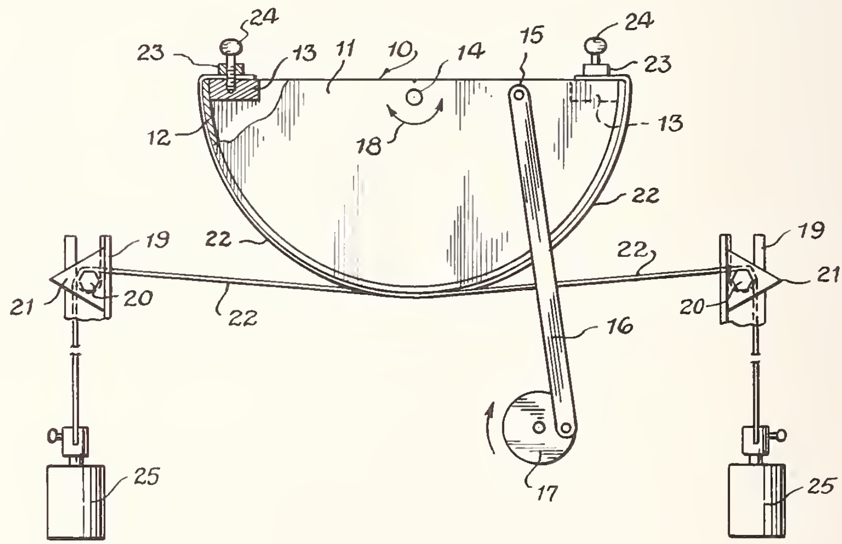

Fig. 2

SEAT BELT WEBBING ABRASION RESISTANCE TESTING MACHINE

Alfred B. Castle, Sr.

This machine comprises a modified, balanced version of the standard machine set forth in 15 USC 9.7(d), and published in the Federal Register, Vol. 31, No. 169, Part II, pages 11531 and 11536, on August 31, 1966, entitled Standards for Seat Belts for Use on Motor Vehicles.

As shown in Figs. 1 and 2, the machine includes a lightweight drum 10 formed from a pair of rigid, semicircular end plates 11, a thin curved sheet 12, and a pair of longitudinal stiffening members 13. The end plates 11 carry centrally-disposed shafts 14 which are journalled in suitable bearings mounted in a frame (not shown) for the machine. The front end plate 12 also carries an eccentrically positioned shaft 15 which is connected by a crank arm 16 to a crank 17. The crank 17 is driven by an electric motor (not shown) secured to the machine frame. In this manner, the rotation of the crank 17 by the motor effects an oscillation of the drum 10, as indicated by the arrow 18. The dimensions of the crank 17, the offset of the shaft 15, and the diameter of the drum 10 are selected to provide an oscillation stroke of 13 inches, as specified in the above-mentioned Sec. 9.7(d) of Title 15. The motor speed is such as to provide the proscribed 60 ± 2 strokes per minute.

The machine further includes a pair of hexagonal steel bars 20, of the type specified in Sec. 9.7(d). These bars are supported by slotted angle brackets 19 secured to the machine frame so that the bars are aligned parallel to the longitudinal axis of drum 10, and slightly above the bottom of the drum on opposite sides thereof. The ends of the bars 20 carry (equilateral) triangular end pieces 21 which key with the angle brackets 19 to position one of the three pairs of edges of the bars to receive a plurality of seat belt webbings 22 to be abraded. The webbings 22 are releasably secured to the drum 10 by metal straps 23, and thumbscrews 24 threaded into the longitudinal stiffening members 13 of the drum. Successive webbings 22 are secured alternately to the right and left sides of the drum, passed under the drum, and over the hexagonal rod 20 on the opposite side of the drum. A plurality of weights 25, each having the mass called for by Sec. 9.7(d), are attached to the remaining ends of the webbings. An even number of webbings are used, such as the six webbings 22 that are illustrated, so that the resulting torques on the drum 10 are evenly distributed and balanced along the length of the drum.

The above-mentioned Sec. 9.7(d) specifies that each webbing shall be abraded over two new edges of the hexagonal bars 20. Accordingly, when a pair of new bars 20 are placed in the angle brackets 19, the numbered faces of the end pieces 21 facing the operator (see numerals "2" on pieces 21 in Fig. 2) are recorded. A set of webbings 22 are then attached to the drum 10, the weights 25 attached thereto, and the drum oscillated for 2,500 cycles, after which the webbings are removed and tested in conformance with Sec. 9.7(d). The next set of webbings are then attached to the drum 10 in a pattern that is the reverse of the preceding pattern. For example, in Fig. 2 the front webbing 22 is attached to the left stiffening member 13; in the next test, the front webbing would be attached to the right stiffening member, the successive webbings being alternated left and right to form the desired alternately spaced pattern. In this way, the second set of webbings would contact the hexagonal bars 20 along the portions that were not used (rubbed) by the first set of webbings. For the third and fourth sets of webbings, the bars 20 would be rotated to cause the second faces of the end pieces 21 to face the operator, and the webbings would be arranged in the two patterns just described. Finally, two more sets of webbings could be tested by rotating the bars 20 to the third positions of end pieces 21, after which it would be necessary to replace the bars 20.

From the foregoing it will be seen that the present machine greatly facilitates the testing of a large number of seat belt webbings for their resistance to abrasion. The machine permits the operator to test a large number of webbings simultaneously, without imposing an unbalanced load on the motor of the machine. The hexagonal abrading bars require a rotation only after the second and fourth tests, and replacement after the sixth test, thereby reducing the number of manipulations required of the operator. In addition, the numbered end pieces 21 on the bars 20 enable the operator to quickly record, for future references, the abrasion bar used to test a given set of set belt webbings.

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