NBS

Technical Note 287

DISCLOSURES ON

Magnetic Tape Handler
Focus Detector,
Multi-pen Recorder,
Signal Averaging Filter,
Electrostatic RMS Voltmeter,
Back-up Ring for O-rings, and
Low Temperature Solid State Thermometer

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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ISSUED APRIL 8, 1966

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Editors: David Robbins and Alvin J. Englert

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TABLE OF CONTENTS

This booklet presents descriptions and drawings of seven devices, embodying interesting and unusual solutions to problems frequently encountered in their respective fields: a high speed magnetic tape handler, an electro-optical focus detector for a point light image, a multi-pen recorder having a time delay arrangement, a multi-segment signal averaging filter, an arrangement for measuring low temperatures using a silicon radiation detector, a high pressure back-up ring for O-rings, and an electrostatic RMS voltmeter.

Other disclosures on various subjects may be found in NBS Technical Notes 237, 253, 263, and 282.

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A HIGH SPEED MAGNETIC TAPE HANDLER

McRae Anderson

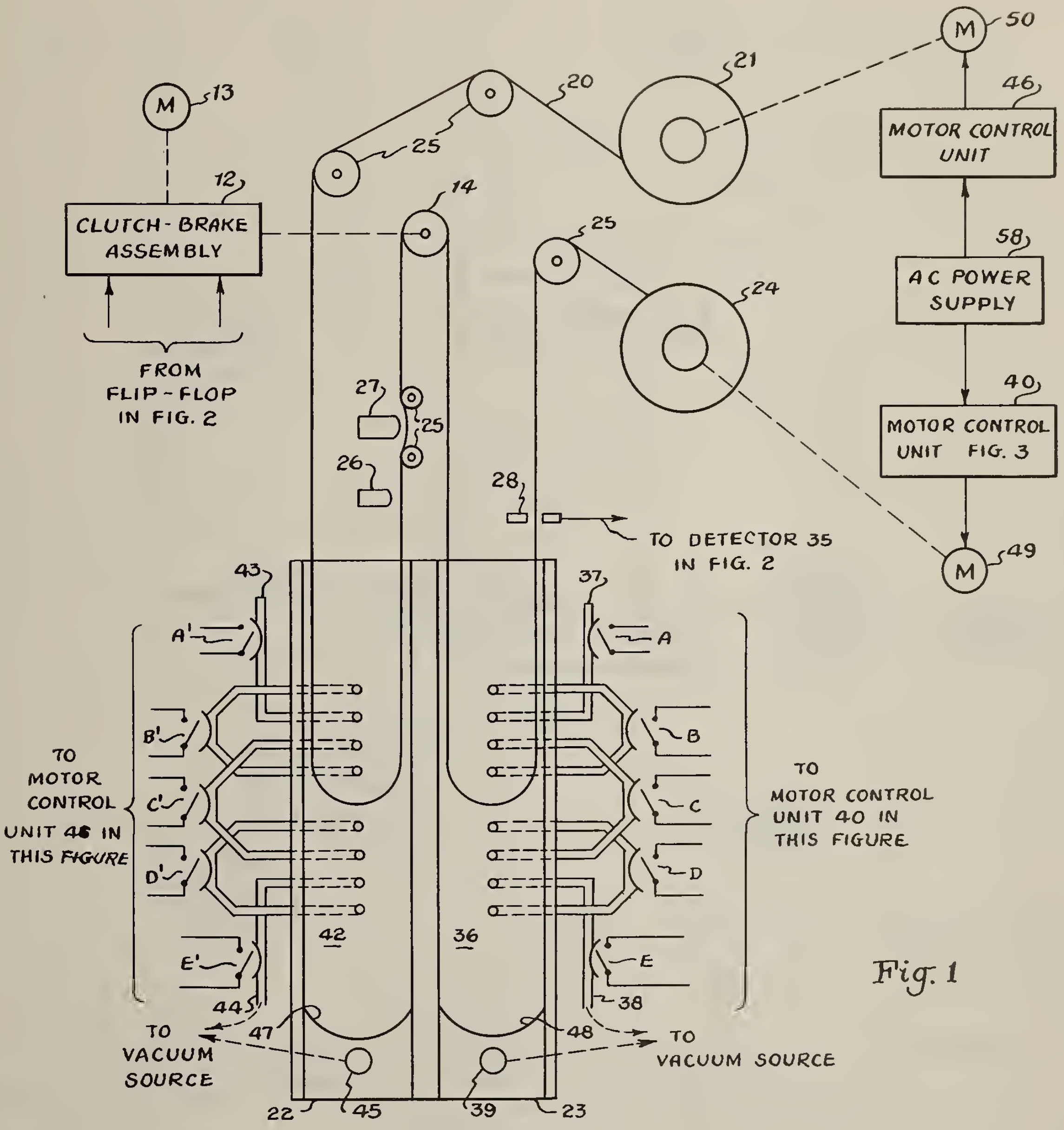


Fig. 1

Tech. Note No. 287, April 8, 1966

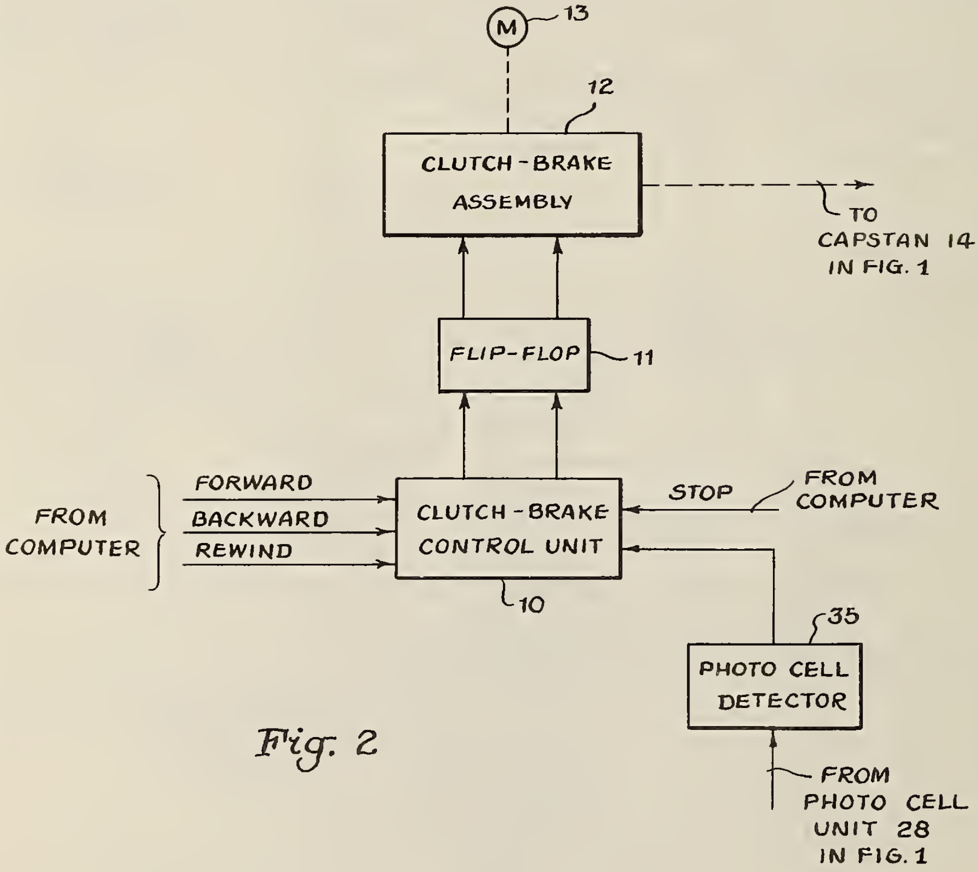

M
13
12
CLUTCH-BRAKE ASSEMBLY
TO CAPSTAN 14 IN FIG. 1
FLIP-FLOP
11
FROM COMPUTER
FORWARD
BACKWARD
REWIND
CLUTCH-BRAKE CONTROL UNIT
10
STOP
FROM COMPUTER
35
PHOTO CELL DETECTOR
FROM PHOTO CELL UNIT 28 IN FIG. 1

Fig. 2

A HIGH SPEED MAGNETIC TAPE HANDLER

McRae Anderson

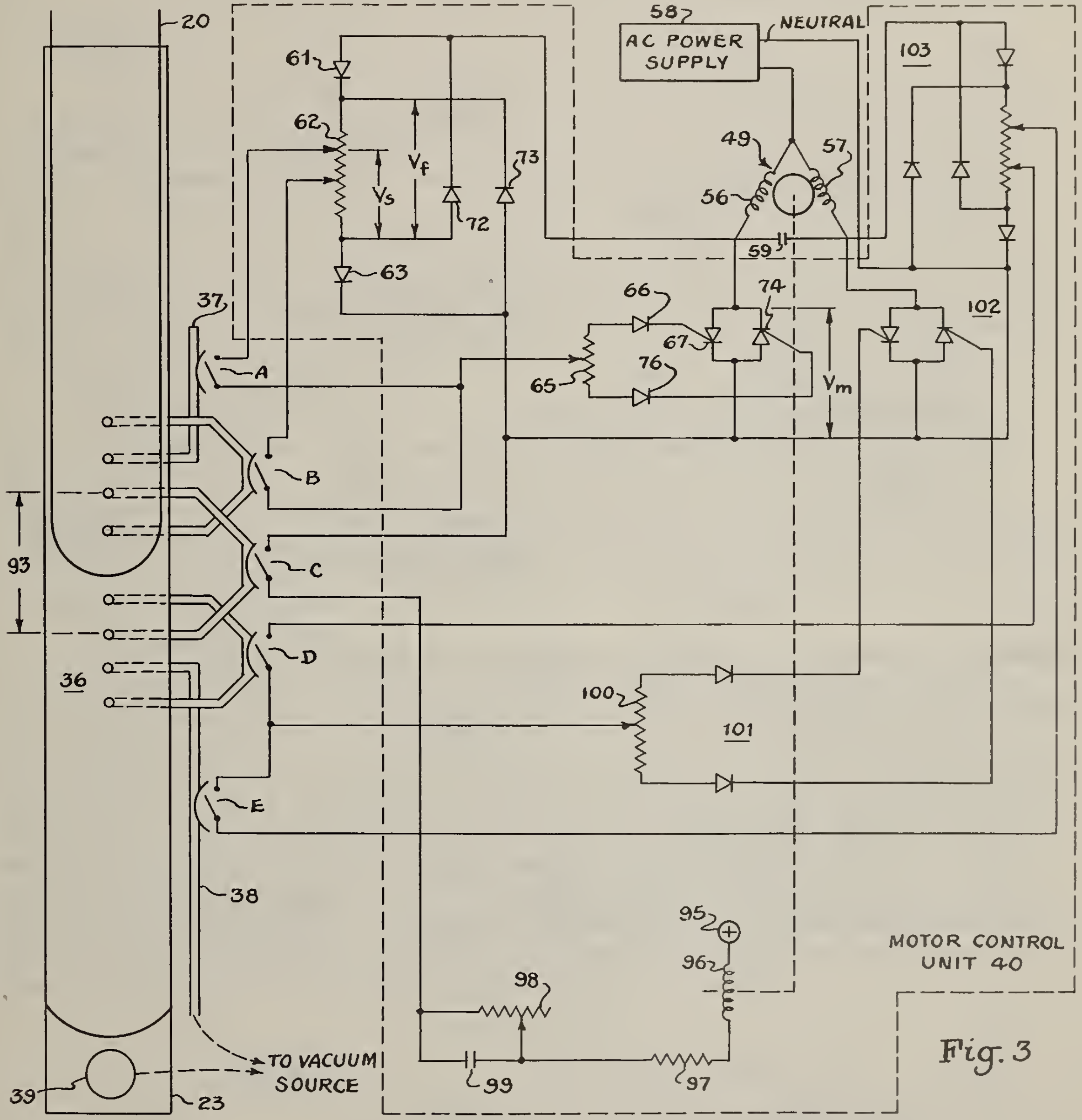


Fig. 3

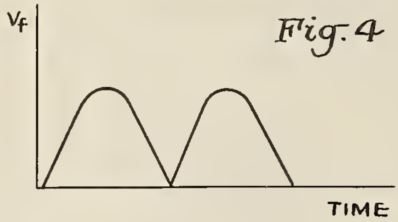


Fig. 4

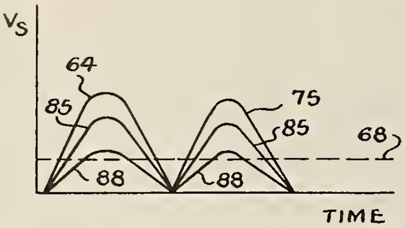


Fig. 5

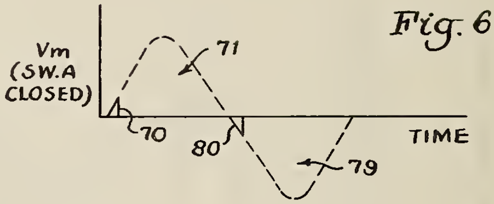


Fig. 6

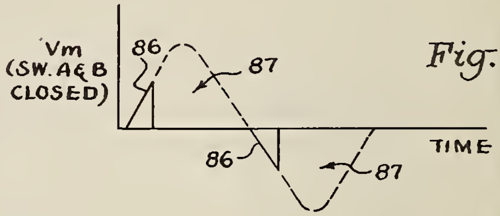


Fig. 7

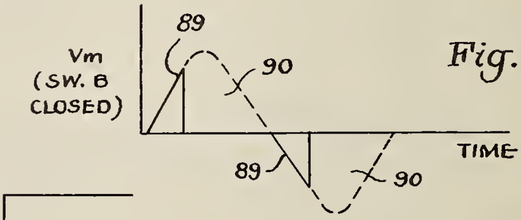


Fig. 8

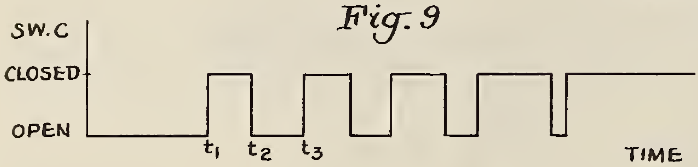


Fig. 9

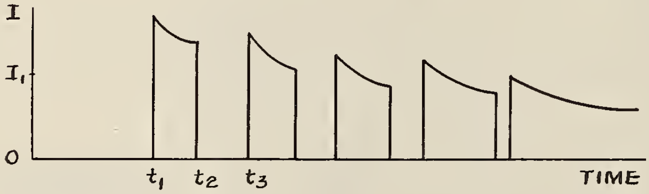


Fig. 10

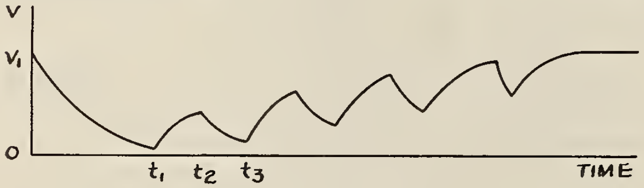


Fig. 11

A HIGH SPEED MAGNETIC TAPE HANDLER

McRae Anderson

This tape handler may be used to drive magnetic tape at high speeds, with precise start-stop characteristics. The handler requires a minimum number of components, has a high degree of electrical efficiency, and can be constructed as a self-contained unit.

With reference to Fig. 2, the clutch-brake control unit 10 receives command signals from the computer. When a forward command signal is received, unit 10 applies a control signal to flip-flop 11, which in turn applies signals to clutch-brake assembly 12 to engage the clutch and release the brake in the latter assembly. Motor 13 will then drive capstan 14 (Fig. 1) in a clockwise direction, and tape 20 is transported from supply reel 21 through vacuum chambers 22 and 23 to take-up reel 24. The tape is guided by idler pulleys 25 and passes in front of erase head 26 and read or record heat 27 and between the components of photocell unit 28.

When a rewind signal is received from the computer, tape 20 is transported from reel 24 to reel 21. Toward the end of the tape, photocell unit 28 senses a clear leader and transmits a signal to photocell detector 35 (Fig. 2) which then applies a stop signal to control unit 10. A series of events are then initiated to disengage the clutch in assembly 12 and thereby stop the counterclockwise rotation of capstan 14 and the movement of tape 20.

Sensing ports 36 (Figs. 1 and 3) are positioned in vacuum chamber 23 and are coupled by means of tubes to pressure-differential switches A to E as illustrated in the figures. The switches are tied to motor control unit 40 as shown in detail in Fig. 3. One end of tube 37 is open to the atmosphere, and one end of tube 38 is connected to a vacuum source, not shown. Port 39 is also connected to the vacuum source so that the pressure in the chamber below the tape is approximately 18" of water while the pressure above the tape is that of the atmosphere. Any one of the switches A to E is open when loop 20 is positioned in such a way that both sensing ports, related to the switch, are at the same pressure, and the switch is closed when the pressure on one of the ports is atmospheric while the pressure on the other is 18" of water.

Tech. Note No. 287, April 8, 1966

Sensing ports 42 are positioned in vacuum chamber 22 and are coupled to pressure-differential switches A' to E' in the manner shown in Fig. 1. One end of tube 43 is open to the atmosphere, and one end of tube 44 is connected to the vacuum source. The vacuum source is also connected to port 45 to maintain the same pressure differential in this chamber as in chamber 23. Motor control unit 46 is identical to unit 40 and switches A' to E' are tied to the former control unit in the same way as A to E are tied to 40.

Perforated metal stops 47 and 48 are positioned in chambers 22 and 23, respectively, to prevent the loops in tape 20 from entering either vacuum port 39 or 45.

When the loop in tape 20 is moved from the center of chamber 22, motor control unit 46 applies power to motor 50 to drive reel 21 and return the loop to the center of the chamber, where under ideal operating conditions the loop should be. The power is applied to the motor in three stages, and the magnitude of power in each successive stage is increased as the distance between the loop and the center of the chamber is increased. Likewise, when the loop is moved from the center of chamber 23, motor control unit 40 applies power to motor 49 which in turn drives reel 24 so that the loop is returned to the center of the chamber.

Motor 50 is identical to motor 49, which is shown schematically in Fig. 3 and is an AC torque motor with balanced windings 56 and 57 having a common point connected to AC power supply 58. Control of the direction of the motor is obtained by phase-shift capacitor 59, coupled across the windings.

As an example of operation, assume that tape 20 is being driven by capstan 14 from supply reel 21 to take-up reel 24 and that one loop is in the center of vacuum chamber 22 while the other is in the center of chamber 23. Assume further that clutch-brake control unit 10 (Fig. 2) receives a command signal from the computer to move the tape backward, i. e., to reverse the direction of tape movement. Clutch-brake assembly 12 will then cause capstan 14 to reverse the direction of movement of tape 20. However, due to inertia, reels 21 and 24 will continue to rotate clockwise for a short period of time and the loop in chamber 22 will move toward the bottom of chamber 22 while the one in chamber 23 will move toward the top of the chamber.

Now assume that a loop is located above the first sensing port 36 from the top of chamber 23. Differential-pressure switch A (Fig. 3) is then closed and during the positive half-cycle of the AC voltage applied to motor 49, diode 61 conducts through tapped resistor 62 and diode 63 to the AC neutral. The first positive pulse of voltage V_f (Fig. 4) then appears across the tapped resistor, and since switch A is closed voltage V_s, represented by curve 64 (Fig. 5), is applied through potentiometer 65 and diode 66 to the gate of silicon-controlled rectifier 67. The firing potential of this rectifier is indicated by dotted line 68. When the magnitude of curve 64 exceeds the magnitude of line 68, the rectifier conducts and continues to conduct as long as positive potential is fed through winding 56 to the rectifier's anode. When the rectifier conducts, a circuit is completed through winding 56 and rectifier 67 to AC neutral so that pulse 70 represents the voltage V_m appearing across rectifier 67 (Fig. 6) and region 71 represents an area in which power is applied to motor 49.

On the negative half-cycle of the AC voltage applied to motor 49, a negative potential is transmitted through diode 72, tapped resistor 62 and diode 73 to neutral. Referenced to the cathode of silicon-controlled rectifier 74, a positive potential appears at the top end of resistor 62 as drawn in Fig. 3 and is applied through diode 73 to the anode of rectifier 74. The voltage appearing across the resistor is represented by the second positive pulse of voltage V_f in Fig. 4. Voltage V_s, illustrated by curve 75 (Fig. 5), is positive relative to the cathode of rectifier 74 and is applied through switch A, potentiometer 65 and diode 76 to the gate of this rectifier. When the magnitude of curve 75 reaches the firing potential indicated by line 68, the rectifier conducts and continues to conduct as long as the anode of the rectifier is positive relative to the cathode. As the rectifier conducts current flows through winding 56, and region 79 represents another area in which power is applied to motor 49. Pulse 80 represents the voltage V_m developed across reactifier 67.

When power is applied to motor 49, as described above, reel 24 is rotated counterclockwise, moving the loop in tape 20 toward the center of chamber 23. As the loop enters the area between the first and second sensing port from the top of the chamber, switch B closes. Since switch A remains closed, a portion of tapped resistor 62 is short circuited and curves 85 (Fig. 5) illustrate voltage V_s, pulses 86 (Fig. 7) the voltage V_m and regions 87 the power applied to motor 49.

As the loop enters the area between the second and third ports from the top of chamber 23, switch A opens and B remains closed. Curves 88 then represent voltage V_s, pulses 89 (Fig. 8) the voltage V_m and regions 90 the power fed to motor 49. Thus it is seen that as the loop moves closer to the center of the chamber, the power transmitted to the motor decreases.

When the loop in tape 20 is in damping zone 93, switch C is closed and a circuit is completed from positive potential source 95 through brake coil 96, current limiting resistor 97 and resistor 98 or capacitor 99 to neutral. If the loop remains in zone 93 for a comparatively long period of time, the current flow through this circuit will have a value I_1 that is dependent upon the resistance values of coil 96 and resistors 97 and 98. The voltage V_1, developed across capacitor 99, will then be the same as that appearing across resistor 98. In the discussion that follows the inductance of coil 96 is considered to be negligible.

When the loop leaves the damping zone 93, as in the example above, switch C is opened (Fig. 9) and the voltage V_1 (Fig. 10) across capacitor 99 is discharged. Since in this example, the loop is out of the zone for a comparatively long period of time, the voltage on the capacitor approaches zero. When at time t_1 the loop is returned to the damping zone 93, switch C is closed, connecting one side of capacitor 99 to neutral so that current flows from positive potential source 95 through the braking coil 96 in the manner illustrated in Fig. 10. This applies a braking force to motor 49 of such a magnitude that the loop will normally come to rest in the damping zone. Meanwhile the voltage across the capacitor increases in magnitude, and if the loop remains in the damping zone for a comparatively long period of time, the voltage across the capacitor will equal V_1 and the current through braking coil 96 will equal I_1. Thus, a "soft" braking force will be applied to motor 49.

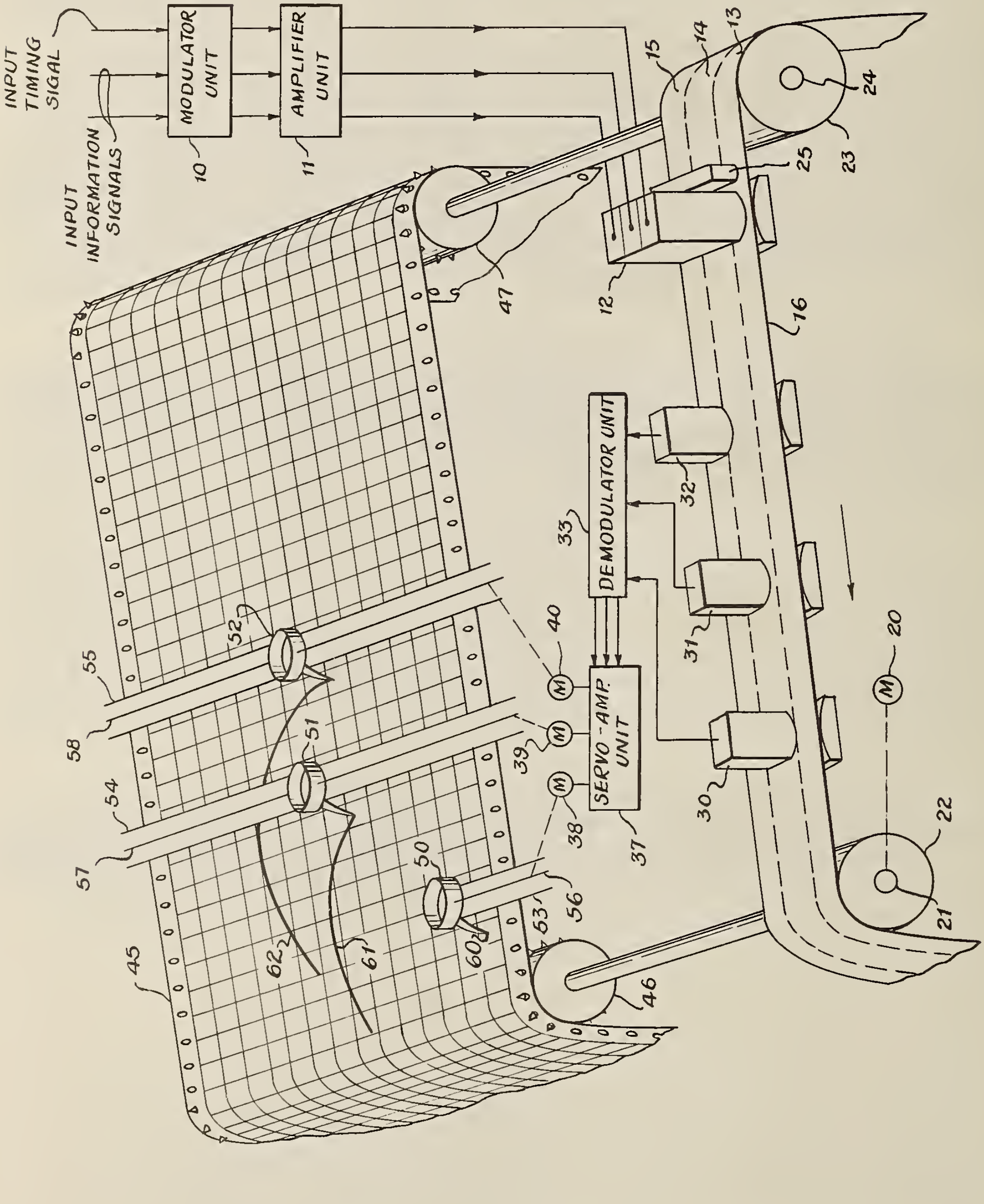
If the loop in tape 20 overshoots the damping zone 93 and approaches the bottom of chamber 23, switches D and E, potentiometer 100, diodes 101, silicon-controlled rectifiers 102 and bridge circuit 103 cooperate with motor 49 to return the loop to the center of the chamber.

Assume in the present example that the loop overshoots damping zone 93. As the loop leaves the zone at time t_2, switch C opens and capacitor 99 starts to discharge through resistor 98. During the overshoot the loop is out of the zone for a shorter period of time than when it first left the zone. As the loop re-enters the zone at time t_3, switch C closes and capacitor 99 starts to charge as shown in Fig. 10. Because a greater potential was stored on the capacitor at time t_3 than at time t_1, the value of current flow into the capacitor is smaller at t_3 than at t_1. If the loop overshoots several times, switch C will open and close as shown in Fig. 9, and the current and voltage waveforms in Figs. 10 and 11, respectively, will be generated until the loop comes to rest in the damping zone. It is noted that after each successive overshoot it takes longer for the loop to pass through the damping zone 93 and each successive overshoot occurs in a shorter period of time. It is also noted that the longer the loop is out of the damping zone, the greater the current flow through coil 96 on the loop's return to the zone and the greater the braking force applied to motor 49.

As indicated in the first example of operation presented above, when the direction of tape movement is toward reel 24 and this direction is reversed, the loop in tape 20 moves toward the bottom of chamber 22. Motor control unit 46 (Fig. 1) will then operate motor 50 to return to the loop to the center of the chamber.

A MULTI-PEN RECORDER HAVING A TIME DELAY ARRANGEMENT

Noboru Wakai



Tech. Note 287, April 8, 1966

A MULTI-PEN RECORDER HAVING A TIME DELAY ARRANGEMENT

Noboru Wakai

This device employs several pens to record a plurality of varying information signals on a suitable medium with the same time ordinate. The signals may be recorded either simultaneously or with a desired time delay between two or more of the signals.

The two input information signals and a reference timing signal are applied to modulator unit 10 where each signal is modulated with an appropriate modulation frequency. The signals are then transmitted to amplifier unit 11 where they are amplified and are then applied to recording heads 12. One of the information signals is recorded in track 14 and the other is recorded in track 15, while the timing signal is recorded in track 13. The tracks are located in magnetic tape 16, which is driven by motor 20 through shaft 21 and drum 22 and is guided by drum 23 and shaft 24. The track is driven in the direction indicated by the arrow in the figure, and consequently eraser 25 will erase previous recordings on the tape before the tape reaches the recording heads.

Reading heads 30, 31, and 32 sense tracks 13, 14, and 15, respectively, and the output of the heads are applied to demodulator unit 33. The latter unit provides three control signals, and each signal is fed to a related servo system in servo-amplifier unit 37 where the signals are amplified and are then used to drive motors 38, 39, and 40. Thus a servo signal, that is dependent upon the timing signal, drives motor 38 while a pair of servo signals, each dependent upon one of the information signals, drives motors 39 and 40, respectively.

A roll of recording paper 45 is driven in the same direction as magnetic tape 16 by motor 20 through shaft 21 and drum 46. The paper is guided by drum 47 which is positioned on shaft 24.

Each of the ink pots 50, 51, and 52 is located on one of the rails 53, 54, or 55 and supplies ink to a pen that is positioned to record data on paper 45. The pots are controlled by strings 56, 57, and 58 which, in turn, are operated by motors 38, 39, and 40, respectively, in a conventional arrangement that is not shown in detail in the figure.

Tech. Note No. 287, April 8, 1966

In a typical operation, assume that the input information signals are sinusoidal and that the input timing signal is a pulse. Assume further that the distance between ink pots 50 and 51 is equal to the distance between reading heads 30 and 31 and that the distance between pots 51 and 52 is equal to that between heads 31 and 32.

Under these conditions, the pen attached to ink pot 52 will, at a predetermined time, start to record sinusoidal curve 62, and after a certain time delay, the pen attached to pot 51 will start recording sinusoidal curve 61. After another period equal to that of the time delay, the pen on pot 50 will record timing dot 60. Due to the spacing between adjacent ink pots relative to the spacing between adjacent reading heads, the time delay in recording on paper 45 are compensated for when the data is read from magnetic tape 16, and the time relations among dot 60 and curves 61 and 62 is the same as those among the information and timing signals. It will be apparent that a desired time delay could be introduced between any two of the input signals recorded on paper 45, or among all three signals, by proper adjustment of the distances between adjacent ink pots relative to those between adjacent reading heads. With this type of staggered pen and time delay arrangement, it is possible for the resulting recorded signals to appear in their real time relationship to each other. Each pen could be allowed to traverse the full width of the recordable area on the chart, thus overlapping, without mutual mechanical interference.

ELECTRO-OPTICAL FOCUS DETECTOR FOR A POINT LIGHT IMAGE

Jurgen R. Meyer-Arendt
Ralph B. Bergman

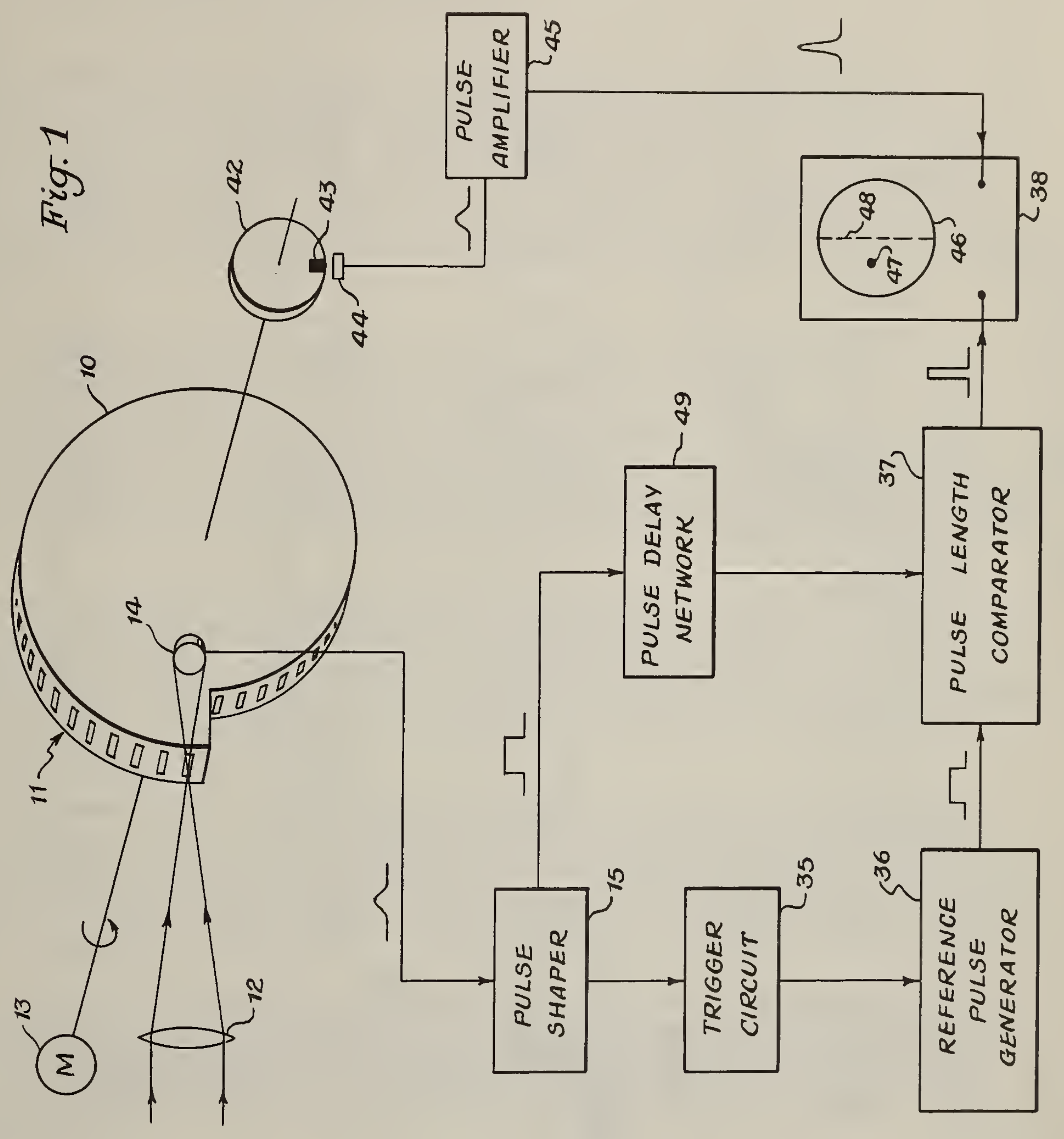


Fig. 1

Tech. Note No. 287, April 8, 1966

ELECTRO-OPTICAL FOCUS DETECTOR FOR A POINT LIGHT IMAGE

Jurgen R. Meyer-Arendt
Ralph B. Bergman

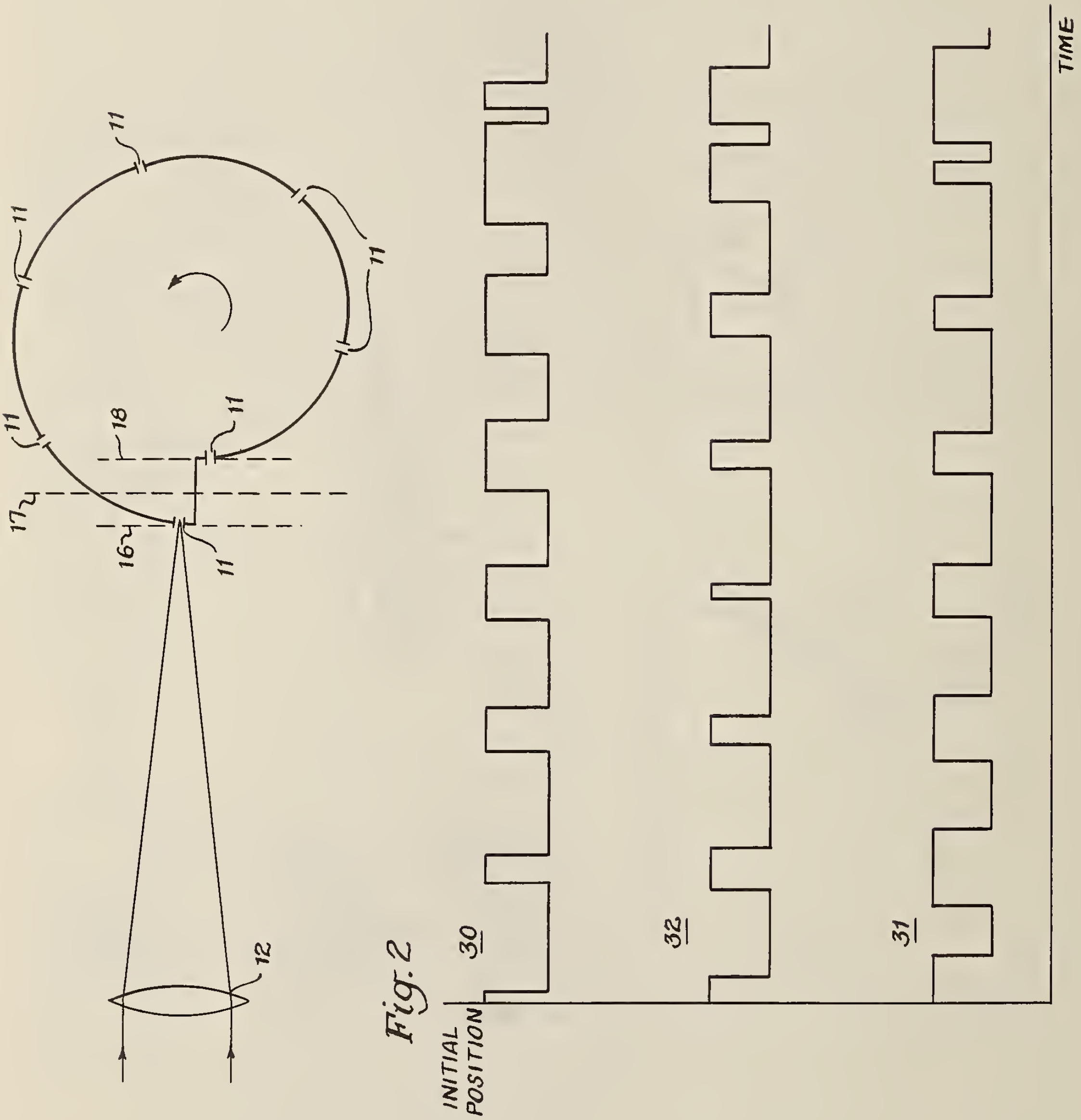


Fig. 2

ELECTRO-OPTICAL FOCUS DETECTOR FOR A POINT LIGHT IMAGE

Jurgen R. Meyer-Arendt
Ralph B. Bergman

This detector may be used to provide information as to when a stationary or moving object is in correct focus.

Its essential equipment is a scanning drum 10 whose outer surface is shaped in the form of a spiral and may be in the form of another suitable curve, e. g. , of a helix. The drum contains several equally spaced, narrow, rectangular slots 11 of equal width. The light is received from the object through lens 12, which may be part of a telescope. As the drum is driven by motor 13, the light passes through the slots and falls on photocell 14 to develop a series of pulses, which are applied to pulse shaper 15.

The pulse shaper generates a waveform that will be described with the assistance of Fig. 2 where, for convenience of explanation, only seven slots are shown. The ideal plane of focus, which is the theoretical focal plane for the optics concerned, is determined by the design of lens 12. Variations in the refractive index of the atmosphere between the lens and the object will change the image distance so that the object may be in focus either in front or behind the theoretical image plane.

When the object comes to focus in plane 16, which is the plane containing the shortest detectable image distance, the slot 11, located at the largest radius of the drum, will intersect the beam of light and produce the narrowest pulse. Thus, if the drum is in its initial position in Fig. 2, the series of pulses generated, as the drum is rotated, is represented by waveform 30.

When the drum is positioned initially so that the light comes to focus in plane 18, or the plane of the longest image distance that can be detected, as the drum is rotated from this initial position, the longest pulse will appear first and the narrowest pulse will appear last in the sequence of generated pulses. This sequence is shown in waveform 31.

Finally, when drum 10 is positioned initially so that the light comes to focus in ideal plane 17, the sequence of generated pulses will start with a longer pulse and the narrowest pulse will occur when the drum is midway through its revolution. This sequence is represented by waveform 32.

Tech. Note No. 287, April 8, 1966

Disk 42 is positioned on the same shaft as drum 10 and is driven by motor 13. The disk contains a small magnetized area 43 which is sensed by reading head 44 whose output is amplified in pulse amplifier 45 and is then used to trigger the horizontal sweep of oscilloscope 38. The horizontal sweep of the oscilloscope is set to cover screen 46 during one revolution of disk 42. Thus, one revolution of drum 10 coincides in time with one horizontal sweep of the screen. The scanning speed of the drum controls the frequency at which focus detection is accomplished.

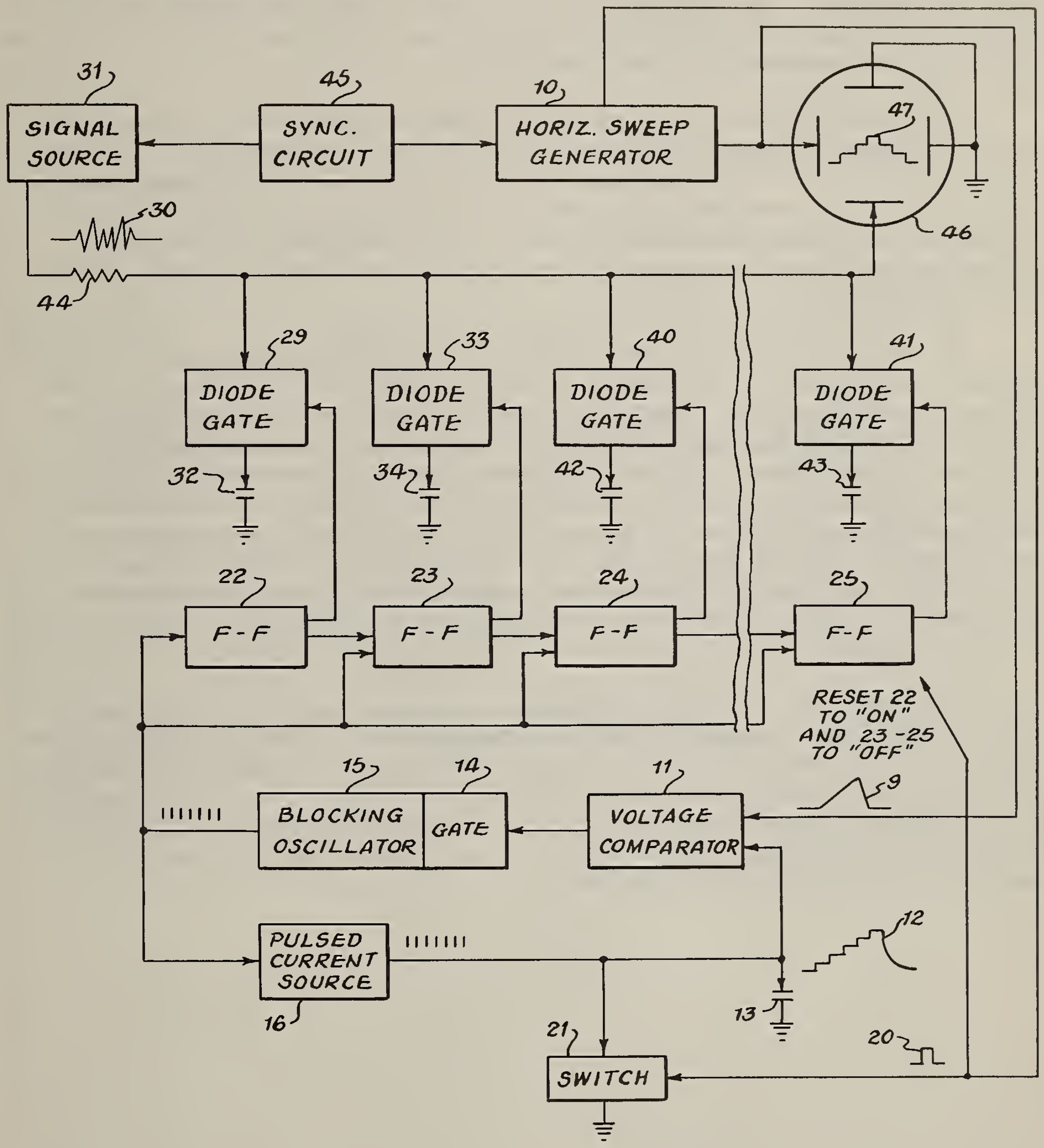
The output of pulse shaper 15 is fed to trigger circuit 35 where the leading edge of each pulse generates a signal that triggers reference pulse generator 36. The output of generator 36 is transmitted to pulse length comparator 37 where each pulse developed by the generator is compared with a respective pulse provided by shaper 15 through pulse delay network 49. The delay network is provided to equalize delays caused in circuits 35 and 36. When the length of the pulse developed by the shaper is equal to or less than the one developed by the reference generator, comparator 37 applies a pulse signal to the intensity control circuit of the horizontal sweep of oscilloscope 38 thereby producing a dot 47 on the screen.

In operation, reading head 44 develops a reference pulse which is amplified and then triggers the horizontal sweep of oscilloscope 38. At the same time, photocell 14 senses slots 11 to provide a series of pulses that are shaped in pulse shaper 15 and applied to comparator 37. When the shaper provides a pulse that is equal to or smaller than the reference pulse developed by generator 36, comparator 37 puts out a pulse signal that controls the beam intensity circuit of oscilloscope 38 to produce a dot 47 on screen 46. When the shaper provides a pulse that is larger than the reference pulse developed by generator 36, comparator 37 does not produce an output pulse. This system insures that only pulses shorter or equal to pulses developed by generator 36 are used to produce an "in focus sensing" by comparator 37 and to produce a dot on the oscilloscope 46 screen. If the dot appears to the left of reference line 48, the image lies in front of the ideal image plane 17. If the dot appears to the right of line 48, the image is behind the ideal image plane; and if the dot appears on the line, the image is correctly in the theoretical image plane and in sharpest focus.

It will be apparent that a continuous recording film camera could be placed in front of screen 46 to record the continuous change in the detected image location, or that an arrangement could be provided, responsive to the output of amplifier 45 and comparator 37, to trigger the shutter of a camera, positioned to photograph the object when in the plane of best focus.

A MULTI-SEGMENT SIGNAL AVERAGING FILTER

Robert J. Carpenter



Tech. Note No. 287, April 8, 1966

A MULTI-SEGMENT SIGNAL AVERAGING FILTER

Robert J. Carpenter

This filter may be used in analyzing a desired signal that is extremely weak in the presence of a strong, unrelated one, such as thermal noise and hum pick-up. The desired signal is repetitively generated and is applied to a filter which by averaging techniques accentuates the desired signal and suppresses the unrelated one.

With reference to the figure, voltage 9 is obtained from horizontal sweep generator 10 and is transmitted to voltage comparator 11. When the magnitude of 9 is greater than that of voltage 12, appearing across capacitor 13, the comparator sends a signal through gate 14 to blocking oscillator 15, triggering the oscillator. The output of 15 is a short voltage pulse that is converted to a current pulse in the pulsed constant current source 16.

Since the duration of each pulse generated by oscillator 15 and the output of source 16 are constant, there is a fixed charge in each pulse applied to capacitor 13. Since a constant relationship exists between the instantaneous amplitude of voltage 9 and the horizontal deflection position on the face of cathode ray tube 46, a predetermined number of equally spaced pulses are generated by oscillator 15 during the sweep. The sweep from generator 10 generally is linear vs. time, consequently the pulses divide the sweep into a number of equal time intervals. Since the pulses are related to horizontal position, not time interval, this system will produce the same number of segments for a wide range of sweep speeds.

At the end of the horizontal sweep a gating pulse 20, obtained from a gate terminal on generator 10, momentarily closes normally-open switch 21, and capacitor 13 discharges through the switch. The gating pulse is also applied to flip-flops 22 to 25, resetting the first flip-flop to "on" and the remaining ones to "off." For convenience of illustration only four flip-flops are shown although as many as desired may be connected as illustrated in the figure.

Tech. Note No. 287, April 8, 1966

The flip-flop 22 is turned on by gating pulse 20 and off by the first pulse in the series generated by oscillator 15. During the time interval that the flip-flop is on, it develops a signal that opens diode gate 29 and a portion of input signal 30 is fed to capacitor 32. The input signal is developed by signal source 31 and contains the desired and unrelated signals. When flip-flop 22 is turned off, it provides a signal that activates flip-flop 23, which in turn is de-activated by the second pulse in the series generated by the oscillator. During the time interval that flip-flop 23 is on, a second portion of input signal 30 is fed through diode gate 33 to capacitor 34. In a similar manner in successive time intervals of the horizontal sweep, the remaining flip-flops 24 and 25 are turned on and off and successive portions of the input signal are applied through diode gates 40 and 41 to capacitors 42 and 43, respectively.

When each diode gate 29, 33, 40, or 41 is open, the R-C time constant, formed by resistor 44 and the related capacitor, is long compared with the duration of the portion of the input signal 30 applied to the capacitor. Thus, only a small charge can flow into or out of a capacitor when the related gate is open.

Signal source 31 develops a series of input signals 30, and synchronizing circuit 45 is used to synchronize these signals with the horizontal sweep developed by generator 10. Thus, each time one of the diode gates 29, 33, 40, or 41 is open it will sense the same portion of one of the input signals 30. When a gate is open the voltage appearing across one of the related capacitors 32, 34, 42, or 43 is applied to the vertical plates of cathode ray tube 46 in an oscilloscope. Thus, after a certain number of input signals 30 have been generated, each capacitor is charged to the average value of the applied portions, and waveform 47 appears on the screen of the cathode ray tube. Since the average of the unrelated signals, appearing in signals 30, over a sufficiently long period is substantially zero, waveform 47 represents the desired signal.

ELECTROSTATIC RMS VOLTMETER

Ephraim W. Hogue

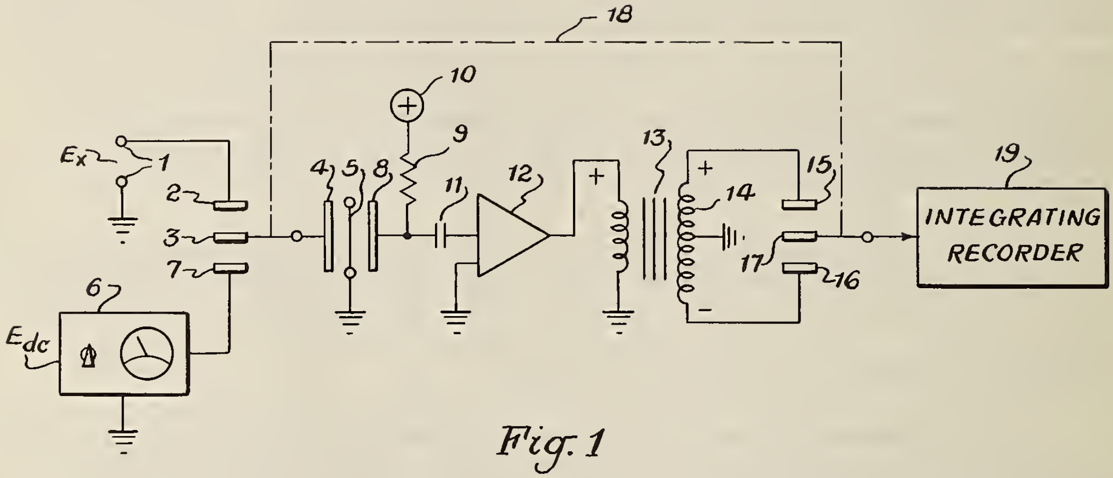


Fig. 1

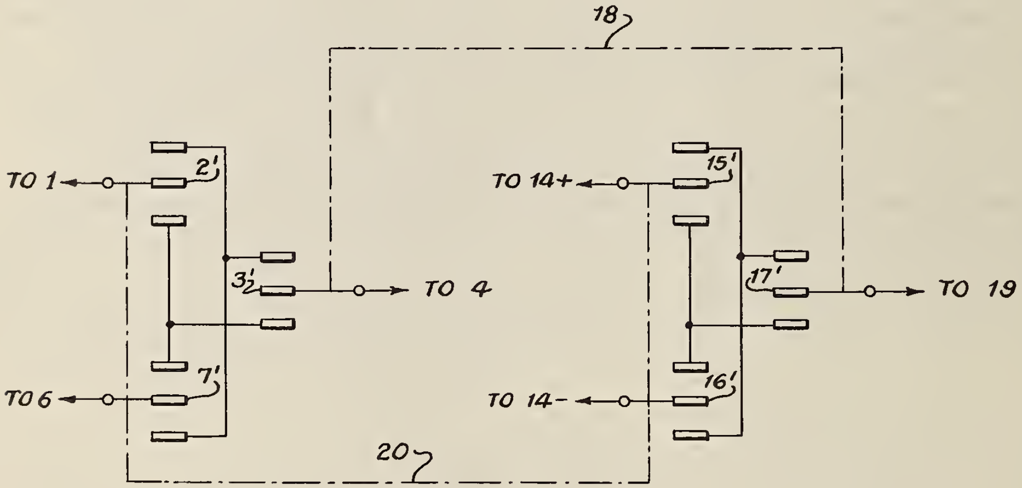


Fig. 2

Tech. Note No. 287, April 8, 1966

ELECTROSTATIC RMS VOLTMETER

Ephraim W. Hogue

This voltmeter provides precise measurements of the root-mean-square (rms) values of random or repetitive voltages.

As shown in Fig. 1, the voltmeter input terminals 1 are connected in series with switch contacts 2, 3, a fixed plate 4, and a flexible metallic diaphragm 5. The closure of contacts 2, 3 connects the input voltage E_x across plate 4 and diaphragm 5, causing the diaphragm 5 to deflect from its rest position towards the plate 4. As can readily be shown, the average deflection of diaphragm 5 is proportional to the mean-squared value of E_x.

This average deflection produced by E_x is periodically compared with an adjustable constant deflection produced by a known dc voltage from a variable, accurately calibrated dc voltage source 6. Source 6 is connected in series with contacts 7 and 3, plate 4, and diaphragm 5. When the average deflection of diaphragm 5 produced by E_x equals the constant deflection produced by E_{dc}, the mean-square of E_x equals the mean-square of E_{dc}, whereby the value of E_{dc} read from the source 6 equals the root-mean-square (rms) of the unknown voltage E_x.

The deflections of diaphragm 5 produced by E_x and E_{dc} are measured in any convenient manner, as by sensing the changes in the capacitance between diaphragm 5 and a fixed electrode 8. For this purpose, the capacitor 5-8 is connected in series with a large resistance 9 and a dc voltage source 10, whereby the capacitance changes produce corresponding voltage changes at the junction between the capacitor and resistor. These voltage signals are coupled by a capacitor 11 to a high gain amplifier 12 whose output is fed to a transformer 13 having a center-tapped secondary winding 14. The positive and negative ends of this winding 14 are connected to switch contacts 15 and 16 which are alternately engaged by a moving contact 17. Contact 17 is vibrated in synchronism with the previously-described moving contact 3, preferably by a common driving means 18. Advantageously, the amplifier 12 is tuned to the frequency of the driving means 18.

Tech. Note No. 287, April 8, 1966

From the foregoing, it will be seen that as contact 3 is alternated between E_x and E_{dc}, contact 17 is simultaneously vibrated between positive and negative voltages having magnitudes proportional to the deflections of diaphragm 5 produced by E_x and E_{dc}. Consequently, when the net voltage on contact 17 is zero, as may be determined from an integrating recorder 19 connected thereto, the deflections produced by E_x and E_{dc} are equal, and hence E_{dc} equals the rms of E_x.

The operation of the voltmeter is thus readily apparent. The voltage E_{dc} of source 6 is varied until the recorder 19 reads zero. The value of E_{dc} is then read and taken as the rms of E_x.

It is possible that the vibration of driving means 18 will be mechanically coupled to the diaphragm 5, causing a spurious deflection thereof unrelated to the voltages E_x and E_{dc}. It is also possible that an asymmetrical dwell-cycle in the operation of the vibrating switch contacts 3, 17 may give rise to a spurious deflection of the diaphragm 5, even when E_x^2 and E_{dc}^2 are equal. To circumvent these problems, the polarities of the signals applied to the fixed contacts (2, 7 and 15, 16) should periodically be reversed, whereby the signal due to mechanical vibrations will be averaged to zero in the integrating recorder 19. A suitable switch arrangement for performing the polarity reversals is illustrated in Fig. 2. The frequency of the vibrating means 20 for the polarity-reversing switches may be fairly low (e. g., 1 cps), in which case the time constant of the integrator in the integrating-recorder 19 should be a minute or so, to provide a good averaging of the reversals, particularly over an even number of equal reversal intervals.

It will be obvious that, if desired, the output of the recorder 19 may be used as an error signal to control a servo that automatically sets E_{dc} of source 6 equal to the rms of the unknown voltage E_x.

The instrument can also be used to measure the rms value of a complex repetitive waveform if none of the components of the wave is harmonically related to the switching frequency or to the reversing frequency.

SILICON RADIATION DETECTOR MEASURES LOW TEMPERATURES

William R. Dodge
Steve R. Domen
Dale R. Hoppes
Alan T. Hirshfeld

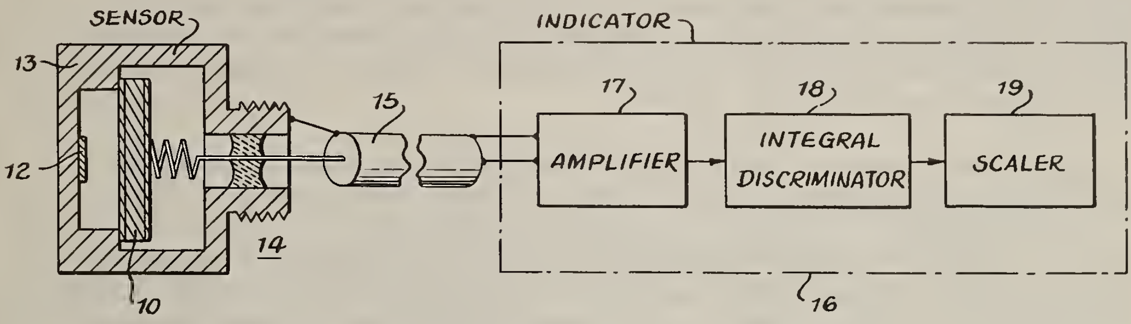


Fig. 1

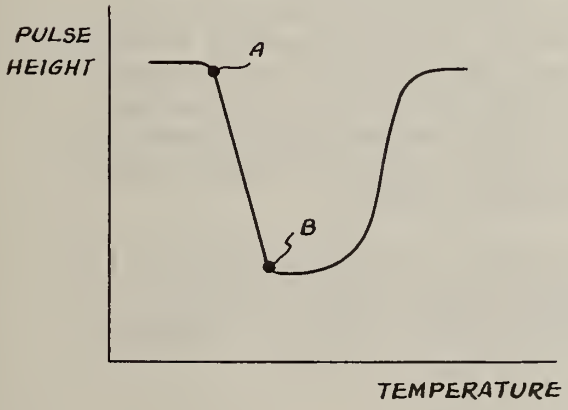


Fig. 2

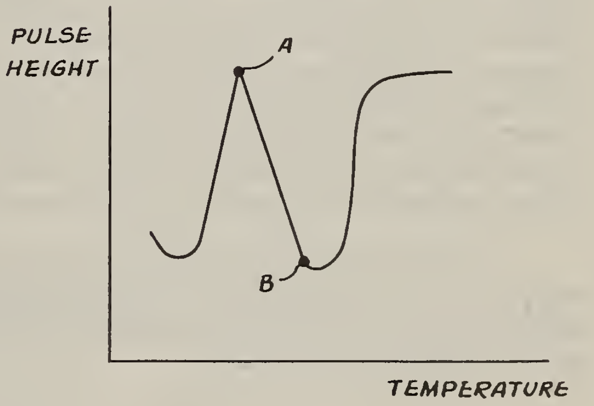


Fig. 3

Tech. Note No. 287, April 8, 1966

SILICON RADIATION DETECTOR MEASURES LOW TEMPERATURES

William R. Dodge
Steve R. Domen
Dale D. Hoppes
Alan T. Hirshfeld

This adaptation of a conventional silicon radiation detector to low temperature thermometry is based on the discovery that the normal, radiation-produced electrical pulses from such a detector essentially shrink by factors of 2-10 when the detector is cooled to temperatures in the range of about 5°-30° Kelvin.

This discovery is utilized in the apparatus of Fig. 1, wherein a silicon radiation detector 10, of known design, and a small mass 12 of Bi^{207}, Po^{210}, or other suitable radioactive material, are mounted in a casing 13 of copper or the like so as to provide a compact low temperature sensor 14. The sensor output pulses, produced by the detector 10 in response to the particles emitted by the radioactive mass 12, are transmitted over a coaxial cable 15 to a remote temperature indicating circuit 16. There, the pulses are amplified in a suitable pulse amplifier 17; discriminated as to pulse height by a conventional integral discriminator 18; and, if passed by the discriminator 18, counted by a scaler 19 of known design.

Fig. 2 illustrates the manner in which the height of the pulses produced by the detector 10, in response to 480 KeV K-conversion electrons emitted from a mass of Bi^{207}, vary with temperature. The portion of the curve between points A and B, which represents a large change in pulse height for a small change (about 3°) in temperature, has been found to be independent of the parameters of the indicating circuit 16, and stable with time. Hence the integral discriminator 18 conveniently is set to pass only those pulses having a height approximately midway between the heights of points A and B.

Fig. 3 is a curve similar to that of Fig. 2, except that the pulse heights are produced by the alpha particles from a mass of Po^{210}. Again, the curve between points A and B is stable, and can be used to set the discriminator 18.

Tech. Note No. 287, April 8, 1966

From the foregoing, it will be evident that in the operation of the apparatus of Fig. 1, the scaler 19 stops counting when the temperature of the sensor 14 goes from point A to point B, and starts when the temperature goes from B to A. Hence the apparatus is well suited for incorporation into a low-temperature-servo system.

The median temperature in the range of temperatures from points A to B, Figs. 2 and 3, can be designed to fall within a range of temperatures about 15° Kelvin, by varying the type and concentration of impurity in the silicon detector 10 of Fig. 1. Therefore, by providing a series of detectors having incrementally arranged median temperatures, a multivalued low temperature thermometer of high precision and stability may readily be obtained.

For further details on the phenomena utilized in the present apparatus, see "The Anomaly in the Response of Semiconductor Detectors" by W. R. Dodge, et al, IEEE Trans. Nuc. Sci., 11, 238 (1964); and, "Investigation of the Anomaly in the Response of Silicon Semiconductor Radiation Detectors at Low Temperatures" by W. R. Dodge et al, IEEE Trans. Nuc. Sci., 12, 295 (1965).

HIGH PRESSURE BACK-UP RING FOR O-RINGS

Hobart S. White

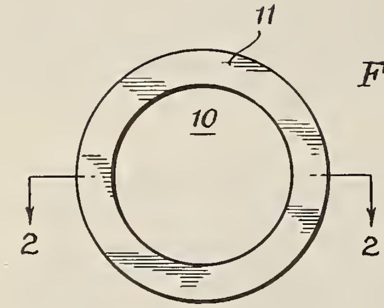


Fig. 1

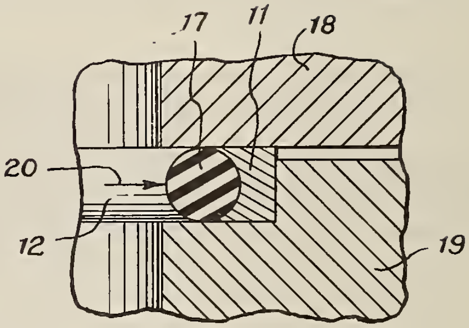


Fig. 5

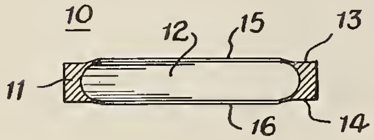


Fig. 2

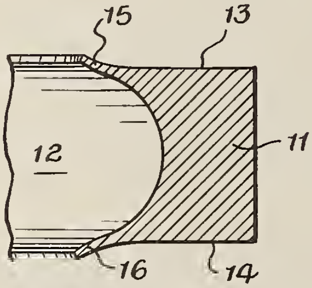


Fig. 3

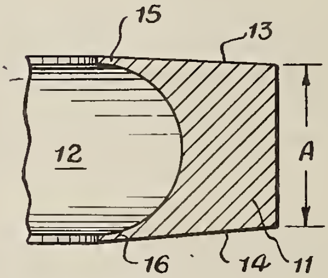


Fig. 4

HIGH PRESSURE BACK-UP RING FOR O-RINGS

Hobart S. White

Conventional elastomeric O-rings are widely used to provide fluid-tight seals. When subjected to varying pressures and temperatures, however, these rings often extrude and cause seal failure. Such extrusion may effectively be avoided by the use of the back-up ring shown in Figs. 1-5.

From Figs. 1 and 2, it will be seen that the back-up ring 10 comprises an annular band 11, which may be brass, stainless steel, or other material of suitable elasticity, strength, and thermal properties, for use at the pressures and temperatures to be encountered. The inner circumferential surface 12 of the band 11 is made approximately semicircular, to receive a conventional O-ring. The intersections of the curved surface 12 with the side walls 13, 14 of the band 11 are raised relative to the body of the band 11, to provide a pair of flexible circular sealing portions 15, 16. As shown in the enlarged detailed drawings of Figs. 3 and 4, the sealing portions 15 and 16 may be formed either by slightly flaring the semicircular surface 12, or by beveling the side walls 13, 14 so as to form a small angle A.

In operation of the back-up ring 10, the ring and its associated elastomeric O-ring 17 (Fig. 5) are disposed between two members 18, 19 forming part of an apparatus designed to contain a compressed fluid, represented by the arrow 20. In accordance with the usual practice, the members 18, 19 initially are drawn firmly together as by screws or the like. The resultant compression of the back-up ring 10 causes the sealing portions 15, 16 to deform to the contours of the adjacent surfaces of the members 18, 19, thereby closing any minute crevices through which the elastomeric O-ring 17 might extrude. The apparatus is then pressurized, which causes the O-ring 17 to press the sealing portions, 15, 16 into extremely firm engagement with the members 18, 19. Subsequently, if the members 18, 19 separate because of differential strains or thermal displacements in the clamping means, the flexible sealing portions 15, 16 will follow the separations, and prevent any extrusion of the O-ring 17. Hence the back-up ring 10 tends to seal tighter as the pressure 20 is increased.

Tech. Note No. 287, April 8, 1966

While the back-up ring 11 of Figs. 1-5 is circular in outline, it will be apparent to those skilled in the art that the ring could be made in various other shapes, such as oval, slot-like with long parallel sides and circular ends, or the like, to seal openings having such shapes.

In an exemplary embodiment of the back-up ring described above, back-up rings of brass and their associated conventional rubber O-rings were used to seal size No. 3 gage glasses (about 1 3/8" x 6 1/2" x 11/16" thick) at slotted apertures in a dilatometer housing subjected to pressures ranging from atmospheric to 30,000 psi, and temperatures ranging from -40° to +200°C. These rings have been operated successfully for over a year.

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