United States Patent

Bothne

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[54] **PNEUMATIC MULTIPLEXER METHOD AND APPARATUS**

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[73] Assignee: **Mobil Oil Corporation,**

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[52] **U.S. Cl.** **235/151.3,** 73/4, 73/388, 444/937, 137/625.41

[51] **Int. Cl.**.....**G011 27/00,** G011 9/04

[58] **Field of Search**.....235/151.1, 151, 151.3; 318/601

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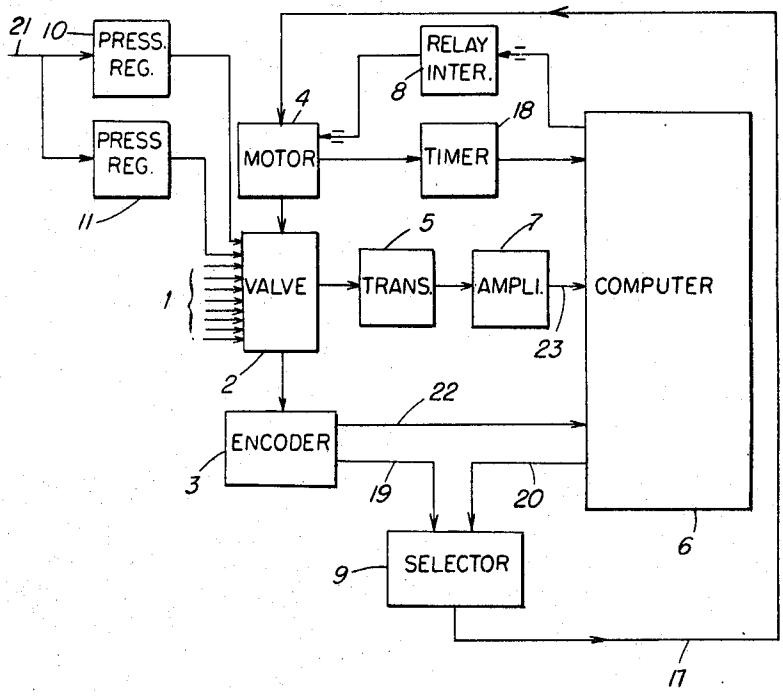
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[57] **ABSTRACT**

A computer controls a multiposition valve so that a plurality of pneumatic signals are sequentially scanned and passed through the valve to a pressure to electric transducer. The computer then stores the output from the transducer. A time delay unit is provided to prevent the computer from reading the early portion of each new transducer output. At the end of a scan of the pneumatic signals, a selector unit permits selective monitoring of one or several of the pneumatic signals. Pneumatic regulators are connected to the valve to provide calibration signals to the computer and a relay interface is provided to isolate the computer from the internal voltage of the valve circuitry.

6 Claims, 10 Drawing Figures



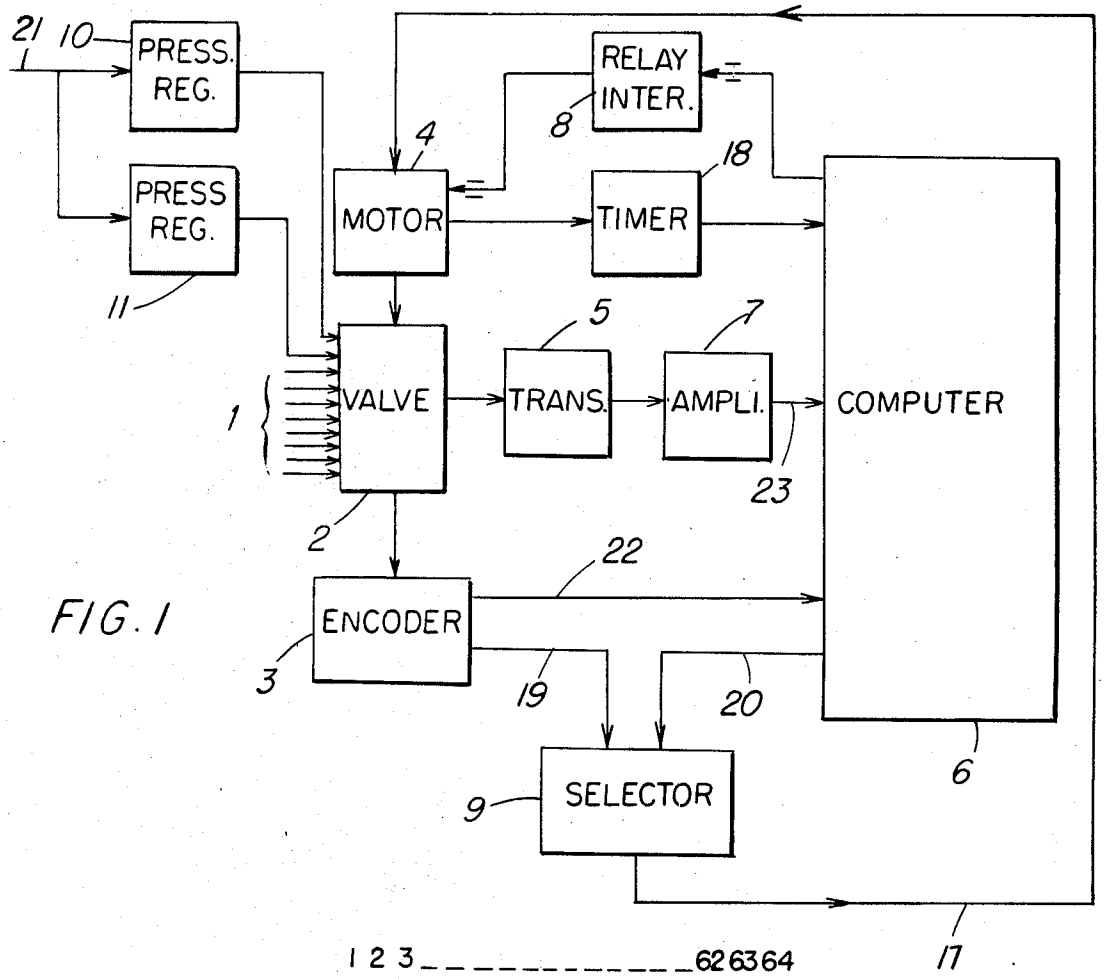


FIG. 1

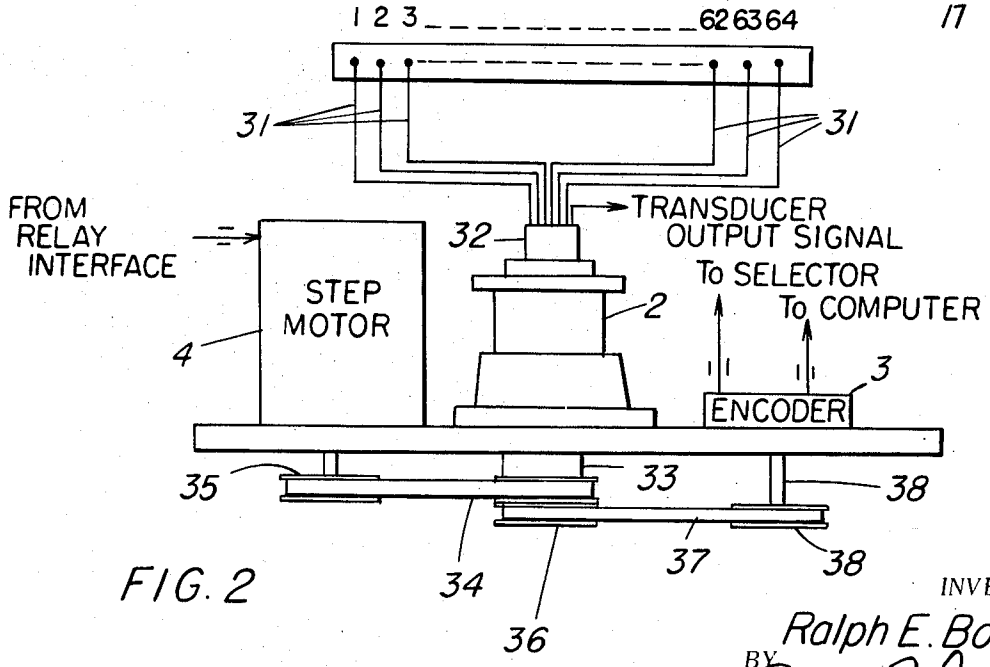


FIG. 2

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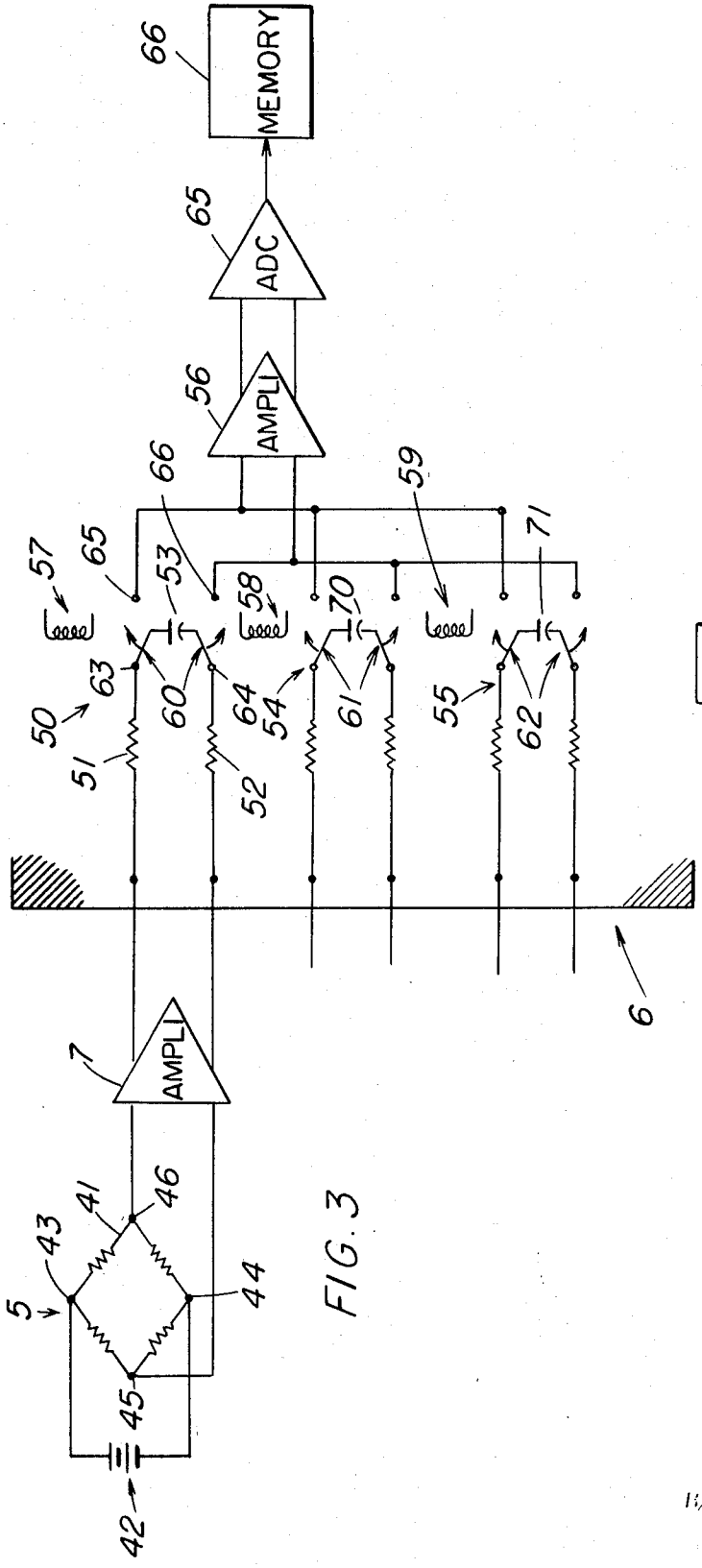


FIG. 3

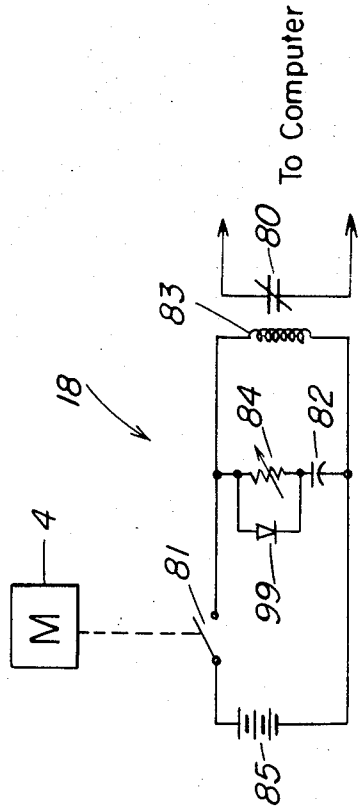


FIG. 5

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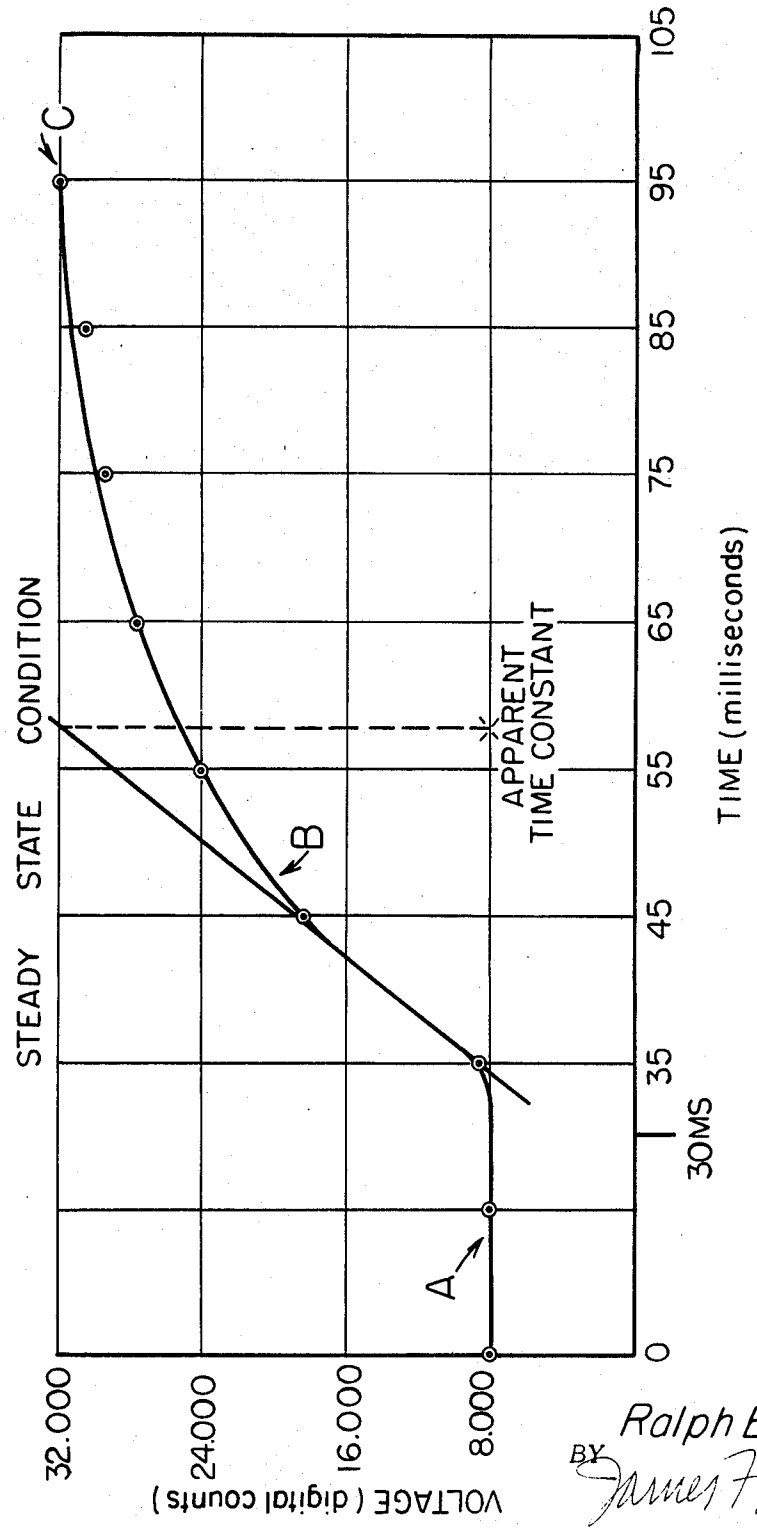


FIG. 4

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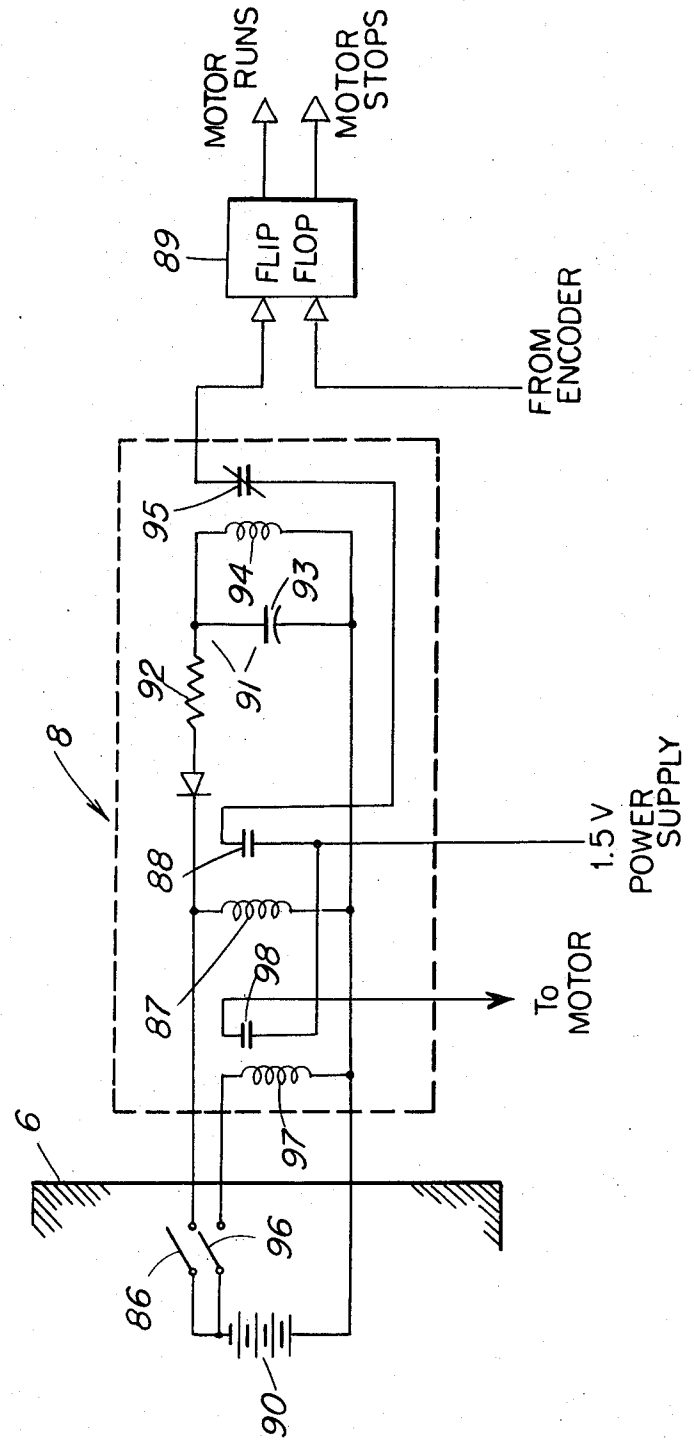


FIG. 6

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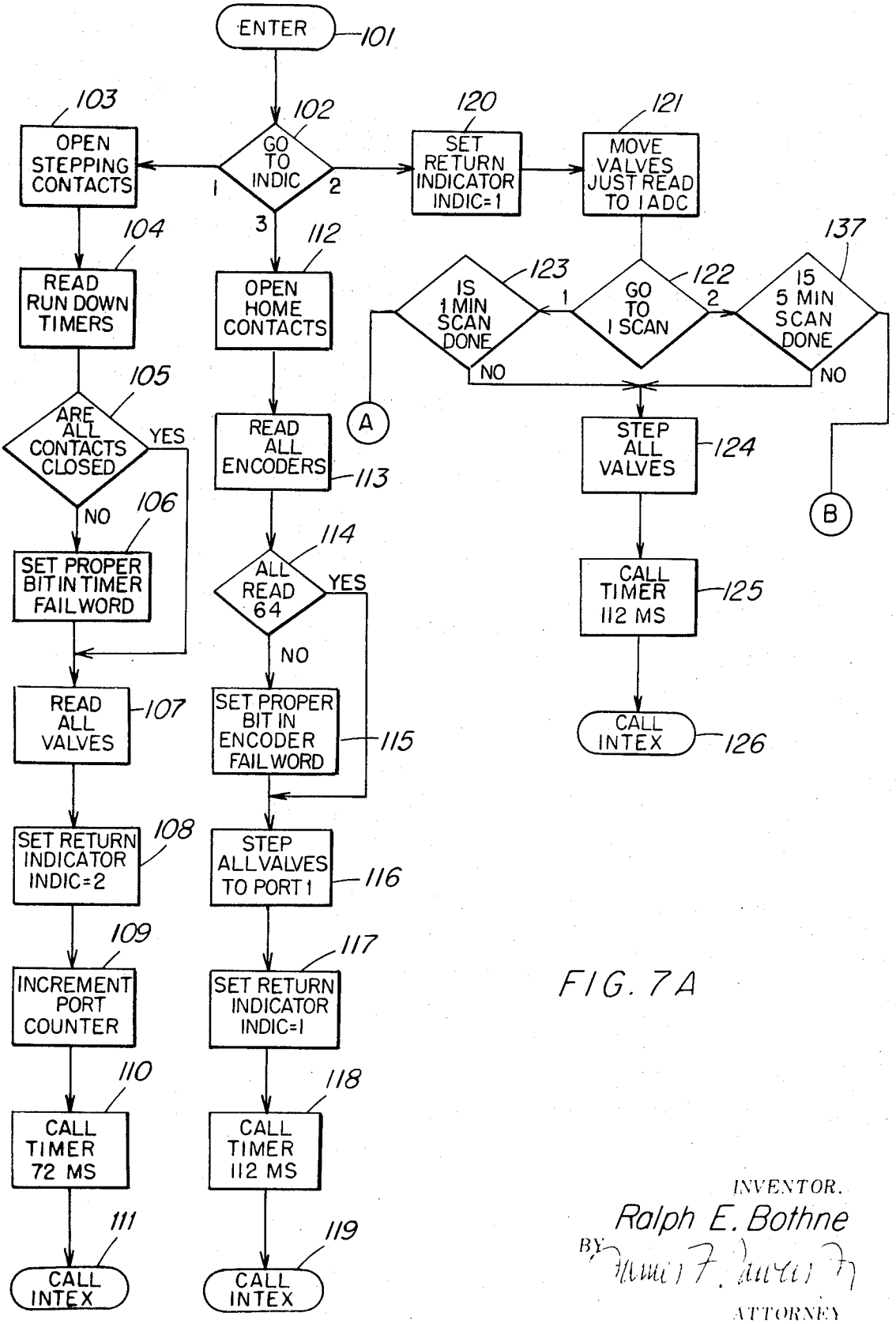
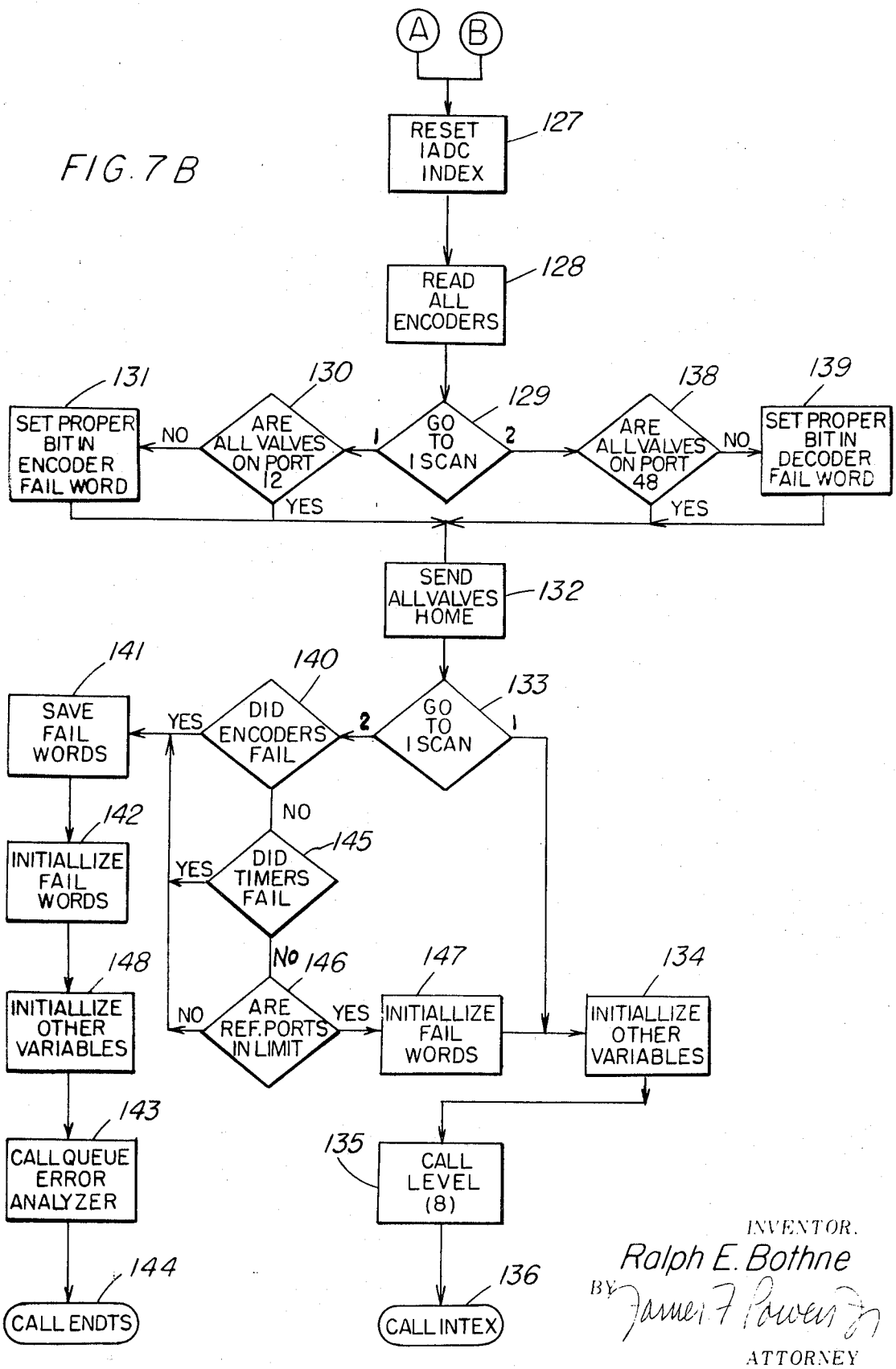


FIG. 7A

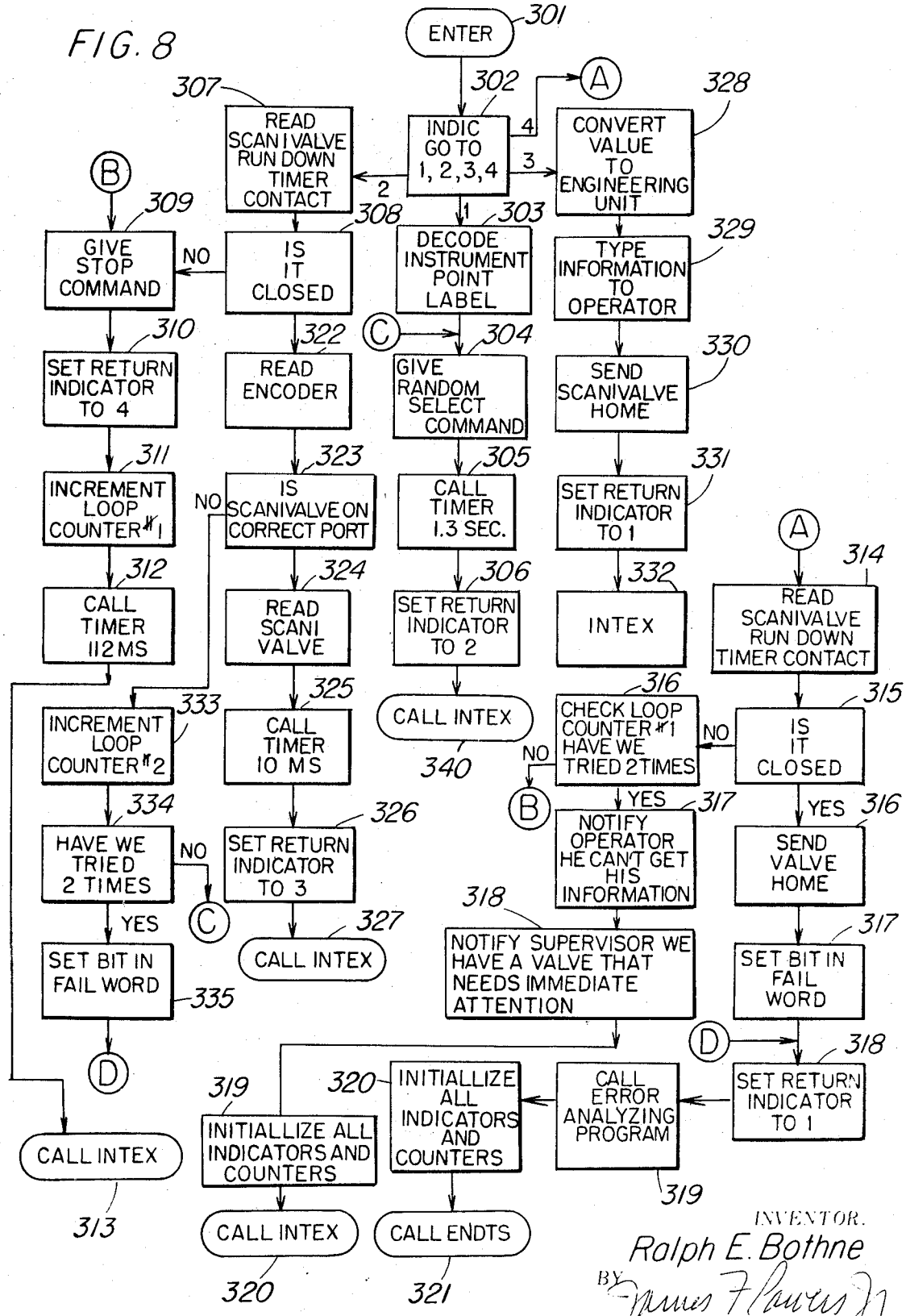
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FIG. 7B



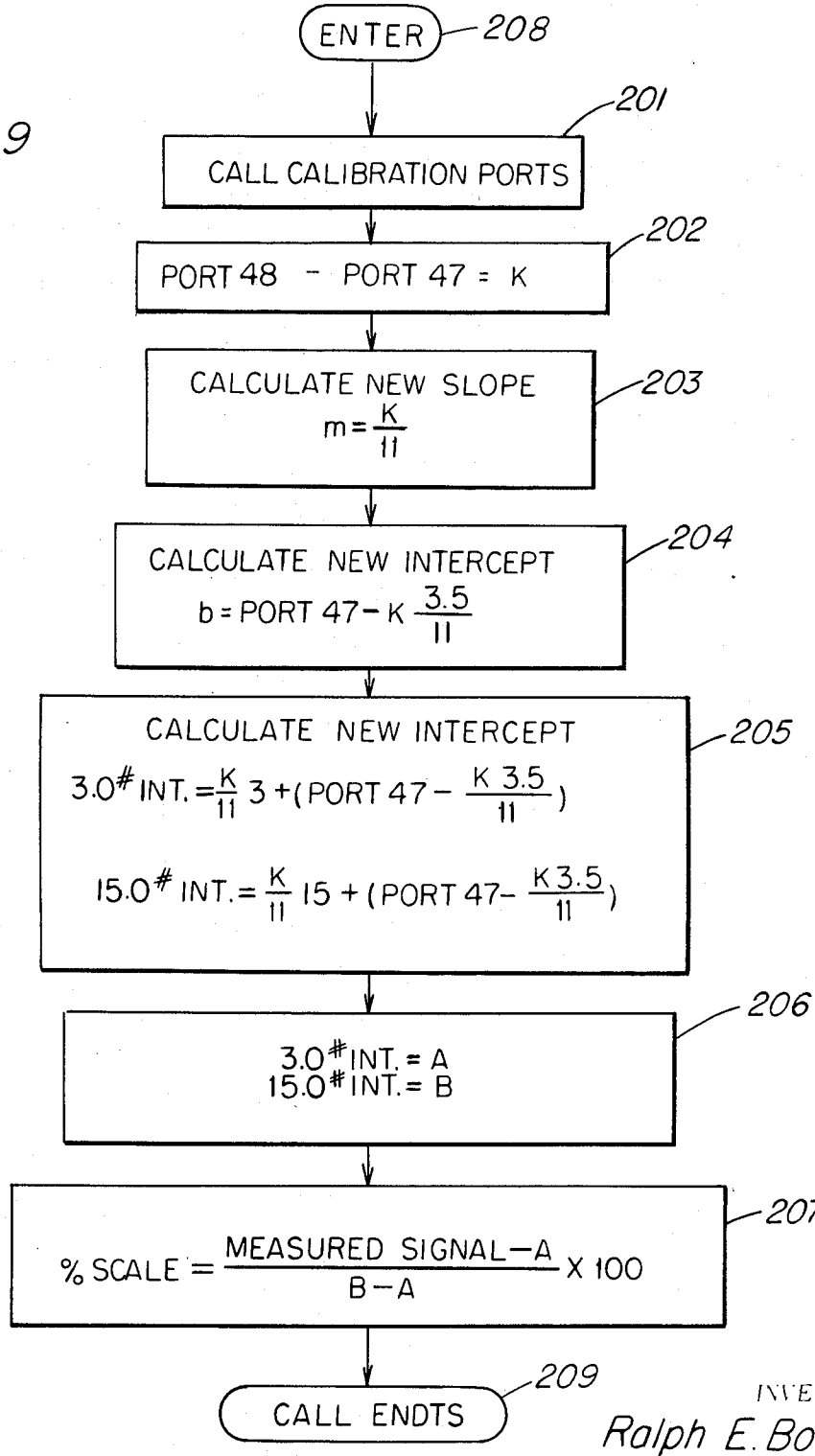
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FIG. 8



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FIG. 9



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PNEUMATIC MULTIPLEXER METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a pneumatic multiplexer system for monitoring a plurality of pneumatic signals. More particularly, the present invention relates to a method and an apparatus for selectively controlling and for calibrating pneumatic multiplexer system.

2. Description of the Prior Art

In the monitoring of a plurality of pneumatic signals, it is conventional to multiplex the signals through a multiposition valve connected to a single pressure to electric transducer. The output signals of the transducer serially represent the pneumatic signals. The transducer is operatively connected to a computer which logs the transducer output signals.

Available pneumatic multiplexing systems perform their normal scanning function very rapidly. These systems have a continuous scanning speed of six pneumatic signals per second. Therefore, a valve having 60 ports will require only ten seconds to complete its scanning mode. Where six or even 12 of these valves are coordinated in a single system to transmit signals to a computer, only 1 or 2 minutes will be required for a complete sampling of all pneumatic signals. In many systems, in view of the enormous number of sampling points, it has been found convenient to sample pneumatic signals every 5 or more minutes. For such processes the monitoring system would therefore be inactive for a relatively long period of time.

Further, the early portion of each pneumatic to electric signal is not accurate. Available systems do not contemplate this problem and permit the inaccuracy to be passed to the computer.

A still further problem in known available systems is providing means for calibrating the signals to the computer.

SUMMARY OF THE INVENTION

In accordance with an aspect of the present invention there is provided a method and a system for utilizing the system during its normally inactive period by selecting desired pneumatic signals.

The present invention provides a method of monitoring a plurality of pneumatic signals that are sequentially sensed at a plurality of ports. First and second signals are generated representative of a desired pneumatic signal and the pneumatic signal being sensed, respectively. The first and second signals are compared, and a third signal is generated to sense the desired signal when there is correspondence between the first and second signals.

Further, the present invention provides a system for monitoring a plurality of pneumatic signals comprising a pneumatic to electric transducer interconnecting a multiposition pneumatic valve means and computer means. Encoder means also operatively interconnect the valve means and the computer means. The computer means generates a signal representative of a desired pneumatic signal and the encoder means generates a signal representative of the pneumatic signal being sensed by the transducer. When there is correspondence between these signals, means generate a further signal that is effective to provide the desired pneumatic signal at the transducer.

Thus, the present invention provides a method and a system for displaying or trend logging of a desired signal during those times when the monitoring system would normally be inactive.

The present invention also provides a method of monitoring a plurality of pneumatic signals wherein the pneumatic signals are passed to corresponding ports in a multiplexing valve. The ports are sequentially scanned and electrical signals representative of the scanned pneumatic signal are generated. The passage of the electrical signal to a storage means is prevented for a predetermined period of time substantially corresponding to the time length of the inaccurate portion of each electrical signal.

Further, the present invention provides a system for monitoring a plurality of pneumatic signals wherein a pneumatic to electric transducer operatively interconnects a multiposition pneumatic valve means and computer means. Encoder means are also provided to operatively interconnect the valve means and the computer means. Means are provided to prevent the passage of at least the inaccurate portion of each electrical signal.

In accordance with another aspect of the present invention there is provided a method and means for calibrating the electrical signals to the computer means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a pneumatic multiplier system in accordance with the present invention;

FIG. **2** is a schematic diagram of a multiposition valve;

FIG. **3** is a schematic diagram of the circuit interconnecting the transducer and the computer shown in FIG. **1**;

FIG. **4** shows the time delay for a capacitor in the RC multiplex circuit of the computer to reach a steady state condition;

FIG. **5** shows a circuit to provide a sufficient delay to permit a capacitor in the RC multiplex circuit of the computer to reach a steady state condition;

FIG. **6** shows a relay interface to isolate the computer from the voltage of the valve circuitry;

FIGS. **7A** and **7B** show a logic flow diagram for a normal scan mode of operating the system in accordance with the present invention;

FIG. **8** shows a logic flow diagram for a random select mode of operating the system in accordance with an aspect of the present invention;

FIG. **9** shows a logic flow diagram for calibrating the system in accordance with an aspect of the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

An illustrative embodiment of the present invention will now be described with reference to FIG. **1**. A process or plant such as a refinery emits a plurality of pneumatic signals **1** representative of temperature, pressure, flow rate or other variables in the process or plant. The pneumatic signals are transmitted to ports (not shown) in a multiposition valve **2**. In a normal scan mode, a step motor **4** actuates the valve **2** to sequen-

tially connect each port to a pneumatic to electric transducer **5**. A position encoder **3** senses the position of the valve **2** and provides a signal **22** representative thereof. A computer **6** is operatively connected to the system to receive signals **23, 22** from the transducer **5** via buffer amplifier **7** and from the encoder **3**. The computer **6** provides signals to a relay interface **8** which in turn actuates the step motor **4**. The valve **2**, encoder **3**, motor **4**, transducer **5** and computer **6** are conventional hardware. For example, the multiposition valve **2**, the encoder **3** and motor **4** comprise a unit sold by Scanivalve Inc., San Diego, Calif. under Model No. SSS–64 CMB/BINY/SLSN 250 /CAB. Multiple units are also available under Model No. MSS 12–64 CMB/BINY/12SN 400/CAB. A wide variety of suitable computers are useful in this invention, an example of which is the IBM 1800 computer.

The system of FIG. **1** also has a random select mode capacity. A selector unit **9** permits the selection of any pneumatic input signal for display or trend logging. If the select mode is disabled, for example, while the system is in the normal scan mode, the computer **6** will store the selection and return to the selection when the computer **6** receives an indication from the encoder **3** that the valve **2** has completed a normal scan mode. The computer then gives a binary output switch closure **20** to the selector unit **9** corresponding to the selected port. The output **17** of the selector unit **9** slews the step motor **4** at approximately 50 ports/second. The selector unit **9** comprises circuit means for performing a logical "AND And" function with the output **19** of the encoder **3** and the binary port selection **20** from the computer **6** when the valve **2** reaches the desired port. The "And" function circuit then provides an output **17** to stop the motor **4**.

Since the system may be subject to drift, calibration means **10, 11, 21** are provided. The calibration means comprises sources of two pneumatic reference signals **10, 11** which are preferably in the order of 3.5 and 14.5 psi, and a source of pressurized air **21** connected to the reference signal source **10, 11**. The reference signals are applied to reference ports, e.g. Nos. 47 and 48. Since these signals are unique to the reference ports, they may be used to calibrate the transducer **5** and to check the encoder **3** output for proper system sequence. These reference signals may be regulated by Nullmatic pressure regulators Model No. 40–30 manufactured by Moore Products Co., Spring House, Pa. that are manifolded to the ports of the valve **2**.

Thus, the reference signals give the computer **6** the opportunity to compare the reference signals to the transducer output signal, and thereby determine the total accuracy of the system.

By reading the 3.5 psi and the 14.5 psi reference signals, the computer **6** can also determine the slope of a curve defined by the voltage outputs from amplifier **7** plotted against the reference signal values, i.e.

$$\text{Slope} = \frac{\text{Voltage port 48} - \text{voltage port 47}}{14.5 - 3.5}$$

Any drift in slope reading will provide the basis for correction due to power supply drift, transducer characteristic changes or amplifier drift **7** occurring during the interval between a normal scan mode.

A suitable model sold by Scanivalve Inc. is schematically shown in FIG. **2** wherein elements equivalent to elements of FIG. **1** have the same reference numerals. A panel **30** has 64 ¼-inch input pressure fittings (not shown) on the back side of the panel **30**. Each pressure source to be measured is connected to one of the 64 input pressure fittings one-sixteenth-inch vinyl tubes **31** are provided to interconnect the input pressure fittings and a valve pneumatic connector **32**.

The vinyl tubes **31** are uniformly spaced around the circumference of the valve connector **32**. A rotor **33** is driven from the bottom of the valve **2** to sequentially connect one of the 64 inputs to a single center port (not shown) within the valve **2**. A pressure to electric transducer is installed within the valve **2** in pressure communication with the center port. A compatible transducer is made by Statham Instruments Inc., Los Angeles, Calif., No. PL131PC–15–350 per spec. 16544.

The step motor **4** drives a timing belt **34** by way of a sprocket **35**. The belt **34** in turn drives a sprocket **36** that is connected to the valve rotor **33**. Thus, each step of the motor **4** advances the valve one port. This drive system may advance the valve **2** at high rates, e.g., at 50 ports/second.

A second timing belt **37** is mounted about the valve sprocket **36** and a position encoder sprocket **38** to drive the encoder sprocket **38** at 1:1 ratio and thereby track the port position of the valve **2**.

The position encoder **3** provides a digital output code by 64 magnetically operated reed switches (not shown) arranged around the circumference of a circle. A rotary arm (not shown) within the encoder **3** carries a permanent magnet which is capable of actuating the reed switch in its immediate vicinity. A rotor **38** interconnects the rotary arm and the encoder sprocket **38** so that the magnet actuates a different reed switch for each one of the 64 pneumatic signals. A resistor matrix (not shown) within the encoder **3** is connected to the reed switches to provide a decimal or binary code indicative of the closed switch and in turn representative of the pneumatic signal being monitored.

The valve **2**, transducer **5**, amplifier **8** and computer **6** of FIG. **1** is shown in more detail in FIG. **3**. The transducer **5** comprises a strain gauge **41** which may be a model PL–131TC sold by Statum Inc. The strain gauge **41** may comprise strain sensitive resistance wire elements which are arranged in a form of a Wheatstone bridge. The strain gauge **41** rests on a diaphragm (not shown) within a cavity formed within transducer **5**. One side of the diaphragm is opened to a reference pressure, for example, the atmosphere. The other side of the diaphragm is in pressure communication with the particular pressure port being monitored by the valve **2**. When there is a pressure differential across the diaphragm, the diaphragm bows to cause an unbalancing of the strain gauge **41** thereby producing a voltage output that is representative of the pressure input.

With reference to FIG. **3**, the strain gauge **41** is biased by a bridge power supply **42**. The power supply **42** which may be of the order of 5 volts and 200 milliamps is connected across terminals **43,44**. The other two terminals **45,46** of the strain gauge **41** are connected to the buffer amplifier **7**. The buffer amplifier **7** is connected to a RC circuit **50** comprising resistors **51,52** and capacitor **53** within the computer **6**. To sim-

plify FIG. 3, only one strain gauge and buffer amplifier is shown connected to the computer. However, a plurality of valves **2** may be required to monitor a process or a plant such as a refinery. In this case, the number of inputs to the computer **6** would correspond to the number of valves. Two additional RC circuits **54,55** are shown in FIG. 3, but the number of RC circuits required is determined by the number of valves needed to monitor the process or plant.

A plurality of RC circuits for reception of a plurality of inputs is a common way for multiplexing input data to the memory bank of a computer. For example, the IBM 1800 uses a RC multiplexing method.

The several RC circuits **50, 54, 55** are multiplexed to an amplifier **56** by relays **57, 58, 59** which are actuated by computer command signals to swing contact terminals **60, 61, 62** from the position shown in FIG. 3 to the contact points to the right of the terminals such that the capacitors **53, 70, 71** are connected to the amplifier **56** in a sequential manner. For example, contact terminals **60** move from points **63, 64** to points **65, 66**. An analog to digital converter **65**, is provided within the computer **6** to interconnect amplifier **56** and a memory unit **66** in the computer **6**. The program for the computer **6** determines the particular memory cell each capacitor reading is stored. The program also determines the sequential operation of the relays **57, 58, 59** to feed the amplified output of the transducers to the amplifier **56** of the computer **6**.

A problem in the RC circuit means for multiplexing computer inputs is that there is a time delay before the capacitor has a potential there across that is representative of the particular pneumatic signal being monitored. The IBM 1800 computer generally has RC networks which comprise resistors of the order of 1,000 ohms and capacitors in the order of 330 microfarads. Therefore, the RC circuit of the IBM 1800 would require 660 milliseconds for the capacitor to charge to 63 of the steady state value. It can therefore be seen that it would require approximately five time constants or 3.3 seconds to insure that a RC network reaches its steady state condition. Further, the Statham Instruments, Inc. strain gage **41** discussed hereinabove has an output impedance of approximately 350 ohms. The strain gage **41** impedance adds to the delay in reaching a steady state condition.

To improve multiplexing capacity of the IBM 1800 computer, the time constant of the RC circuits may be lowered, for example by providing 49 ohm resistors and 100 microfarad capacitors in the RC circuits **50, 54, 55**. However, the Scanivalve, Inc. model and Statham Instruments, Inc. gage discussed hereinabove provides a 10–50 millivolt output range for a preferred 5 to 15 psi monitoring range. Thus, the lowering of the time constant decreases the signal to noise ratio to an unexceptable level. To overcome this problem, a buffer amplifier **7** is provided between the strain gage **41** output and the RC input to the computer to raise the voltage output range to 1 to 5 volts for the preferred 3 to 15 psi operating range. A suitable buffer amplifier is one that will drive an RC filter with 20 ohm series resistance and 80 microfarad capacitor such that the voltage across the capacitor will be within 0.1 percent of steady state condition within 140 milliseconds after the beginning of the input to the amplifier. The buffer amplifier should also be capable of bringing 100 ohm series resistors and a 10 microfarad capacitor circuits to within one tenth of 1 percent of the steady state condition within 100 milliseconds.

As shown by the curve of FIG. 4, a buffer amplifier meeting the foregoing specification in combination with the Rc circuit **50** having 49 ohm resistors and a 100 microfarad capacitor will provide a steady state condition on the capacitor **53** in approximating 65 milliseconds.

FIG. 4 provides a plot of voltage in digital counts on the capacitor **53** versus time measured in milliseconds. The early portion of the curve indicated by A represents a pressure reading of 3.5 pounds per square inch measured at one of the pressure ports, e.g. No. 47, of the valve **2**. At zero time the valve is stepped to a pressure port, e.g. No. 48, having a pressure of 14.5 pounds per square inch. The stepping motor **4** takes a period of time to complete its stepping operation. The stepping motor **4** of the Scanivalve, Inc. model described with reference to FIG. **2**, requires approximately 30 milliseconds to complete its operation. After the valve **2** has been stepped to the port having a 14.5 pounds per square inch pressure there is a time lag during which the capacitor **53** of the RC circuit **50** within the computer **6** is being charged to a steady state, value C which indicates the 14.5 reading. As shown by the curve, the total response time is approximately 95 milliseconds from the actuation of the stepping motor **4**.

A rundown timer circuit **18** to delay actuation of the relays **57, 58, 59** is shown in FIG. **1** interconnecting the motor **4** and the computer **6**. FIG. **5** shows a circuit to provide a **30** to 150 millisecond delay to permit the capacitors **53, 70, 71** within the computer to reach their steady state condition. Normally closed contacts **80** are connected to the computer **6**. The computer **6** is programmed to close the RC network relay **57** when the contacts **80** are opened. When the motor **4** is running, a switch **81** is closed to thereby charge a capacitor **82** through a diode **99** by a power supply **85**. After the motor **4** completes its stepping operation, approximately 30 milliseconds, the switch **81** is opened and the capacitor **82** discharges through a time delay relay **83** and a variable resistor **84**. The time constant of the RC network comprising the capacitor **82**, the relay **83** and the variable resistor **84** is fixed such that relay **83** holds contacts **80** in the open position for a period of 30–150 milliseconds after the switch **81** is opened. Therefore, the computer **6** will not actuate the RC network relays **57, 58, 59** for a period of approximately 60–180 milliseconds depending upon the time constant of the RC network shown in FIG. **5**. A time delay relay suitable for the practice of the present invention is sold by Potter and Brumfield, Division of AMF Company, Princeton, Ind. under Catalog No. CDD-21-30003. This particular time delay relay is capable of providing a delay of 100 to 150 milliseconds.

To provide a reference from which the valve **2** begins its scan, one port, e.g. No. 64, is designated home port. Since the preferred operating pressure range is between 3 and 15 pounds per square inch, it is necessary to provide a pressure at the home port that is outside of the operating range. A high pressure, e.g. 20 pounds per square inch would cause a hysteresis effect as the valve **2** is stepped from home port to the first monitor-

ing port. Specifically, it would take the transducer diaphragm a measurable amount of time to relax after being at the elevated pressure. To avoid a hysteresis effect, the home port should preferably be opened to atmosphere such that the transducer output would be zero.

FIG. 6 shows the circuit of the relay interface 8 between the computer 6 and the motor 4 which isolates the computer from the internal voltage of the valve circuitry. When a home switch 86 is closed within the computer, current flows from a power supply 90 through relay 87 to close contacts 88. Closure of contacts 88 sets flip-flop 89 by means of a 1.5 volt power supply in the above described Scanivalve, Inc. valve 2. When the flip-flop 89 is set the motor will run the valve 2 until encoder 3 reads home port, e.g. No. 64. Upon reading home port, the encoder 3 resets the flip-flop 89 to stop the motor 4. The power supply 90 of the computer 6 is also impressed across an RC circuit 91 comprising resistor 92 and capacitor 93. The resistor 92 in the RC circuit 91 delays the voltage impressed across the capacitor 93 and the relay 94 to momentarily prevent actuation of the relay 94. The RC circuit 91 need only provide a short delay, e.g. 2 milliseconds, before a sufficient charge is developed across the capacitor 93 to actuate relay 94. When relay 94 is actuated it opens normally closed contacts 95 to remove the 1.5 volt power supply from the flip-flop 89 to thereby permit a signal from the encoder 3 to reset the flip-flop 89 when the valve 2 is on home port.

A step switch 96 is also provided with the computer 6. When the step switch 96 is closed, the power supply 90 actuates relay 97 to thereby close contacts 98. Closure of contacts 98 impresses the 1.5 volt power supply on the motor 4 to initiate a step cycle in the motor of the valve 2. The motor 4 will then turn a predetermined fraction of a complete cycle. For example, the Scanivalve, Inc. model described hereinabove will turn one-fiftieth of a cycle.

An example of a normal scan mode of operating the system will now be described with reference to the logic flow char shown in FIGS. 7A and 7B. In this example a plurality of valves start a scan of their respective ports Nos. 1 to 12 at the beginning each one minute interval, and at the beginning of the fifth minute plurality of valves begin a scan of their respective ports Nos. 1 to 48.

With reference to FIG. 7A, the program is entered 101 and the indicator, INDIC, 102 priorly set to position 3 causes the computer to carry out the function designated by open home contacts 112. The home contacts that are opened during this function are the home contacts in the relay interface 8. Next, the subroutine calls for reading of all encoders 113. The home ports should be port No. 64 on each valve and are preferably vented to atmosphere to provide a zero reading. If the computer does not read the home port by sensing the encoder output, the failure to read is recorded by setting the proper bit in the encoder fail word 115, and all valves are stepped to port No. 1 116. If the encoders read on the home ports, the valves are set to port No. 1 116. The set return indicator (INDIC) 102 is set to 1 and call timer 118 which provides a rundown time of 112 ms. The 112 ms is an arbitrary delay to provide the transfer of port No. 1 information to the memory of the computer. Then, call INTEX 119 to exit the program and return control to the computer. At the end of 112 ms, the computer will enter 101 the subroutine.

Indicator 102 is now in the 1 position and causes the computer to carry out the function designated by open stepping contacts 103. The contacts that are open during this function are the stepping contacts in the relay interface 8. The motor 4 automatically stops. To restart the motor 4, the stepping contacts in the relay interface 8 must open and then close. The rundown timers are then read 104. The contacts are then checked to insure that they are all closed 105. If no, set proper bit in timer fail word 106 to record the failure and continue the subroutine by reading all valves 107. If all the contacts are closed 105, the subroutine moves directly to read all valves 107. The return indicator 108, INDIC, is set to 2 and a port counter is incremented 109 to record the number of ports that have been read. A 72 ms timer is called 110 to provide sufficient time to read the valves. For example, the IBM 1800 computer requires 10 ms to read each valve and has rundown timers that may be set in increments in only 8 ms. Thus, if the computer is monitoring seven valves, the rundown timer must be set to 72 ms to provide sufficient time to read the valves. Next, call INTEX 111 to exit the program and return control to the computer. At the end of 72 ms, the computer will enter 101.

Since the indicator, INDIC, is now set to 2 the computer carrier out the functions to the right of INDIC 102 by setting return indicator 120, INDIC, to 1. The port values just read are moved to IADC 121. IADC indicates the permanent storage to which the port values are transferred from a temporary storage within the computer. They go to ISCAN function 122 is then carried out. When ISCAN is set to 1 the computer will check to determine whether the 1 minute scan is completed 123. Should the 1 minute scan not be completed, the valves are stepped 123. A 112 ms rundown timer is called 125 to permit the transfer of port readings to the temporary storage within the computer. Then, call INTEX 126 to exit the program and to enter 101 the subroutine at the end of 112 ms.

If the 1 minute scan is completed 123, the IADC index is reset 127 (FIG. 7B) to condition the computer for the beginning of the next scan. All encoders are read 128 and the go to ISCAN function 129 is carried out. If on the 1 minute scan which comprises a 12 port check, the encoder is monitored 130 to determine whether all valves are on port No. 12. If the valves are all not on port No. 12, the failure is recorded by setting the proper bit in encoder fail word 131 and the routine is continued by sending all valves home 132 by closing the home contacts in the computer. If all the valves are on port 12 130, the valves are also sent to home 132.

After a 1 minute scan of 12 ports go to ISCAN 133 is stepped to initialize other variables 134. For example the port counters are returned to 0 and INDIC is reset to 3. Then, call levels (8) 135 to obtain desired program for monitoring the limits of the values read. Next call INTEX 136 to exit the program and return control to the computer.

The above subroutine program will be run four times to obtain the 1 minute scans which comprise 12 ports. At the end of the four 1 minute scans the five minute scan program is entered. The routine is the same for the

5 minute scan until go to ISCAN **122** which is set such that a check is made to determine whether the 5 minute scan is completed **137**. If the 5 minute scan, e.g. 48 ports has not been completed then all valves are stepped **124**, call rundown timer of 112 ms **125** and call INTEX **126** to exit program and return at the end of 112 ms to enter **101**. If the 5 minute scan **137** is completed then reset IADC index **127** to condition the computer for the beginning of the next scan. Then read all encoders **128**, go to ISCAN **129** which is set to determine whether all valves are on port 48 **138**. If all valves are not on port 48 record the failure by setting the proper bit in encoder fail word **139** and send all valves home **132**. If all valves are on port 48 **138**, send all valves home **132**. During the 5 minute scan go to ISCAN **133** is set to determine whether any encoders failed **140**. If any encoders failed, save fail words **141** by transferring such indication to permanent storage, and initialize the fail words **142** and other variables **143**. The other variables include returning the port word to zero and resetting INDIC to 3. Next call QUEUE **143** which is an error analyzing program. The call ENDTS **144** to end time sharing to insure that the QUEUE is executed. At the end of the error analyzing program, control will be returned to the computer.

If no encoders failed **140** then check to determine whether the timers failed **145**. If no time is failed **145** then determine whether the reference ports are within limits **146**. If the reference ports are within limits **146** then initialize fail words **147**, e.g. timer fail word **106** and encoder fail word **115**. Then initialize other variables **134**, call level (8) **135** and call INTEX **136** as discussed above.

If any timers failed **145** or if the reference ports are not within limits **146**, then save fail words **141**, initalize fail words **142**, initialize other variables **142**, call QUEUE error analyzer **143** and call ENDTS **144** as discussed hereinabove.

FIG. **8** shows a subroutine program for the random select mode of operation. A job scheduling program calls enter **301** to begin the subroutine. INDIC **302** is set to 1 to decode the instrument point **303** to determine which valve and port corresponds to the specified instrument to be read. Then a random select command corresponding to the valve and port to be read is given **304** and a 1.3 second timer is called **305**. Then indicator, INDIC, is set **306** to 2. At the end of 1.3 seconds, the computer will re-enter the program at enter **301**. Since INDIC **302** is now set to 2, read the rundown timer contact in the valve **307**. If the rundown timer contact is not closed **308** give stop command to stop the motor **309** and set indicator **310**, INDIC, to 4. Loop counter 1 is incremented **311** and a 112 ms timer is called **312** to provide time to insure that the valve rundown timer has an opportunity to rundown and close the valve timer contact. Then call INTEX **313** and reenter the program **301** at the end of 112 ms. Since INDIC, **302** is now set to 4, the computer will again read the valve rundown timer contact **314** to determine whether it is closed **315**. If the timer contact is not closed, then check loop counter 1 to determine whether the timer contact has been read twice **316**. If the timer has been checked twice, then notify the operator that he can not get his information **317** and notify the supervisor that a valve requires attention **318** and initialize all indicators and counters **319**, for example reset loop counters to zero and return INDIC **302** to 1. Then call INTEX **320** to return control to the computer. If the loop counter check **316** indicates that the rundown timer contact has not been checked twice, then repeat the portion of the subroutine program beginning at give stop command **309**.

If the rundown timer contact of the valve is closed **315**, then send the valve home **136** and record the failure by setting the proper bit in fail word **317**. Also set indicator, INDIC, **301** to 1 **318**, and call error analyzing program **319**. Initialize all indicators and counters **320**, e.g. the loop counters are set to zero and the indicator, INDIC, is returned to 1. Then call ENDTS **321** to end time sharing of the programer, thereby insuring that the error analyzing program is executed. At the end of the error analyzing program, control will be returned to the computer.

If the first reading of the valves rundown timer contact **307** indicates that it is closed, then read the encoder **322**. If the valve is on the correct port **323**, read the valve **324** and call a 10 ms timer **325** to provide the necessary time for the computer to complete the reading. Step return indicator **326** to 3 and call INTEX **327**. At the end of 10 ms, the computer will re-enter the program **301**. Since the indicator, INDIC, **302** is now set to 3, convert the digital values to engineering units **328** and send reference to the operator, for example in the refinery control room **329**. The valve is then sent home **330** and the indicator, INDIC, **302** is set **331** to 1. Next call INTEX to exit the program and return control to the computer **332**. If the read encoder function **322** does not indicate that the valve is on the correct port **323**, then increment loop counter No. 2 333 and if loop counter indicates that the loop has been tried only once **334**, re-enter the program at give random select command **304**. If loop counter No. 2 indicates that the loop has been tried twice, set bit in fail word **335** to record the failure and re-enter the program at set return indicators **318** to 1.

A calibration routine is shown in FIG. **9** upon entering the routine **208**, the calibration ports Nos. 47 and 48, are called **201** and read. The port values are subtracted **202** to provide K. Then, a new slope, m, is calculated **203** by dividing K by 11. The 11 value is determined by subtracting the pressures at the two pressure regulators i.e., 14.5–3.5=11. Then a new y intercept is calculated **204**, i.e., y intercept $= b =$ Port No. 47 reading $- K3.5/11$.

Next new y coordinates on a line defined by the above calculated slope, m, and y intercept, b are calculated **205** for the 3 and 15 psig signals. 3 psig y coordinate $= K3/11 +$ [Port 47–(K3.5/11)] 15 psig y coordinate $= K15/11 +$ [Port 47–(K3.5/11)]

The y coordinates for the 3 and 15 psig signals are stored as A and B **206**.

Then, a percent of scale correction for each measured signal is computed **207** as follows and the measured signal is corrected accordingly.

$$\text{Percent scale} = \frac{\text{Measured signal} - \text{A}}{\text{B} - \text{A}} \times 100$$

Then call ENDTS **209** to exit program and return control to the computer.

It will be understood by those skilled in the art that the above described embodiments are exemplary and that they are susceptible of modification and variation without departing from the spirit and scope of the invention. Accordingly, the invention is not deemed to be limited except as it is defined in the following claims.

What is claimed is:

1. In a system for monitoring a plurality of pneumatic signals, the combination comprising:

multiplexing means including a multiposition valve for sequentially passing said pneumatic signals;

a pneumatic to electric transducer connected to said valve for generating electrical analog signals representative of said pneumatic signals passed by said multiplexing means;

a computer operatively connected to said transducer and comprising:

means including a capacitor for temporarily storing said electrical analog signals,

means for converting said electrical analog signals to digital signals,

means for transferring said electrical analog signals from said capacitor to said converting means, and

memory means operatively connected to said converting means for storing digital signals representative of said pneumatic signals; and

means interconnecting said multiplexing means and said computer for delaying operation of said transferring means for a predetermined time interval of sufficient duration to permit each of said electrical analog signals temporarily stored on said capacitor to attain a steady state condition.

2. The system of claim 1 further including means for providing at least two references pneumatic signals having predetermined values to said valve, and wherein said computer includes programming means for (1) generating a slope of a linear curve in response to the predetermined values of said reference pneumatic signals and the electrical signals generated by said transducer in response to said reference pneumatic signals, and (2) generating in response to said slope correction factors for said electrical signals representative of the values of said monitored pneumatic signals.

3. The system of claim 1 further including:

encoder means connected to said multiplexing means for generating a signal representative of the pneumatic signal being passed,

signal selection means connected to said encoder means and to said computer and responsive to a signal representative of a desired pneumatic signal generated by said computer for indicating in a first state correspondence between said pneumatic signal being passed and said desired pneumatic signal and indicating in a second state noncorrespondence between said pneumatic signal being passed and said desired pneumatic signal, and

said multiplexing means being responsive to said signal selection means in said first state for passing said desired pneumatic signal for a predetermined period of time, and being responsive to said signal selection means in said second state for stepping said valve until said signal selection means is in said first state.

4. The system of claim 1 wherein said multiposition valve has a predetermined operating range defined by P'_a and P'_b where $P'_b > P'_a$, further comprising means for supplying a home reference pneumatic signal P_h, $P'_a > P_h$, to said valve to provide a position reference for said multiplexing means.

5. The system of claim 1 wherein said home reference pneumatic signal is at atmospheric pressure.

6. The system of claim 1 further comprising:

means for applying two predetermined reference pneumatic signals, P_a and P_b, $P_B > P_a$, to said multiposition valve,

said multiplexing means having a predetermined pneumatic input operating range defined by P'_a and P'_b, where $P'_b > P'_a$, $P_a > P'_a$ and $P'_b > P_b'$,

said computer comprising programming means for:

generating a signal representing the slope of a linear curve as defined by

$$(V_b - V_a)/(P_b - P_a)$$

wherein:

V_a and V_b represent the voltage values of the reference pneumatic signals generated by the transducer, and

P_a and P_b represent the predetermined pressures of the reference pneumatic signals,

generating signals A and B representing the y-coordinates of points on said linear curve having x-coordinates of P'_a and P'_b,

generating a correction signal, C, for each of said signals, E, representative of the values of the monitored pnuematic signals, each of said correction signals, C, being defined by

$$(E\text{-}A/B\text{-}A) \times 100$$

wherein:

E represents the voltage value of the transducer electrical signal representative of the monitored pneumatic signal, and A and B are the y-coordinates, and

correcting each of said signals E in accordance with the corresponding correction signal C prior to storage in said memory means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,689,748 Dated September 5, 1972

Inventor(s) RALPH E. BOTHNE

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 15	:	"CMB/BINY/12SN" should read --CMB/BINY/12LSN--
Column 3, line 22	:	Before the word "select" insert --random--
Column 3, line 32	:	Delete "AND" (the one in solid caps)
Column 3, line 43	:	"source 10,11" should read --sources 10,11--
Column 5, line 41	:	"63" should read --63%--
Column 6, line 7	:	"Rc" should read --RC--
Column 6, line 34	:	The "30" should not be in bold numbers
Column 7, line 44	:	"char" should read --chart--
Column 8, line 35	:	"They" should read --The--
Column 10, " 36	:	"333" should be in bold numbers
Column 12, " 21	:	"P_B" should read --P_b--
Column 12, " 25	:	"$P'_b > P_b$'" should read --$P'_b > P_b$--

Signed and sealed this 20th day of February 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

15D

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