

[54] **RANDOM-ACCESS PRESSURE
MULTIPLEXER VALVING
ARRANGEMENT AND SYSTEM**

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[58] Field of Search **73/420**, 422, 147; 137/312,
137/625.11, 624.18, 624.2; 222/309; 340/413;
235/199

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[57] **ABSTRACT**

The present invention relates to a unique multiple-sampling valve and system to provide a random-addressable time-division multiplex arrangement for pressure measurements which makes it more compatible with computer process control. A single pressure to electrical signal transducer forms one side of a common predetermined volume chamber and responds to pressure signals channeled to the chamber as a result of selective actuation from a plurality of sample ports wherein open connections may be established in random order or by predetermined sequence for measurements in the sample mode. A plurality of individual (energizeable linear solenoid) valve rods, disposed in proximity with the predetermined volume, minimizes the common volume and length of passageway between the valve rods and the transducer, substantially eliminating restrictions therebetween, thus decreasing the time required for the transducer to respond to one pressure signal from any given port. A second (and/or third) position of the valve rods serves to connect high-pressure fluid to all conduits sequentially (one at a time) for the diagnostic mode; and, simultaneously for the purging mode. Logical controls select the connections to be established, modes of operation, and analyze output conditions for locating any restrictions to determine sources of error.

26 Claims, 12 Drawing Figures

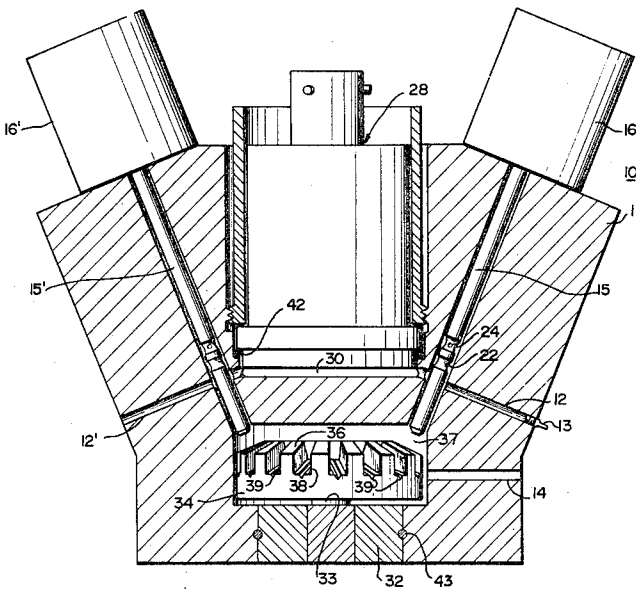
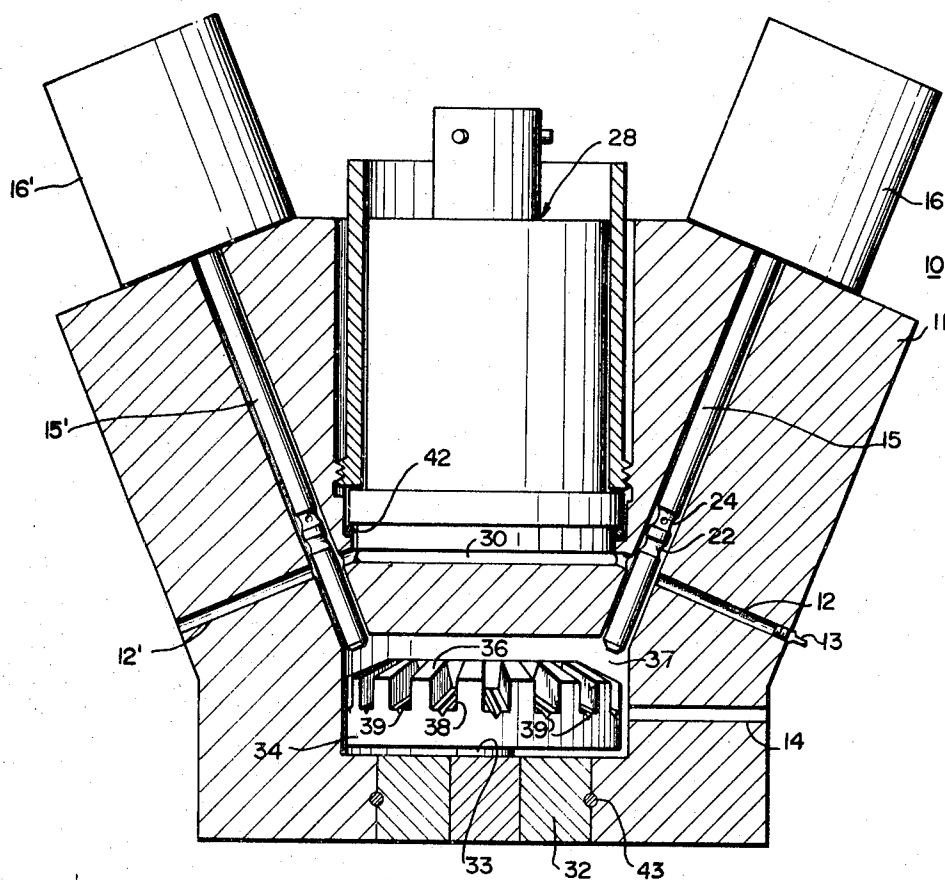
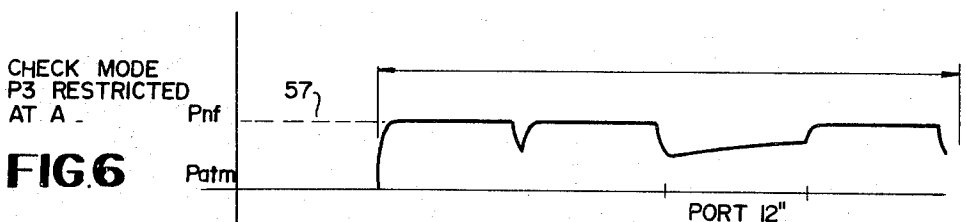
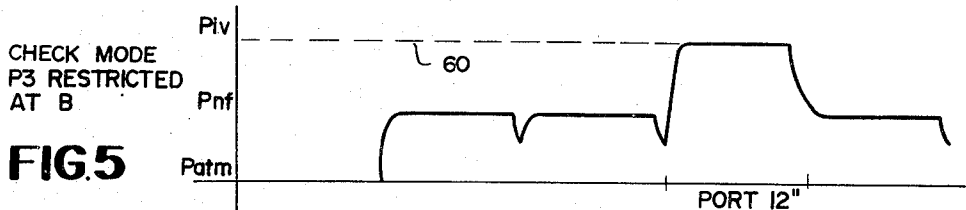
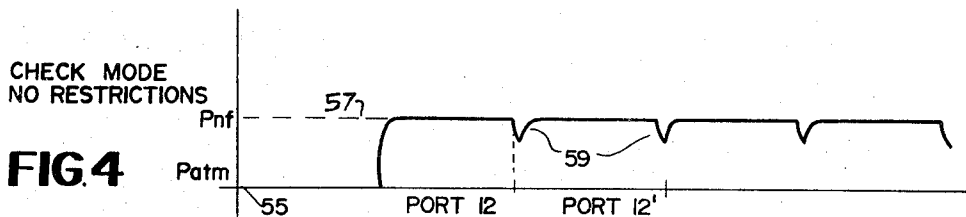
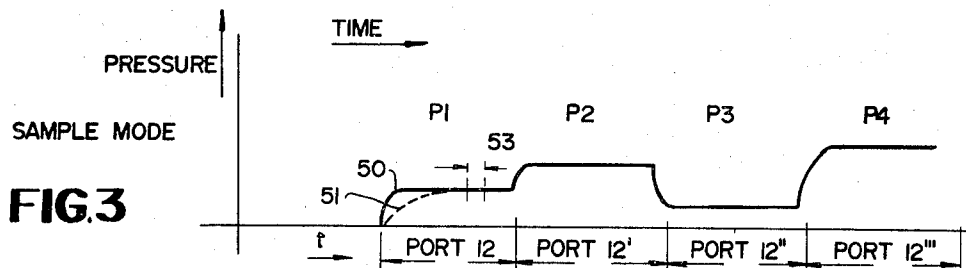


FIG. 1



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FIG. 7

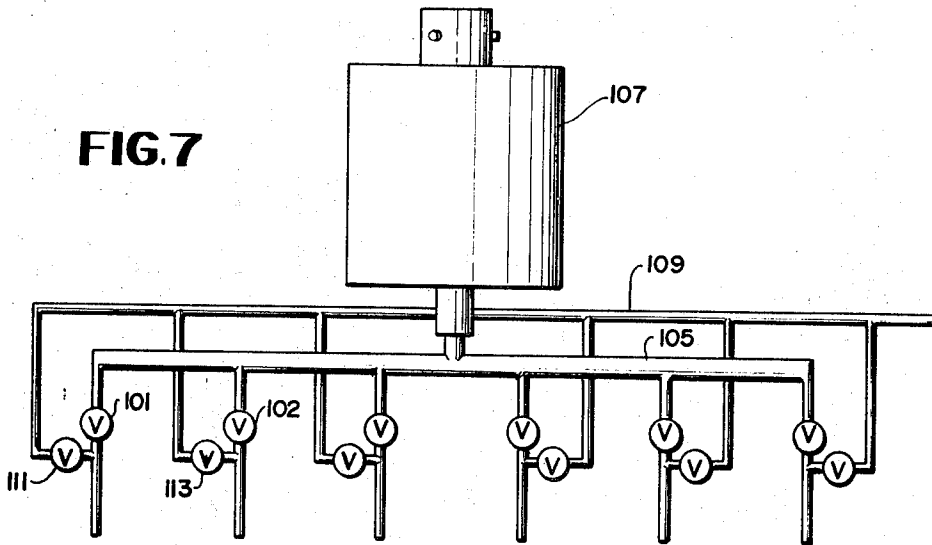
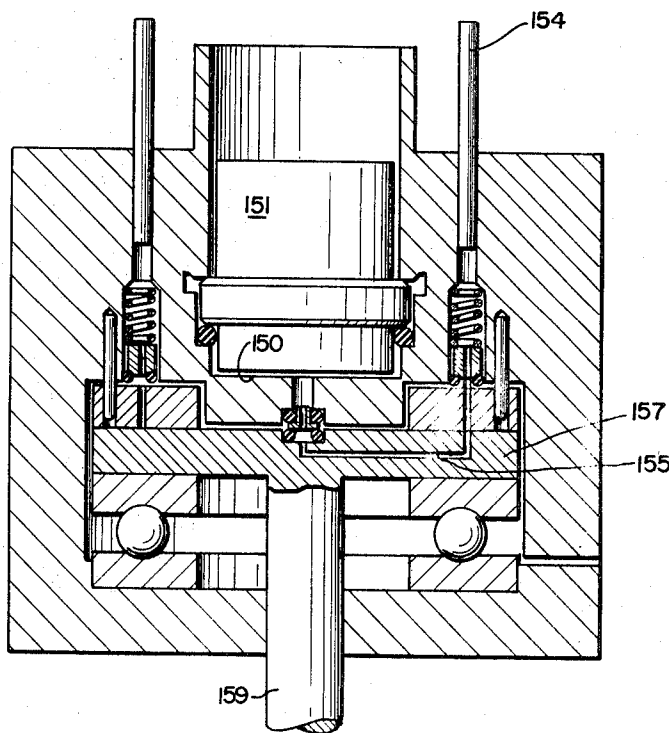


FIG. 8

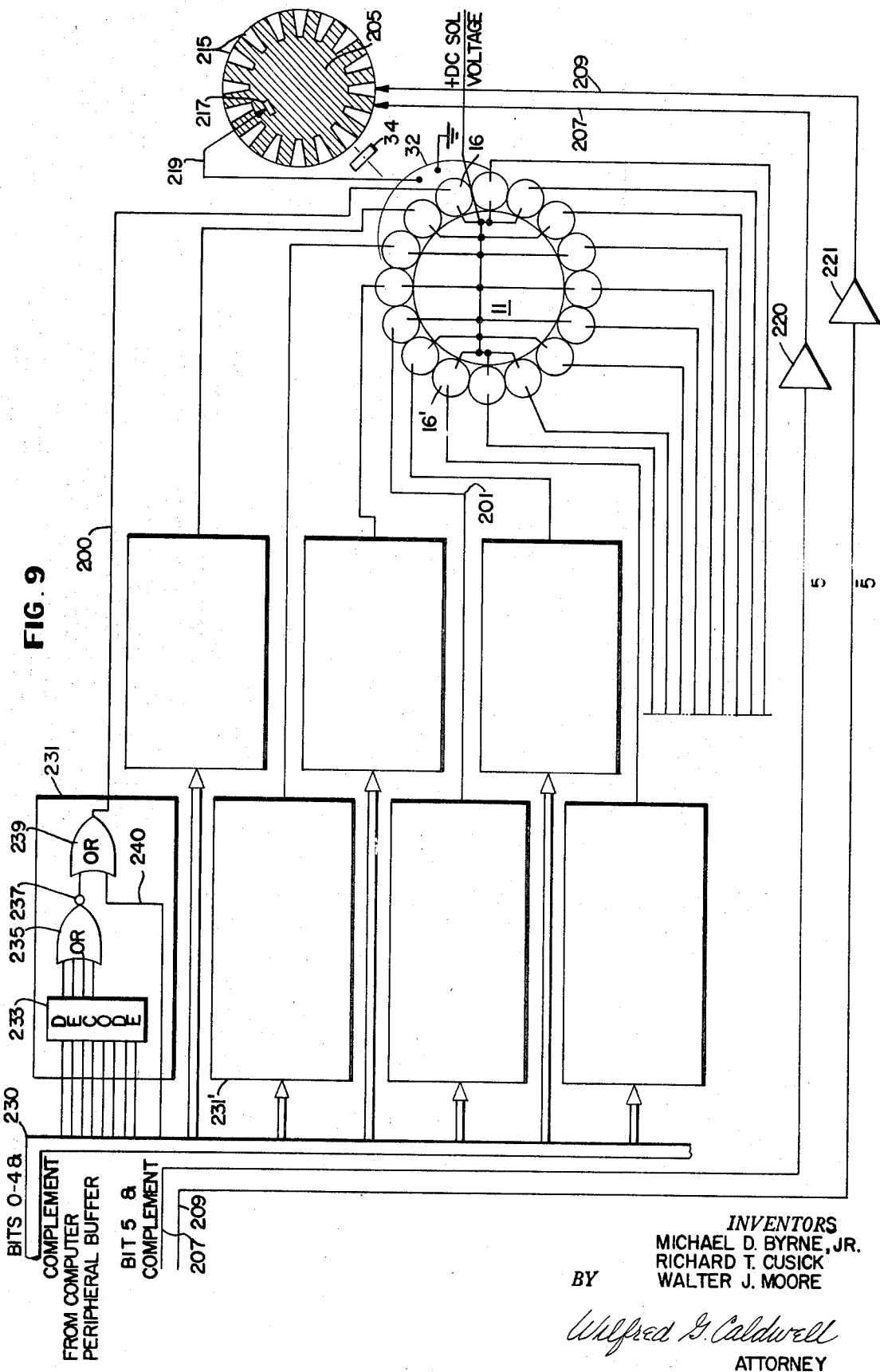


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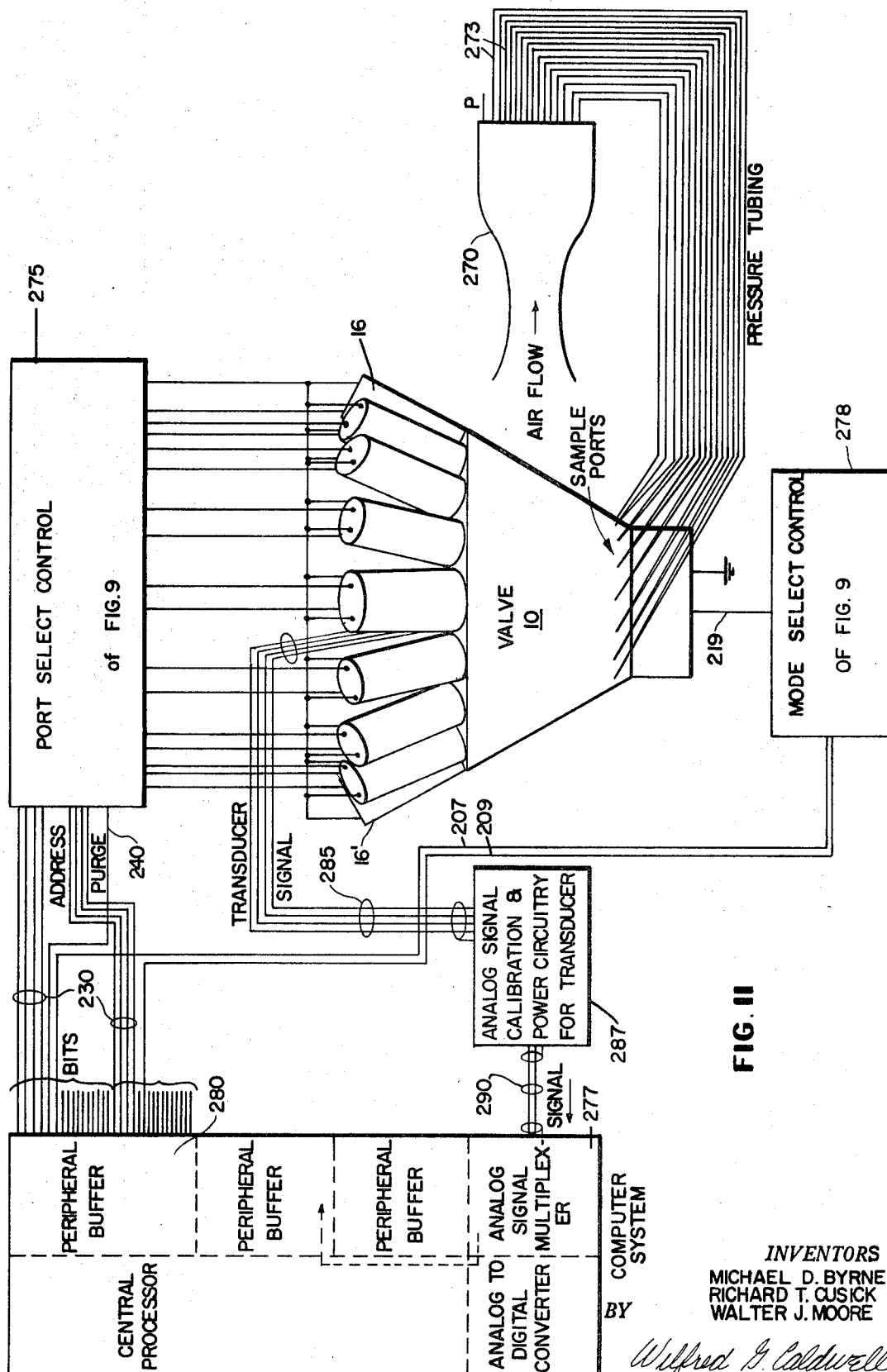
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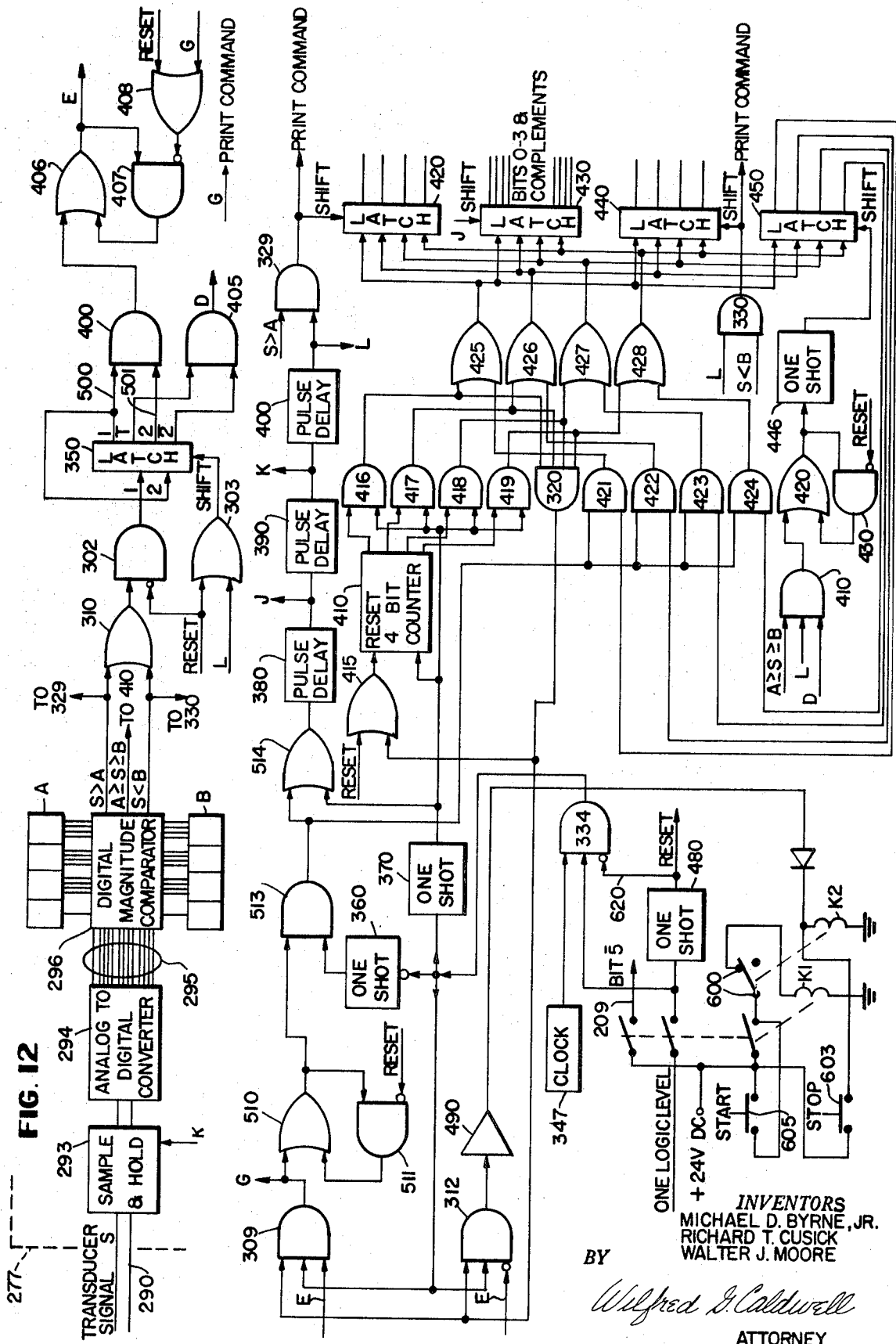
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RANDOM-ACCESS PRESSURE MULTIPLEXER VALVING ARRANGEMENT AND SYSTEM

The present measuring and testing system is provided to accommodate the handling of a plurality of pressure conduits, e.g., 16, at a single station or module, with rapid random access being available to permit selection of individual conduits, one at a time, to provide a capability to use with a common sensor, thereby minimizing cost expenses for installation.

A single transducer provides a movable wall of the common chamber which is then available for connection to any of the 16 ports for taking a pressure measurement. A positioning arrangement is simply provided for each port by incorporating a movable stop member which permits the individual valve rods of the solenoids to be positioned to a first position for the sample mode to permit selective pressure measurements from the conduits, or to a second position to permit purging of all conduits simultaneously or selection, one by one, for diagnostic checking. Thus, selecting a solenoid for energization and selecting the sample (upper stop or middle) position for the stop member enables a pressure measurement, whereas the energization of all solenoid valves and movement of the stop member to the purge (lower stop) position serves to introduce high-pressure fluid to all conduits for cleaning of the conduits and associated ports. Also, with the stop member in the purge position, diagnostic checking of any or all selected lines is achieved through selective energization of the part solenoids to connect one conduit at a time to the purge pressure.

Analysis of the output pressure levels by sampling the transducer signal levels, in the diagnostic mode, provides information for comparison against a standard signal or preset signal levels to determine if a restriction exists, and if so, its location. The diagnostic mode incorporates certain predetermined sequences automatically programmed to enable the module to serve as a reliable remote-control unit. For example, encountering restrictions in two conduits sequentially sampled, automatically initiates a second checking sequence for all ports. The second sequence is the same order as the first sequence except that a good port (selected from the first pass) is checked between adjacent ports of the first sequence to insure that two bad (restricted) ports are not sequentially encountered.

If, during the first pass, restricted ports are detected, their identification and the type of restriction are printed or otherwise displayed. If two ports adjacent in the first pass are restricted, the second pass is initiated and the event is printed or displayed. In this event, the restriction data printed or displayed during the second pass should be used and the data of the first pass ignored. If, during the first pass no two adjacent ports are restricted, diagnosis stops and the first pass data is usable.

The analysis procedure is facilitated by incorporating a reduced orifice or passageway for providing a restriction to pressure flow between the source of high-pressure purging fluid and a common junction between the inlet to the predetermined transducer chamber and the port or pressure line.

If there is no clogging in the line, the high pressure will pass out through the line, but will be reduced from its high-pressure level by the pressure drop occasioned by the orifice. A corresponding difference or drop in transducer signals is manifested in the logic circuitry or computer, as the case may be, to indicate this part of the normal condition, i.e., a level below purge-pressure level which means no clogging to the line side of the valve.

The absence of a normal purge-pressure signal indicates a clogging in the connection between the valve and chamber. In this case, only a minimal signal level is experienced at the transducer volume chamber. This signal is a result of a lack of response at the common chamber to the pressure existing in the valve downstream of the orifice.

It must be assumed in these examples that the restrictions block all airflow caused by the pressure present in the lower volume and that the boundary conditions exclude clogged ports preceding or following the port of interest. If a partial

restriction were assumed, it could be determined using the principles herein taught, but the resulting waveforms are so numerous as to exclude being completely shown and described in connection with further levels for comparison.

One major application of the invention is as pressure-measuring systems, such as would be particularly useful in plants producing synthetic materials, or in distillation or cracking processes, wherein the efficiency of such automatic or semiautomatic plants could be substantially increased if pressures at a great number of points could be sampled continuously and computer logic applied thereto for determining whether or not each is operative or effective within predetermined limits, to maintain acceptable production.

Other applications of the invention include monitoring of multiple pressures of jet engines or airplane pressure profiles in general, including wind-tunnel-type testing wherein multiple pressures along the length of a wing or a combustor are measured for developing pressure profiles or even area profiles.

With the foregoing in mind, it is an object of the present invention to provide a multiplexer-type arrangement for multiple pressure inputs.

Another object of the invention is the provision of a combination multiple-sample pressure input, checking and purging valve arrangement employing a single transducer per unit module.

Another object is the provision of such a combination valving arrangement or system capable of sequential or random checking or measuring of sample pressures.

Another object is the provision for purging the pressure conduits to prevent and correct clogging conditions which might be caused by particles and foreign matter present in the pressure media.

A further object enables diagnosis of the ports for clogging with rechecking available following detection of adjacent clogged ports, and thus providing the capability of isolating single or multiple restrictions.

Another object is the provision of simple, logical control of inexpensive nature for such a combination multiple-sample and multiple-mode valving arrangement and system wherein a minimum word command enables simple and reliable programming control.

A still further object is the provision of such a valving arrangement operable with only a singularity of transducer cabling, calibration, power supply, and transducer per unit module.

With the foregoing in mind, the invention will be better understood from a reading of the following detailed description thereof when taken in the light of the accompanying drawings wherein:

FIG. 1 is a view partly in section and partly in elevation of the preferred structure of a commutating valve in accordance with this invention;

FIG. 2 is an enlarged, primarily sectional, view of a portion of a valve in accordance with FIG. 1;

FIGS. 3 through 6 are pressure vs. time graphs or charts to illustrate various conditions which may occur during operation of the valve ports;

FIG. 7 is a schematic showing of the use of conventional components to fabricate a multiple valve capable of but a few of the functions of the valve of the present invention for purposes of comparison therewith;

FIG. 8 is a view, primarily in section, of the closest known prior-art-type valve;

FIG. 9 is a selection schematic drawing to show the electrical selection of any port or all ports for any or all modes of operation;

FIG. 10 is a detailed showing of the electrical components for the logical selection to energize a given port;

FIG. 11 is a block-type schematic arrangement to show the random-access valving arrangement in one typical application, in its preferred form and,

FIG. 12 schematically illustrates the logic for performing the diagnostic function in the random-access valving arrangement.

The invention, now to be described in detail, relates to a multiple-pressure measuring and testing valve system of random-addressable type, which is capable of sampling at random any one or a sequence of a plurality of pressure lines, and it is further capable of purging all of the pressure lines or selectively purging the lines with the capability of checking for clogged lines. The selection of a particular line is accomplished by activating a port solenoid to position its associated plunger valve to a position selected from more than a single position. The selection of a particular function is accomplished by positioning a rotary solenoid or other device capable of stopping or locating a selected plunger in its sample or purge check position or mode for locating all plungers simultaneously in the position of the purge mode.

Referring now specifically to FIGURE 1, the random-addressable pressure commutating valve, per se, is shown as a multiple-port valve, generally designated at 10. The valve 10 has a plurality of inlet ports 12, 12', etc., with a typical valve accommodating, for example, 16 such inlet or sample ports, the individual ports of which are addressable by four-bit binary numbers. Of course, other numbers of valves may comprise a valve 10 with or without regard to the binary system. Each of the sample ports 12, 12', etc., is fitted with a connector such as the threaded nipple 13. Single purge inlet port 14 is fitted with pressure top means (not shown).

In the preferred embodiment described, the plunger or plunger valves 15, 15', are adapted to be driven to different positions for the various functions by the associated solenoids, 16 and 16', etc. It will be appreciated that in FIG. 1, only solenoids 16 and 16' are shown, but in a typical valve, up to 16 or more, such solenoids would usually be disposed in a circle for use with the single common pressure transducer 28 and its chamber 30.

The individual plungers, such as 15, each have a sample annulus 22 (best seen in FIGURE 2), a purge annulus 24, and a bore 26, extending from the purge annulus 24 to the lowermost portion of each of the plungers 15. The plungers 15 and 15' are shown in a first position, which is inoperative position, and their associated solenoids 16 and 16' are deenergized.

In the preferred embodiment, the plungers such as 15, are adapted to be driven by their associated solenoids 16 to a second and third position, with the latter two being determined by a notched rotatable stop plate, shown generally at 34, and which has upper lands or bearing surfaces 36 and lower lands or bearing surfaces 38. A rotary solenoid 32 is provided to move the plate 34 to stop the plungers 15 at the second position through contact with upper lands 36 or at the third position through contact with lower lands 38. The drive member 33 is coupled from the rotary solenoid 32 to the plate 34, and it should be noted that for stability a bearing plate or ratchet may be included about driving member 33 to preclude any misalignment or tilting of the plate 34. Moreover, it will be appreciated that the rotary solenoid drive could be replaced by other driven, such as ratchet or other position-stepping arrangements. Similarly, the plate 34 could be replaced by vertically movable frustal conical surfaces or its stopping or positioning function could even be carried out by slots and notches not shown, engaging the plungers 15 protruding from the support or walls 11.

It should be noted that the plungers and lands are aligned such that all high lands 36 are beneath the plungers 15 at the same time, and the same is true with respect to the low lands 38. Thus, the stop plate 34 need move only one land step to achieve the second and third positions for the plungers 15, and this step may be in the same direction or may be backward and forward.

With respect to the operation of the devices, the third position of each plunger 15 will now be described, the first position being the inactive position depicted in FIG. 1 with solenoid 16 deenergized. Thus, it may be seen that the lower por-

tion of plunger 15 blocks its sample passage 12 and gas cannot pass from an external pressure line (not shown) via inlet port 12 to chamber 30 to influence the transducer 28.

For measuring the pressure in one of the pressure lines (not shown), the solenoid 16 (associated with that line) is energized, thereby forcing its associated plunger 15 into one of the two lower positions. However, for measurement, this position must be the middle position; and it is therefore necessary to locate an upper land 36 beneath the plunger 15 to align the sample annulus 22 with the port 12 and pressure-measuring chamber 30.

The third position is that of purge/check for any selected plunger or purge for all plungers and is attained by aligning the lower lands 38 with the plungers 15. Thus, the purge annulus 24 will align with inlet port 12 and gas under high pressure present in chamber 37, is forced to follow a flow path into bore 26 of plunger 15. This flow path is best seen in FIG. 2, wherein the pressure from port 14 enters annular space 37 and proceeds along passageway 39 (also seen in FIG. 1), where it exists at orifice 41 and flows out sample port 12, if unclogged, chamber 30 being a closed chamber.

It is noted that the driving motor or rotary solenoid 32 is sealed by O-ring 43, as is also the case with the pressure transducer 28, by O-ring 42.

The principle of the commutating valve, which forms the heart of the system next to be described, should be fully appreciated by noting that if further functions are required of this unit, it is possible to incorporate stepped or further leveled stepping plates, i.e., for a four-position plunger valve, a third level stop plate would be used, etc.

Next, the valve 10 will further be described in connection with the operational and diagnostic waveform charts of FIGS. 3-6. The operational waveform of FIG. 3 permits measurement of the various pressures in the external pressure line indicated as p_1 , p_2 , p_3 , and p_4 , which lines may be sampled by or coupled to valve 10, respectively, at ports 12, 12', and 12'', 12'''.

The sample mode of FIG. 3 provides the relative measurement of the pressure of the various lines which appear as a typical graph taken from a recorder. However, the subject commutating valve, when used in the system hereinafter to be described, enables the computerized measurement and diagnostic use thereof; and, thus, the pressure patterns or measurements (FIG. 3) would normally be directly applied to the analog-to-digital converter from the output of transducer 28.

A most important advantage of the present invention may be appreciated from noting the relatively fast rise time of pressure wave 50 compared to a typical rise time, shown by the dotted curve 51. Thus, the valve of this invention enables pressure measurement or sampling quickly for each line or number of lines. Looking at FIG. 2, it may be seen that the steep slope or rapid rise 50 of FIG. 3 is enabled because of the reduction of the sensed volume, i.e., the volume which must be influenced by pressure change. The sensed volume is the volume of chamber 30, along with the volume of passageway between the plungers 15 and chamber 30, for each operative plunger and the construction of valve 10 minimizes this sensitive volume.

In FIG. 3, the time bracketed at 53 may be indicative of a computer sampling for the pressure at port 12; and since the rise time of curve 50 is less, i.e., the curve is steeper, the computer sampling time may be taken at an earlier time with the valve stepped to measure the pressure at port 12' sooner, thereby speeding the measurement of many pressures.

Another important advantage of valve 10 may be seen in the curves of FIGS. 4 through 6 wherein the self-diagnostic capability of the valve permits the checkout of the various pressure sample lines for restrictions and even the determination of where the restriction has occurred. In checking for restrictions, obviously the check mode is employed and while this is similar to the purge mode, it is only done on a selective port-by-port basis in order that the proper determinations may be made. Thus, in FIG. 3 there is depicted a pressure-time

waveform taken over four selected ports wherein no restrictions are present. The reference line 55 may represent the atmospheric or ambient pressure and the upper pressure, represented by dotted line 57, is normal flow pressure, i.e., flow in the absence of restrictions, but as a result of the purge or highest pressure in the system, as admitted at port 14 but measured at chamber 30. The pressure dips located at 59 represent pressure drops due to venting via the sample annulus 22 as it passes the sample port 12 for the adjacent ports or successively selected ports. For example, in FIG. 3, after the pressure-line-attached port 12 has been sampled, it is necessary to move its plunger 15 to its inoperative position to permit checking of port 12', thus, slight intermittent leakage occurs from chamber 30 via annulus 22.

As a result of plunger 15 being raised to its inoperative position and, further, as a result of plunger 15' for port 12' being driven down to its third or lowermost position for the check mode, pressure loss also occurs via sample annulus 22.

In FIG. 5 the waveform illustrates restriction at point B of FIG. 2 (but for port 12'' not port 12) and the level of the pressure rise indicated at dashed line 60 is that of the purge pressure sampled as a result of the restriction. The reason for the pressure rise to line 60 for port 12'' is because it can no longer flow out its sample port; and, thus, the full purge pressure is measured in chamber 30.

In FIG. 6 the restriction is now located at point A in the structure of FIG. 2 (but for port 12'') and the reduced pressure encountered throughout the region of p_3 or port 12'' is as a result of chamber 30 now being a sealed chamber and transducer 28 not experiencing the usual effects of the purge pressure in the check mode. The computer will recognize this condition as a departure, during operation of port 12'', from the relatively straight normal flow pressure line 57 for the other ports. The present invention, however, tends to eliminate the condition of FIG. 6 because the plungers 15 are located in such close proximity to the chamber 30 that the effect of their sliding or reciprocating action tends to clear this opening or short passageway.

FIG. 7 is provided to illustrate the problems and inadequacies of the combination of prior art components in attempting to duplicate the random-addressable commutating valve of the present invention. In the first place, in order to accommodate a plurality of sample valves, such as 101, 102, etc., it is necessary to provide a sample manifold 105 connected to the transducer 107. Similarly, a purge manifold 109 is required for purged valves, such as 111 and 113. Therefore, immediately, it is seen that the volume between the valves and the transducer or manifold valves is not minimized, and there is no common selector for unitary multiple-position valves which automatically provides a purge stop or a sample stop regardless of the port selected; and, moreover, there is no common land or stop for purging of all ports simultaneously. Obviously, the speed of operation could not be expedited, as in the case of the present invention, for full utilization by computer techniques nor is it so simple to adapt the structure of FIG. 7 to accommodate simple coding and selection.

In FIG. 8 there is shown a typical prior-art-type commutating valve which provides at least a good approach to minimizing the transducer volume 150 of transducer 151 and disposing the individual sample ports 154 close to transducer 151 via commutating passageways 155 in rotating member 157 coupled to drive shaft 159. However, it is noted that the present invention provides a possibility of locating the plungers directly or at an infinitesimally small distance from the transducer volume (i.e., chamber 30 of FIG. 2) to minimize this feature even further.

Next, it will be noted that the valve of FIG. 8 is a sequential valve, not a random-addressable valve as is valve 10 of the present invention, in which any port may be selected in any sequence without movement of the bearing land plate or any other rotatable member. Additionally, purging and checking are not available with the structure of FIG. 1; and, thus, the advantages of valve 10 of this invention are appreciable.

The discussions are next to be concerned with a system enabled by the use of the random-addressable valve heretofore illustrated and described. The system enables automatic application of the valve to such problems as multiple-pressure measurements in wind tunnels, in control of process plants or factories, for use with airplane engines, and for external airframe surfaces and the like where fundamentally it is desirable to have multiple high-speed operation and random selection, in addition to purge and check features -- all available at a considerable cost savings over known devices and by a system uniquely capable of these many functions. Thus, in FIG. 9 there is illustrated a block-type schematic arrangement wherein a logical encoded four-bit computer word provides for random selection of the pressure lines to be measured and enables the purge or check modes.

In FIG. 9 the solenoids such as 16, 16', are shown schematically carried by the valve base or frame 11 for selection by the leads, such as 200, 201, etc. The rotary solenoid plate 34 of rotary solenoid 32 is shown with a bearing shaft surface positioned encoder 205 connected to its shaft for position control of the bearing plate member 34 over leads 207 and 209. The encoder 205 is provided to obviate any problem of synchronizing the bearing surface plate 34 with the required operation. For example, bearing plate 34 would simply have a "0" or short position, but could inadvertently be physically moved without use of synchronism with such coding. This problem cannot arise when the encoder 205 is employed, as will be described.

The encoder 205 comprises basically a conductive disc with alternating dielectric inserts 215. The dielectric segments 215 correspond to either the lower or upper lands with the alternative conductive portions corresponding to the other lands and a brush pickup 217 contacts the conductive disc and applies potential over lead 219 to rotary solenoid 232 whenever the logic carried by leads 207 and 209 applies potential to the disc or encoder 205. Thus, if lead 207 were the high lead (true), potential would be applied to encoder 205 and cause the rotary solenoid to step one step and to align a dielectric segment 215 with the now true lead 207, precluding any further stepping.

Since bits 0-4 may be employed for selecting at random any solenoid 16 to be energized, bit 5 and its complement from the computer peripheral buffer may be used for the logic of leads 207 and 209. Assume in FIG. 9 that when lead 207 receives a short, this condition indicates that the sample mode is required; and if rotary solenoid 32 is not in the sample mode, it must be moved to the sample mode position. Thus, a "1" applied to line driver 220 produces a high or true output on lead 207 to the conductor disc of encoder 205 and causes a voltage to be applied over lead 219 to step the rotary solenoid 32 to the sample position, it currently being in the check position. If lead 207 were already on a dielectric segment 215, the rotary solenoid would not be stepped. A "1" applied to line driver 221 will produce a high on lead 209 to provide stepping if the latter lead is on a conductive segment.

In FIG. 9 more or less conventional selection for energizing one or all of the solenoids 16 is provided from the computer peripheral buffer over cable 230 and by way of identical logic circuits 231, 231', etc., with the single exception being that each is uniquely coded for energization of its output lead to its solenoid. The Decoder section 233 merely provides an output to OR-circuit 235, if its input coincides with its preselected diodes. This logic is carried through Inverter 237 for application to output OR-circuit 239 provided to permit override by a lead 240 when the purge mode is required by enabling all solenoids to be energized simultaneously regardless of any code.

The details of the logic block 231 are shown in FIG. 10 for a single block. The computer or counter 250 uses bits 0 through 3 and their complements for the inputs to the Decoder 233 with OR-circuit 235, jointly shown at 251. The logic 251 is coded for the number 3 and provides a "1" output. Thus, a "0" output is provided for all inputs except number 3. The first transistor 255 is connected as an Inverting OR and the

second transistor 257 as an output OR for the coil 16a of solenoid 16 to energize solenoid 16. A "0" output from logic 251 turns transistor 255 off to provide a short to transistor 257 which turns it on to energize coil 16a.

The lead 240 for purging is directly connected to output transistor 257 for energization of all of the solenoid coils simultaneously.

In FIG. 11 there is shown a schematic arrangement depicting the invention in a typical application. An aerodynamic nozzle 270 is shown in which it is desired to measure a pressure profile in the region *p*. Thus, a plurality of pressure lines 273 is shown extending from the nozzle 270 to the valve, which is the valve 10 of FIG. 1.

The solenoids, such as 16 and 16', are provided for the individual ports and the Port Select Control 275 is connected between the Computer System 277 and the solenoids, the details of the circuitry of block 275 having been previously explained in connection with the description in FIG. 9.

The solenoid power line 219 of FIG. 9 is shown in FIG. 11 as extending from the Valve 10 to the Mode Select Control block 278, including the line drivers 220, 221, etc., with the selection leads 207 and 209 being connected to the Peripheral Buffer 280 of the Computer System 277. In this manner, the mode of operation, sample check, or purge may be selected from the Computer System 277 and the various pressures measured and then recorded in the computer system or the valve system analyzed at the computer by virtue of the transducer leads 285 extending from Valve 10 to the Analog Signal Calibration and Power Circuitry block 287, with the various analog signals being relayed to the Computer System 277 over signal leads 290. The analysis performed by the computer has been explained in connection with FIGS. 3-6, the signals being brought via the Analog Signal Multiplexer and Analog-To-digital Converter into the Central Processor for storage and analysis.

It will, of course, be appreciated that the nozzle 270 is merely one application for the present invention, and the pressure at region *p* could be derived from wind tunnels, engines, or the like, and the flow may be fluid, i.e., liquid or gas.

In FIG. 12 there is shown suitable logic for analyzing or diagnosing the conditions sensed by Valve 10, as discussed in connection with FIGS. 4-6. This logical function may be implemented as a discreet unit as shown in FIG. 12 and included in the Computer System 277 or it may be implemented in the Central Processor. The transducer signal from transducer 28 of FIG. 2 is applied over leads 290 to a Sample and Hold circuit 293 which may comprise a portion of the Analog-To-Digital Converter 294 (also depicted in FIG. 11) and thence via the multiple leads 295 (provided to accommodate a 12-bit word) to a Digital-Magnitude-Comparator circuit, shown as block 296. Thus, the transducer analog signal *S* is compared, after conversion to digital form, to the digital values encoded electrically by the upper and lower limit thumbwheel switches *A* and *B*. These switches are preset depending upon the type transducer employed and the particular valve installation.

The Digital-Magnitude Comparator 296 has three outputs as follows:

S is greater than *A*

A is greater than or equal to *S* which is greater than or equal to *B*

S is less than *B*

Looking at FIG. 4, the upper limit *A* would be set above the level 57, and the lower limit *B* would be set below the level 57, such that if *A* is greater than or equal to *S* which is greater than or equal to *B*, the port being checked is not clogged and the clock pulse generated by Clock 347 (FIG. 12) after being shaped and shortened by the One-Shot or monostable multivibrator 370, increments Counter 410 (which may be a 4-bit counter) which in turn supplies the 4-bit current address. This 4-bit address is transmitted to Latches 420, 430, 440, and 450 via AND-gates 416, 417, 418, and 419, which allow the 4-bit address to be transmitted only during the positive part of the shortened clock pulse from multivibrator 370.

This 4-bit address is shifted into Latch 430 by pulse *J* derived from the clock pulse through Pulse Delay circuit 380. The *J* pulse is connected to the input of Latch 430 under shift control, the Latch 430 incorporating the shift control being available as commercial circuitry.

The output of Latch 430 is the 4-bit (and complement) valve sample port address which is thus incremented in a sequential manner. In this manner, all the valve ports are checked sequentially in a first pass which is sufficient for all conditions except where two adjacent valves are clogged or appear to be clogged.

If after the digital comparison is made, the transducer signal *S* is greater than the upper limit *A*, and the clock pulse, delayed by circuits 380, 390, and 400 (identified as clock pulse *L*) is present at AND-gate 329, the output shifts the 4-bit current address to the output of Latch 420. The output of AND-gate 329 is also used to initiate a printer which is programmed simply to print the message "sample port clogged" or a unique symbol therefore along with the port number which is the 4-bit address on the output of Latch 420.

Similarly, if the transducer signal *S* is less than the lower limit *B*, the port number will be shifted by the outputs *S* is less than *B*, and *L*, shifting being effected by AND-gate 330 to the output of Latch 440. The message or symbol and port number may also be printed in accordance with this output, and in both cases the Counter 410 is incremented.

The only condition which is not completely diagnosed on the first pass is the situation where ports which are adjacent to each other, in sequence of checking, are both clogged. This is because chamber 30 of FIG. 1 cannot be vented after testing a clogged line and prior to testing an adjacent port.

The present invention resolves this problem by providing diagnostic logic for checking the ports a second time, and on this pass checking a clear port in between the sequenced ports. This second pass is only initiated if two successive signal *S*'s are greater than *A* or less than *B*, providing pulses appearing on the output of the Comparator 296 in sequence. OR-gate 310 is provided for ORing, *S* is greater than *A*, and, *S* is less than *B*. The output of OR-gate 310 provides a first input to Latch 350 via AND-gate 302 which inhibits an input when the Reset is applied. Latch 350 has its first output fed back to its second input. Both inputs to Latch 350 are shifted to the outputs every time clock pulse *L* or Reset is present, as derived from OR-gate 303.

If a "1" appears at the output of OR-gate 310 for two consecutive clock pulses, then a "1" will be present on both the 1 and 2 outputs 500 and 501, respectively of Latch 350 at the same time. These outputs are connected to AND-gate 400, which causes the *E* output via OR-gate 406 to lock in a "1" state due to the feedback to AND-gate 407. *E* is reset to "0," when Reset or *G* inhibits the feedback through AND-gate 407 from OR-gate 408.

For use during the second pass, when needed, the address of an unclogged port must be stored or available. Thus, to achieve this the logic during the first pass stores the address of the first port checked in the first pass if the first port checked is not a good port, then the logic checks for two good ports consecutively tested and stores the address of the second. The complements of the 1 and 2 outputs of Latch 350 make the output *D* of AND-gate 405 a 1 if the first port checked is unclogged or if two other ports checked consecutively are unclogged. Latch 450 is used to store the address of an unclogged port when, coincidentally, *D* equal 1, the condition *A* is greater than or equal to *S* is greater than or equal to *B* is "1" and the clock pulse *L* is "1," the output of AND-gate 410 causes the output of OR-gate 420 to be a "1." Once set to a "1," the output of OR-gate 420 stays "1" due to the feedback of AND-gate 430. The output of OR-gate 420 will return to "0" only when Reset inhibits the feedback through AND-gate 430. A "1" output from OR-gate 420 fires the One Shot or multivibrator 446. One Shot 446 will not fire again until the input resets to "0" followed by a "1." The output of One Shot 446 shifts the contents of Counter 410 into Latch 450. The

output of Latch 450 will then have the address of an unclogged port for use during a second pass.

When two clogged ports are detected in sequence on the first pass, E is set to "1" to initiate the second pass. The second pass is initiated when Counter 410 reaches full count as determined by AND-gate 320 which has four inputs, upon the occurrence of the next clock pulse, and when E is set to "1." Thus, when these conditions exist, the output of AND-gate 309, G, is a "1." The condition that G is present as a "1" is used to Reset E so that further passes beyond the second are not made. It also initiates a printer to print the message "use second pass data only" or to issue such a symbol. Further, G as a "1" is used to set the output of OR-gate 510 to a "1." The output of OR-gate 510 is fed back to the input via AND-gate 511 and remains a "1" until the feedback is inhibited by Reset. A "1" output from OR-gate 510 allows the output from One Shot 360 to pass through AND-gate 513. The output of this One Shot 360 is the shortened and shaped clock complement.

The output of AND-gate 513 is used in two phases. First, it is ORed with the regular clock signals (shortened and shaped in One shot 370) in gate 514 to make up delayed clock pulses J, K, and L. This means that during the second pass the pulses J, K, and L occur at twice the clock frequency.

The second use of the output of AND-gate 513 is to allow the unclogged port's address on the output of Latch 450 through AND-gates 421, 422, 423, and 424, and to the inputs of Latches 420, 430, 440, and 450, while the clock complement is positive.

The sequence of events during the second pass is to check the first port, check the known unclogged port, (stored in Latch 450) increment the counter 410 and check the second port, check the known unclogged port, increment counter 410 and check the third port and so forth on throughout the second pass.

If E has not been set to "1" during a pass, then AND-gate 312 will have a "1" on the output at the end of the pass (signified by a "1" from AND-gate 320 due to a full count and the occurrence of the next clock pulse). The output of AND-gate 312 is connected by line driver 490 to pull in relay K2. The power to relay K1 is wired through the normally closed contacts 600 of K2 and is disconnected when relay K2 is energized. When K1 drops out, AND-gate 334 inhibits the clock pulses and the diagnostic operation ceases. The operation may also be stopped by switching the stop switch 603 which also energizes relay K2.

To start a pass, the start switch 605 is closed momentarily to energize relay K1. This makes bit 5 applied to lead 209 of FIG. 9 high. Due to the plus 24-volt DC, encoder 205 steps stop plate 34 (FIGS. 9 and 1) to the purge or diagnostic position with the lower lands under the plungers 15.

Closing the start switch also puts a "1" on AND-gate 334 and fires One Shot 480. The output of One Shot 480 is Reset. The Reset pulse shifts a "0" into Latch 350 via AND-gate 302 and OR-gate 303, Resets E to "0" via OR-gate 408, Resets the outputs of OR-gates 510 and 420 to "0," Resets counter 410 and inhibits the clock 347 over lead 620 for the duration of the pulse.

Counter 410 is reset via OR-circuit 415 each time AND-gate 320 is "1." It is, of course, also reset when the Reset pulse is applied to OR-gate 415.

The first pass starts at the end of the Reset pulse, thus starting the diagnostic operation already described.

What is claimed is:

1. Random-access pressure-multiplexing valving apparatus employing transducing means to provide output electric signals, comprising in combination a valve body; a common sensing chamber in the valve body for influencing the transducing means to produce output electrical signals corresponding to the pressure in the chamber; a plurality of input sample ports in the valve body adapted to receive respective pressure lines; a plurality of passageways in the body respectively connecting the ports to the common chamber; a plurality of in-

dividually and independently operable valve means each at least partly movable relative to the valve body for connecting the sample ports respectively to the common chamber by opening the associated passageway; said valve means each having at least two operating states, one for connecting its associated sample port to the common chamber and the other for disconnecting its associated sample port from the common chamber; and a plurality of valve-operating means for activating the valve means selectively and independently in any sequence to establish connection between their respective sample ports and said chamber in a sample mode when used as a pressure multiplexer.

2. The apparatus of claim 1 further comprising a common input port and passageway in said valve body for connection to said chamber by any and by all said valve means, means for selectively addressing the valve means in a sample mode; and means for simultaneously addressing all valve means in a purge mode.

3. The apparatus of claim 2 further comprising means for selectively fixing the position of each valve means to more than a single position; means electrically coding the fixing means for positioning it to a selected position for the valve means only for one of a given number of conditions; and logical means for detecting said one condition to drive said fixing means to said position if not in said position and not to drive said fixing means if already there.

4. The apparatus of claim 1 further comprising a common input port and passageway in said valve body for connection to said chamber by any of said valve means; sequential addressing means for sequentially connecting the common input port passageway to said chamber by way of said valve means; magnitude comparison means for receiving the transducer output signals for each sequential valve means connected to determine if a restriction to flow exists; and output means for noting any such restrictions or the absence of any restrictions.

5. The apparatus of claim 4 further comprising means responsive to restrictions in two sequentially addressed ports to initiate a different sequential addressing of said ports for further comparison.

6. The apparatus of claim 5 further comprising means responsive to the magnitude comparison means to select a nonrestricted port; and means for interposing the nonrestricted port into the initial sequential addressing of said ports in between all successive ports addressed to preclude the detection of two sequentially addressed restricted ports, thereby insuring unique determination of the restricted port and location of the restriction relative thereto.

7. The apparatus of claim 6 further comprising means for determining if the signal output level from said transducer means is above a threshold region level of said magnitude comparison means, thereby to influence the output means to indicate that the restriction is between the selected addressed valve means and its sample port.

8. The apparatus of claim 6 further comprising means for determining if the signal output level from said transducer means is below a threshold region level of said magnitude comparison means, thereby to influence the output means to indicate that the restriction is between the selected addressed valve means and said chamber.

9. Random-access pressure-multiplexing valving apparatus employing transducing means to provide output electric signals; comprising in combination a valve body, a common sensing chamber in the valve body for influencing the transducing means to produce output electrical signals corresponding to the pressure in the chamber; a plurality of input sample ports in the valve body adapted to receive respective pressure lines; a plurality of individually operable valve means one for each port and each at least partly movable relative to the valve body for connecting the sample ports respectively to the common chamber; each said valve means comprising a movable member and a passageway in the valve body from the chamber to its sample port via the movable member with said movable member being disposed in proximity to the closed chamber to

minimize the portion of passageway between the closed chamber and the movable member; and a plurality of valve operating means for activating the valve means selectively in any sequence to establish connection between their respective sample ports and said chamber in a sample mode when used as a pressure multiplexer.

10. The apparatus of claim 9 further comprising a common input port and passageway in said valve body for connection to said chamber by any and by all valve means.

11. The apparatus of claim 10 wherein said valve means respectively include orifice means for connecting the common input port passageway to the chamber.

12. The apparatus of claim 10 further comprising orifice means included in said movable member for communication from the common input port and passageway to the chamber and the sample port therefor.

13. The apparatus of claim 9 further comprising a common input port and passageway in said valve body for connection to said chamber by any and by all valve movable members and the minimized portion of their associated passageways.

14. The apparatus of claim 13 wherein said valve movable members comprise orifice means and a bore in each valve member for connecting common input port passageway to the chamber via the minimized portion of the associated passageway.

15. The apparatus of claim 14 further comprising valve-positioning stop means for the movable members for locating any and all movable members in a selected one of a plurality of positions.

16. The apparatus of claim 15 wherein said plurality of positions comprises a first position for connecting selected sample ports to the chamber and a second position for connecting the common input port passageway to the chamber.

17. The apparatus of claim 16 further comprising electrically operable means for driving the valve position stop means selectively to establish the first and second stop positions.

18. The apparatus of claim 9 wherein said means individually activating the valve means comprises electrically movable means, and further comprising electrically operable means for selectively fixing the position for each movable member.

19. A random-addressable pressure-multiplexing valve means comprising in combination a common valve body; transducer means forming a chamber with the body; a plurality of pressure inlet passageways through the body each communicating with the chamber; means for connecting one end of each of the passageways to a plurality of pressure lines; a plurality of individually and independently actuatable means normally closing the pressure inlet passageways at respective

locations adjacent to the other ends of said passageways in proximity to said chamber; and a plurality of random-addressable means for independently opening and closing selected passageways via the associated actuatable means.

20. The valve means of claim 19 further comprising stop limit means for the individually actuatable means to stop the actuatable means in selected locations.

21. The valve means of claim 19 wherein the valve body comprises a second common chamber, and includes a further passageway in communication with the second common chamber.

22. The valve means of claim 21 further comprising stop limit means disposed in said second common chamber to receive the individually actuatable means in selected positions.

23. The valve means of claim 22 wherein said individually actuatable means comprise passageways adapted to communicate from the second common chamber internally of the valve body to the transducer chamber via the inlet passageways.

24. The valve means of claim 23 wherein said stop limit means is movable, and said actuatable means are movable to positions determined by the stop limit means.

25. A random-addressable pressure-sampling valve system, comprising in combination a valve body; transducer means forming a chamber with the body; a plurality of pressure inlet passageways through the body each communicating with the chamber; a plurality of individually actuatable valve means normally closing the pressure inlet passageways; purge inlet means common to the chamber via the respective valve means; said valve means opening the passageways to the chamber in one position and introducing purge pressure from the purge inlet means to the inlet passageways and to the chamber in another position of the valve means; a plurality of actuator means independently switching the valve means between their positions; and means for randomly addressing the actuator means and for sampling the output from the transducer means for each randomly addressed actuator means.

26. The valve system of claim 25 wherein the means for addressing and sampling comprises a comparator circuit connected to sample the transducer output signal and to produce an output indicative of a clogged inlet passageway; registering means adapted to register the address for the individually actuatable means; means for indicating the identity and condition of each individually actuatable means passageway normally closing said passageways under control of the comparator and the registering means; and means for incrementing the registering means to select a different actuatable means and its passageway for sampling.

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