

Sept. 16, 1958

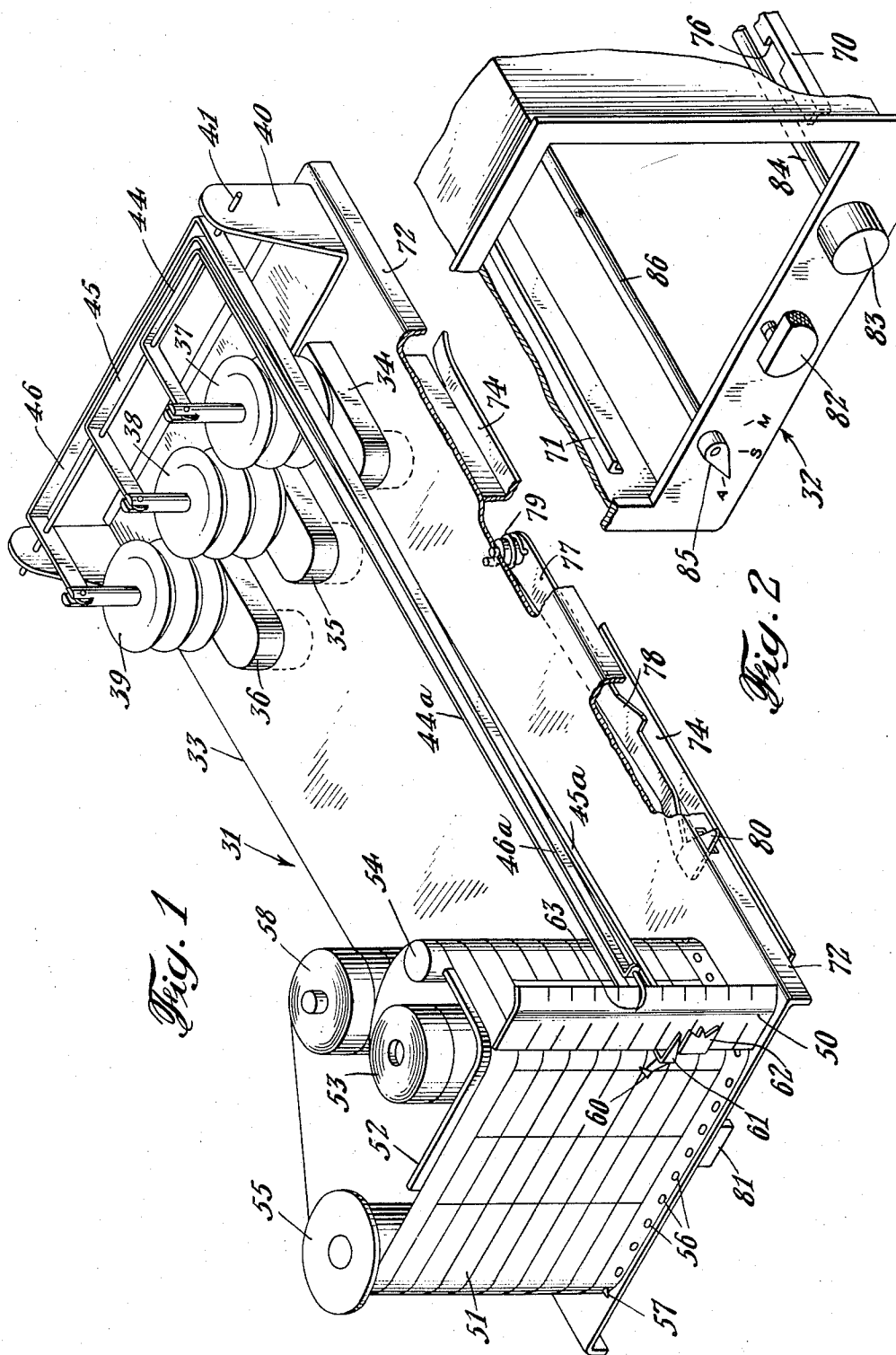
W. C. VIRBILA

2,852,197

CONTROLLING AND EXHIBITING APPARATUS

Filed Dec. 31, 1953

4 Sheets-Sheet 1



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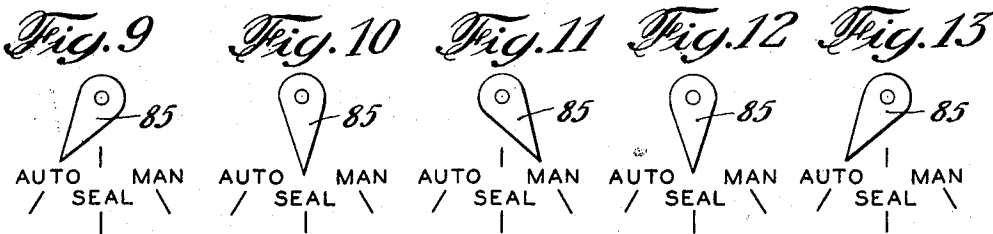
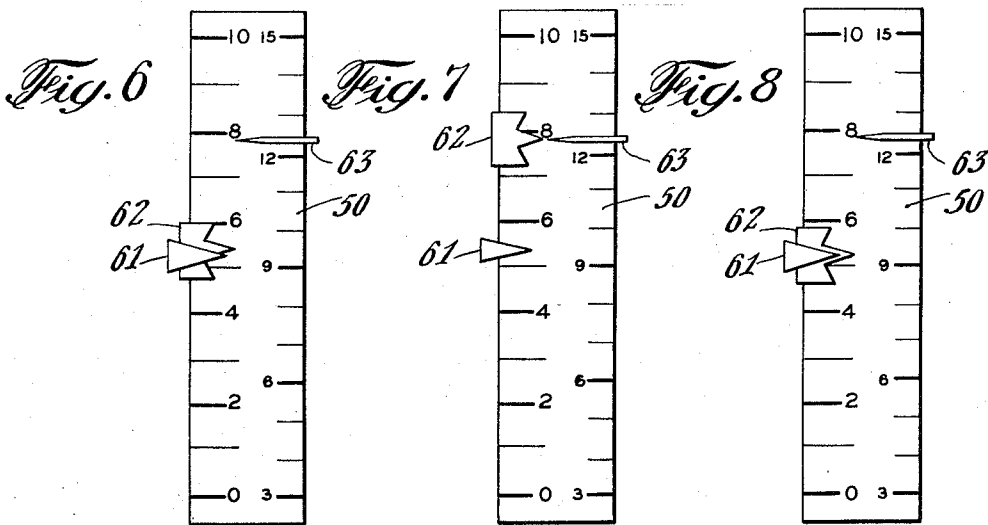
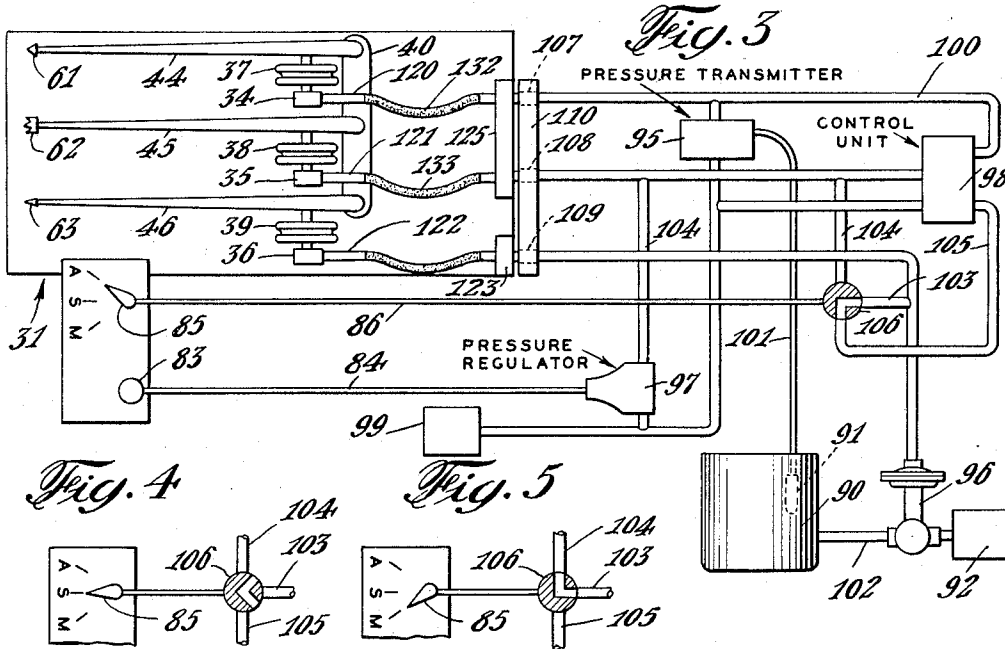
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Fig. 14

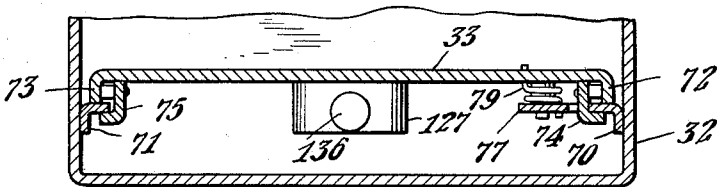


Fig. 20

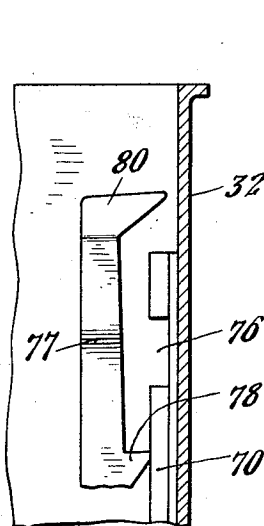


Fig. 21

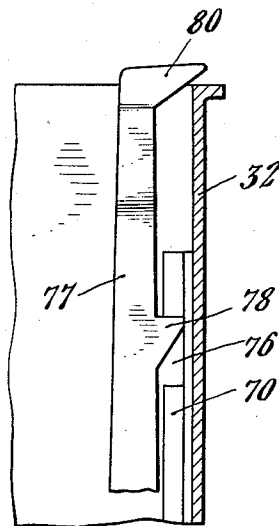


Fig. 22

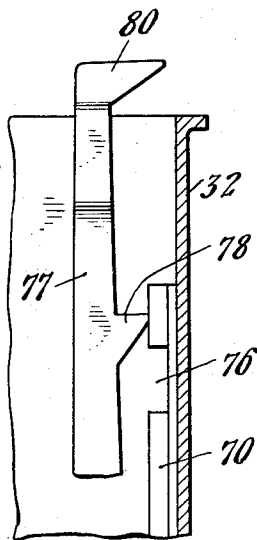
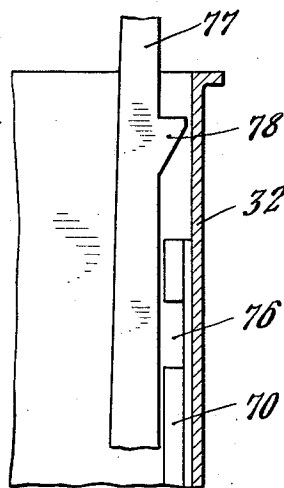


Fig. 23



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2,852,197

CONTROLLING AND EXHIBITING APPARATUS

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Application December 31, 1953, Serial No. 401,634

14 Claims. (Cl. 236—82)

This invention relates to panel-mounted instruments, and more especially to "miniature" indicators, recorders and controllers, or combinations of the same, adapted for removable and interchangeable installation in suitable mounting spaces provided in a common and standardized panel structure.

The complexity of control functions in many modern industrial processes, as, for example, oil refining, has led to an accumulation of controlling and recording instruments; and attempts to centralize these in a common location have tended toward large and cumbersome panels, occupying a prohibitive amount of valuable space, and likely to prove confusing to operators. Such considerations have led to a policy of "miniaturization," involving a decrease in the size—especially in the panel area—of instruments, and also provision for maximum flexibility and interchangeability, making it possible to install indicators, recorders or controllers (or units combining any or all of these functions), as required, and, with a minimum of manipulation or adjustment, to remove one or more such instruments for replacement by a perfect instrument of the same type in case of damage or by a corresponding instrument of another type, as might be dictated by a change in process or procedure.

Since, in many instances, the interacting elements necessary to an instrument performing its allotted function cannot practicably be reduced below certain critical dimensions, and therefore the volume of an instrument cannot always be decreased in correspondence with the desired reduction in panel area, it follows that redesign for miniaturization will result in a tendency to increase the length of an instrument in a sense measured perpendicular to the face of the mounting panel, so that the trend of design is toward a long and relatively slender instrument, having a substantially square panel projection and a depth of the order of double the panel width or height.

It will be apparent that with a device of such proportions little in the way of servicing or adjustment can be done while the instrument is in place on the panel, necessitating its withdrawal for even such routine matters as inking the pen or changing the chart. It will further be apparent that such withdrawal and all manipulations involved in securing the instrument in place or releasing it for removal must be effected from the front. Otherwise, work on one instrument might require removal of one or more adjacent units to permit of necessary access to the elements.

It is an object of the present invention to provide an instrument, alternatively of the indicating, recording or controlling form, or of a combination of two or more of the above functions, adapted for removable and interchangeable installation in a standard panel mounting.

It is a further object to provide an instrument of the above nature which shall be adapted to non-interfering installation in immediate proximity to other, and similar, instruments and with a minimum of mechanical clearance therefrom.

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It is a further object to provide an instrument of the above nature which may be securely and rigidly mounted in its operating location, and readily removable therefrom with a minimum of interference with measured or controlled functions or with the functioning of adjacent instruments.

It is a further object to provide an instrument of the above nature which may be partially withdrawn from its normal operating position for routine servicing and without in any way interfering with its normal functioning, and which may be further and completely withdrawn, and removed from the installation, without the need for manipulating electrical or piping connections.

It is a further object to provide an instrument of the above nature wherein the control function may readily be transferred from automatic to manual, or manual to automatic, without a "bump" due to sudden transition from one to another of pressures in the control system, and without the necessity for comparing or coordinating readings on different gauges.

The type of automatic regulating system to which the instrument embodying the principles of the invention is especially applicable is the pneumatic control of the "force-balance" class, embodying four units: (1) a pressure transmitter adapted to develop a fluid pressure representative of the magnitude of a measured variable, (2) a fluid-actuated control valve adapted to regulate the measured variable in accordance with the pressure of an actuating fluid applied thereto, (3) a pressure regulator adapted to receive pressure fluid from a source of supply, and to deliver fluid at an output pressure which may be adjusted at will by means of a mechanical device, (4) a force-balance control unit responsive to the difference between the pressures derived from the transmitter and the pressure regulator and adapted thereby to regulate the fluid pressure applied to the control valve. Such an installation, as well as its component elements, is fully set forth and described in a paper "The Solution of Instrumentation Problems by the Pneumatic Null Balance Method" by C. B. Moore, in the periodical "Instruments," vol. 18 (1945), page 598.

In the drawings:

Figure 1 is an isometric representation of a recording instrument embodying the principles of the invention.

Figure 2 is an isometric representation of a portion of the enclosing case in which the instrument shown in Figure 1 is normally positioned for operation.

Figure 3 is a diagram of a pneumatic control system incorporating the principles of the invention.

Figures 4 and 5 illustrate alternative positions of certain elements shown in Figure 3.

Figures 6, 7 and 8 illustrate the indicating scales of the instrument, respectively showing the several interrelated pointers or indexes in three characteristic relative positions.

Figures 9, 10, 11, 12 and 13 illustrate positions of a manually actuated member of the apparatus corresponding respectively to different stages in transition from one to another of several possible operating positions. (Figures 12 and 13 are duplicates respectively of Figures 10 and 9, and are repeated in order to maintain a sequence of views corresponding to a sequence of events in manipulation of the apparatus.)

Figure 14 is a sectional view of certain mechanical elements of the apparatus embodying the principles of the invention.

Figures 15, 16 and 17 are bottom views, showing the removable instrument in three possible positions relative to its enclosing case.

Figures 18 and 19 are side elevations showing respectively two possible relative positions of certain elements of the instrument and its casing.

Figures 20, 21, 22 and 23 are bottom views to a slightly enlarged scale showing relative positions of certain coacting members corresponding to different positions of the removable instrument assembly relative to its enclosing casing.

Referring now to the drawings, an indicating and recording instrument assembly, generally designated as 31 in Figure 1, is adapted for removable mounting in an enclosing case 32 normally forming a permanent part of a panel member. As indicated by way of example, the instrument 31 comprises an elongated sheet metal base-plate 33 having upon its upper surface near one extremity (hereinafter to be known as the rear end), three mounting members 34, 35 and 36, carrying respectively three fluid-pressure-responsive elements 37, 38 and 39. While said pressure-responsive elements are here shown as bellows members, it will be apparent that they may take the form of Bourdon tubes or equivalent devices whereby a fluid pressure may be caused to affect the position of a mechanical element. Each of the mounting members 34, 35 and 36 includes a portion projecting through the base plate 33 to its lower side, as indicated in Figures 15, 16 and 17, and also contains an internal passage, not shown in the drawings, whereby the interior of the corresponding pressure element may be placed in communication with exterior conduit means hereinafter to be described.

A bearing pedestal 40 mounted upon the base-plate 33 carries a shaft or spindle member 41 upon which are freely pivoted three J-shaped lever members 44, 45 and 46, each having a short arm and a long arm. The short arms of the lever members 44, 45 and 46 are linked respectively to the pressure-responsive elements 37, 38 and 39, whereby deflection of any of the latter due to variations of internal fluid pressure will produce a corresponding angular displacement of the corresponding lever member about the spindle 41.

Carried by the base-plate 33 at the extremity thereof remote from the mounting of the pressure-responsive elements (said extremity hereinafter to be known as the front end) is indicating and recording means comprising a calibrated scale member 50 and a juxtaposed strip chart member 51. The scale member is vertically disposed and may carry two sets of graduations adapted to cooperate with index and pointer members hereinafter to be described in providing a plurality of indications of measured variables. The graduations at the left side of the scale are preferably calibrated in terms of the measured and regulated variable, and those at the right side of the scale in terms of fluid pressure existing in certain parts of the control system with which the instrument assembly will be operatively associated. The general nature of the scale graduations will be understood from Figures 6, 7 and 8; and, as indicated in Figure 1, the right-hand edge of the scale may expediently be bent into a different plane from its front surface, rendering inconspicuous the usually less important control pressure readings and facilitating uninhibited determination of the significant magnitudes of the controlled variable.

The chart member 51 is disposed to lie in a vertical plane and is backed by a platen member 52, whereby to present a flat surface occupying substantially three quarters of the front elevation of the instrument. The chart is supplied from a stock roll 53, passes around a guide member 54 and a curved portion of the platen 52, between said platen and the scale 50 and around a drum 55 adapted for continuous rotation by means of a timing motor or clock, not shown in the drawings. The chart paper is preferably provided with uniformly spaced perforations 56 near one edge, and adapted to be engaged by correspondingly spaced pins 57 on the periphery of the drum 55, whereby to assure positive driving. After leaving the driving drum 55 the chart is collected on a re-

ceiving roll 58, or other suitable receptacle, from which it may be removed as required.

The long arm 44a of the lever member 44 extends from the rear to the front end of the instrument, near one side thereof, passes between the scale 50 and the platen 52 and carries on its extremity a recording pen or stylus 60, which bears upon the chart 51 near the right-hand edge of the platen. With changes in pressure values within the element 37, the lever member 44 will be correspondingly deflected, resulting in vertical displacement of the recording member 60, whereby there will be inscribed on the chart a graphic record of said pressure values. The long arm 44a of the lever member 44 carries also an index or pointer 61 movable with the recording member 60, and providing upon the scale 50 an indication of the pressure value as recorded upon the chart 51.

The long arm 45a of the lever 45 is extended in substantial parallelism to that of the lever 44 and in non-interfering relationship thereto, and terminates in an indicating member 62 cooperating, like the pointer 61, with the scale 50 to provide an indication of its deflected position, and hence of the pressure within the element 38. The indicating member 62, while reading on the same scale as the pointer 61, moves independently thereof, and may occupy any position with respect thereto, including a position of coincidence between the two. In order to avoid confusion of reading, the member 62 (hereinafter, for reasons which will become apparent, referred to as the spotter) is made of a different shape from the pointer 61, a preferred form being that in which it is provided with flanking wings as indicated, so that it will at no time be wholly concealed by said pointer 61.

The long arm 46a of the lever member 46 is extended in a manner similar to those of the levers 44 and 45 and terminates in an index 63, passing preferably on the side of the scale 50 remote from the pointer 61 and the spotter 62, and so formed as to follow a path substantially coincident with that followed by said pointer and spotter, whereby its deflected position may be matched with that of either of the same without reference to actual scale readings. It will be understood that any or all of the long arms of the lever members 44, 45 and 46 may be replaced by straight-line motions, well known in the art and forming no part of the present invention, whereby to eliminate the need for curvature from the scale 50 and from the surface of the chart 51.

For an understanding of the manner of supporting and securing the instrument assembly 31 within the case 32, reference may be had to Figures 1 and 2 taken in conjunction with the sectional view of Figure 14. To the opposed inner faces of the side walls of the case 32 are secured parallel rail members 70 and 71, extending for a considerable portion of the length of the casing. The base-plate 33 of the instrument assembly 31 is provided with turned-down edge portions 72 and 73 adapted to engage said rails, whereby to support said assembly in longitudinally sliding relationship. Secured to the inner faces of the edge portions 72 and 73 respectively, and preferably spaced inwardly therefrom, are angle strips 74 and 75, disposed in a manner to project outward beneath the rails 70 and 71, forming longitudinal grooves or slots wherein said rails may lie, and constraining the plate 33 and parts carried thereby to longitudinal displacement relative to the enclosing casing 32.

Formed in the rail 70 at a location near its front end is a gap or slot 76, seen in Figure 2, and clearly shown in Figures 20-23, inclusive. Said slot is positioned for engagement by a latch member 77 carried by the base-plate 33 and having a detent portion 78 adapted to enter said slot as the plate 33 attains a predetermined longitudinal displacement with respect to the casing 32. The latch member 77 is pivotally mounted on the lower face of said base-plate, and by means of a spring member 79 is urged for angular displacement in a clockwise sense as seen from the bottom of the assembly, and as shown

in various figures of the drawings. Said latch member is provided with a finger piece 80 normally enclosed within the casing 32, but projecting through an opening in the edge portion 72 when the instrument assembly is partially withdrawn, and thus accessible for manual operation of the latch. Several possible positions of the latch member 77 in its coaction with the slot 76 are shown in Figures 20, 21, 22 and 23, and will hereinafter be more fully discussed.

The base-plate 33 is provided at its front end with a downwardly projecting lug 81 and the front portion of the case 32 carries a thumb-screw 82 having a mutilated head, whereby as the instrument is inserted in the case the lug will pass over the screw, after which the latter may be rotated through a portion of a turn, securing and clamping the instrument assembly in its operating position. A manually operable knob 83 projecting through the lower portion of the front of the case 32 is carried by a rotatable rod 84, whereby to actuate regulating instrumentalities presently to be described. A manually operable indicating handle 85 carried by a rotatable rod 86, whereby to establish the position of a three-way valve also subsequently to be described, projects through the front of the case, may at will be set in any one of three positions designated "Automatic," "Seal" and "Manual," or by equivalent abbreviations.

Attention may now be directed to Figure 3, wherein is diagrammatically shown a pneumatic control system of the class with which the invention is especially useful. The express purpose of the control installation used as an example is to measure the temperature of material within a container or enclosure 90, as determined by a temperature-sensitive element 91 positioned therein, and on the basis of such measurement to regulate said temperature to a predetermined value by controlling the admission of a temperature-affecting agent from a source 92 to heat-exchange relation with said material. The control system embodies four more or less mutually distinct units as previously set forth in a general manner. These units may be recapitulated as (1) a pressure transmitter 95, (2) a control valve 96, (3) a pressure regulator 97, and (4) a force-balance control unit 98.

The pressure transmitter 95 is a device adapted to develop a fluid pressure representative of the magnitude of a measured variable. In the form shown, the device 95 is provided with an inlet connected to a source of substantially constant air pressure 99, and with an outlet connected to a conduit 100, while connection to the temperature-responsive element 91 is provided by means of a capillary tube 101. Transmitters of this class are well known in the art of telemetering and automatic control, and may be of either the force-balance or the position-balance type. The force-balance type of pressure transmitter is described in the hereinbefore mentioned paper by Moore in "Instruments," 1945. Alternatively, the position-balance type of transmitter is described in the book "Principles and Methods of Telemetering," by P. A. Borden and G. M. Thynell (Reinhold, 1948), page 191. This device is also shown in British Patent No. 525,674 issued November 21, 1940.

The control valve 96 is of a conventional form well known in the art, and here needs no description. It is provided with a body portion connected to a conduit 102, whereby to regulate the flow of heat-affecting agent there-through from the source 92 to the container 90. It is further provided with a fluid-pressure motor element operatively responsive to fluid pressure in a conduit 103 connected thereto, whereby to close or open the passage through the body portion in accordance with the magnitude of said pressure.

The pressure regulator 97 and the control unit 98 are both described in said paper by Moore. The regulator is connected to receive a supply of air from the source 99 and to deliver it to a connected conduit 104, and at a constant pressure as established by adjustment effected

by the knob 83 through the rod 84. The control unit 98 is adapted to respond to the difference between the pressures in the conduits 100 and 104 connected thereto, and thereby to supply from the source 99 to a connected outlet conduit 105 an air pressure regulated in accordance with said pressure difference.

A three-way valve 106, operable from the handle 85 through the rod 86, has connected thereto the conduits 103, 104 and 105 in such a manner that conduit 103 may at will be connected to either of the conduits 104 and 105 or that all three of said conduits may be simultaneously sealed. The three positions of said valve are indicated in Figures 3, 4 and 5, respectively. While the apparatus of Figure 3, as thus far described, comprises a complete automatic control system, the manner of operatively associating the recording instrument 31 therewith will be briefly set forth before considering the performance of the controlling apparatus.

The conduits 100, 104 and 103 are individually and respectively connected to self-sealing pneumatic receptacles 107, 108 and 109 in a block 110 mounted in the rear portion of the enclosing case 32. The internal passages within the mounting members 34, 35 and 36 of the instrument 31 are respectively connected to tubular plug members 114, 115 and 116, carried by the base-plate 33 in a manner hereinafter to be set forth, and adapted to be removably inserted in the receptacles 107, 108 and 109 whereby to provide separable connection of the respective conduits 100, 103 and 104 to the interiors of pressure-responsive bellows members 37, 39 and 38. Thus, it will be seen that the pen 60 will provide on the chart 51 a continuous record, and the pointer 61 on the scale 50 a continuous indication, of the pressure in the conduit 100, and therefore of the temperature to which the sensitive element 91 is exposed. Similarly, the spotter 62 will provide on the scale 50 a continuous indication of the adjusted pressure in the conduit 104, against which the pressure in the conduit 100 is balanced in the control unit 98. Likewise, the index 63 will provide an indication of the control pressure existing in the conduit 103 and applied to the motor element of the valve 96.

As previously stated, the scale 50 is provided with two sets of graduations, those at the left, as seen in the drawings, being common to the pointer 61 and the spotter 62, and those at the right cooperating with the index 63 to provide an indication of its deflected position. It will be further observed that the index 63 extends across its allotted graduations so that its tip follows a path substantially coincident with those of said pointer and spotter, thus facilitating comparison of the physical position of said index with that of either of said last named elements. The graduations on the left-hand side of the scale are in terms of the controlled variable—in the present instance, temperature—while those on the right-hand edge are in units of pressure applied to the motor element of the valve 96.

Attention may now be directed to the performance of the control system under normal operating conditions. With the three-way valve set to the "Automatic" position, as shown in Figure 3, and as indicated by the manually operable handle 85, the conduit 105 will be placed in direct communication with the conduit 103, so that the output pressure of the control unit 98 will be applied to the motor element of the valve 96. The pressure in the conduit 104, as adjusted by the regulator 97 according to its manual setting by means of the knob 83, and as indicated by the spotter 62 on the scale 50, will be impressed upon one side of the differentially responsive element forming a part of the control unit 98. The pressure in the conduit 100, representative of the temperature in the enclosure 90, will be opposed in the control unit to said adjusted pressure, whereby there will be produced at the outlet of said unit and impressed through the conduits 105 and 103 upon the motor element of the valve 96 a pressure representing the difference of said opposed pres-

By suitable interrelation of elements, and by adjustments well known in the art, but forming no part of the present invention, the performance of the valve 96 may be made such that its admission of temperature-effecting agent to the enclosure 90 will be of a sense and magnitude to tend to reduce to zero the difference between the opposed pressures applied to the control unit 98, and thus to maintain the temperature in said enclosure at a value predetermined by the setting of the regulator 97 through manual adjustment of the knob 83.

If the valve 106 be turned to the position shown in Figure 4, with the handle 85 opposite "Seal" on the associated plate, the conduits 103, 104 and 105 will become mutually isolated, and sealed. Thus, fluid in the conduit 103 will be trapped, so that the pressure applied to the motor element of the valve 96 will remain constant, and the valve will rest in its established position. Pressure in the conduit 105 will continue to be regulated by the control unit 98 but will be ineffective to produce any operative result. Pressure in the conduit 104 will continue subject to adjustment by the regulator 97, and will be indicated by the spotter 62 in the instrument 31, but will produce no effect on the operation of the system.

If the valve 106 be turned to the position shown in Figure 5, designated "Manual," the conduit 105 will remain cut off from the control valve and the pressure in the conduit 104 will be directly applied through the conduit 103 to the motor element of the valve 96. Since said pressure is adjustable by setting of the regulator 97, the operation of the control valve 96 thus becomes directly subject to the knob 83, whereby the opening of said valve may be manually established at any desired value.

Attention may now be directed to details of the mechanical features characterizing the mounting of the removable instrument 31 in the enclosing casing 32, and to the manner of its removal and replacement. Referring to Figures 15-19, inclusive, it will be seen that the mounting members 34, 35 and 36 which extend through the base-plate 33 are provided with short pipe or tubular projections 120, 121 and 122 respectively, interiorly communicating with said mounting members, and thus with the interiors of the respectively attached fluid-pressure-responsive elements. The tubular projections 120 and 121 are extended a short distance toward the front of the instrument near its center line, and the tube 122 is directly connected to the hollow plug member 116, which in turn is supported and maintained in alignment with the receptacle 109 by means of a mounting block 123 secured to the lower face of the plate 33 at its rear extremity and toward one side thereof.

The tubular plug members 114 and 115 are each carried by a block member 125 which in turn is secured to one extremity of a rod 126 slidably mounted in brackets 127 and 128 positioned on the lower surface of plate 33. Also carried by the block member 125 are rearwardly projecting tubular members 130 and 131 internally communicating respectively with the tubular plug members 114 and 115. Internal communication between the tubular member 130 and the tubular projection 120 is provided by means of a looped element 132 formed of flexible tubing, such as "Saran" and coupled at its extremities with said tubular member and projection. Similar connection is made between the tubular member 131 and the tubular projection 121 by means of a looped flexible element 133.

The rod 126 is, in the present instance, provided with a keyway, as indicated, in which a pin rides to constrain the same against rotation about its axis, whereby its displacement relative to its mounting is rendered solely longitudinal. Rod 126 may otherwise be constrained against rotation as by being splined or formed of non-circular cross-section. A yieldable spring-latch 135 resiliently secured to the block 110 and engaging a lip portion of the block 125 tends to maintain the same mutually juxtaposed, so that as the plate 33 is subjected to withdrawal

from the enclosing casing 32 along the rails 70-71 the tubular plug members 114 and 115 for a portion of said withdrawal are retained in engagement with the receptacles 107 and 108 respectively, communication between the pressure-responsive members 37-38 and the control piping being maintained through the looped flexible tubular elements 132 and 133 which, as indicated in the respective figures of the drawings, will be yieldably deformed with different relative positions of the stationary and the movable parts of the combination.

Longitudinal excursion of the rod 126 relative to its supports is limited by a head portion 136 formed upon the forward extremity of said rod, whereby upon withdrawal of the plate 33 beyond a predetermined distance, as indicated in Figures 16 and 17, said head portion is engaged by the bracket 127, and the rod 126 and the block 125 carried thereby forcibly displaced against the influence of the spring-latch 135, withdrawing the tubular plugs 114 and 115 from their corresponding receptacles and fully disconnecting the recording instrument from the control piping, as indicated in Figures 17 and 19.

When the instrument assembly 31 is located in its normal operating position and fully inserted within the case 32, and secured therein by means of the retaining screw 82, the three tubular plug members 114, 115 and 116 are in operative communication with their respective associated receptacles, as indicated in Figure 15, and the latch member 77, carried by the base-plate 33, occupies the position indicated in Figure 20, being constrained inwardly by engagement of the detent portion 78 with the unbroken side face of the rail 70, and exerting no holding action.

In order to withdraw the instrument assembly from the case, the retaining screw 82 is rotated to a position with its flat side uppermost, as indicated in Figure 2, when it will clear the lug 81, leaving the instrument assembly free for longitudinal displacement. As the assembly is withdrawn, the blocks 125 and 110 are maintained in mutual engagement by the spring-latch 135, and the brackets 127 and 128 slide freely along the rod 126. Displacement of the base-plate 33 with respect to the rod 126 and block 125 is coordinated with the longitudinal positioning of the detent 78 and the slot 76 in the rail 70 so that as the assembly is partially withdrawn, the latch 77 will assume the position indicated in Figure 14, the detent portion 78 entering the slot and providing a positive restraint against further withdrawal at the same time as the bracket 127, sliding along the rod 126 approaches the head portion 136. Under this condition, the relative disposition of cooperating elements beneath the plate 33 is as indicated in Figure 16, the blocks 125 and 110 remaining in cooperative engagement and pressure-fluid connections being maintained between the receptacles 107-108 and the respectively associated pressure-responsive members of the partially withdrawn instrument assembly.

In the partially withdrawn position of the instrument assembly 31, as determined by the latch member 77 in its engagement with the slot 76, the indicating and recording instrumentalities, comprising the scale 50 and cooperating pointers, the chart 51 and chart-drive, as well as the recording pen 60, are rendered readily accessible for inspection and servicing, while at the same time remaining operative to produce an indication and an uninterrupted record of the controlled variable, as well as the indication of the control point. In the present instance, only two of the pressure-responsive elements, those representing the controlled variable and the set point, remain operative under the condition of partial withdrawal of the instrument assembly, but as indicated in Figure 3, all the pressure-deflecting members may remain active under such condition, and the same can be effected by modification of the design of the cooperating plug and receptacle members. Since the mechanical connections between the handle 85 and the valve 106 and

between the knob 83 and the regulator 97 are incorporated within the stationary casing 32 and are in no way disturbed by withdrawal of the instrument assembly, it will be apparent that while the instrument is in this condition complete control is retained, with indication of the set point and both an indication and a record of the measured and controlled variable.

Should it become desirable to effect complete withdrawal of the instrument assembly 31 from the casing 32, the detent 78 is released from engagement with the slot 76 by manual depression of the finger-piece 80, shown in Figures 1 and 16 as projecting through the edge portion 72 of the plate 33 slightly to the front of the enclosing casing 32. The latch member thus disengages the slot 76 and assumes the position indicated in Figure 22, releasing the instrument assembly for complete withdrawal from the case, as indicated in Figure 17. As said assembly is withdrawn, the bracket 127 engages the head portion 136 of the rod 126, thereby overcoming the restraint of the spring-latch 135 and withdrawing the block 125 and the plugs 114 and 115 from engagement with the block 110 and the receptacles 107 and 108 respectively, whereupon said receptacles exercise their self-sealing characteristic to close the associated conduits against leakage to the atmosphere, and the spring-latch 135 reverts to the position indicated in Figure 19. At the same time, the latch 77, passing the forward extremity of the rail 70, assumes the position shown in Figure 23.

As hereinbefore pointed out, removal of the complete instrument assembly 31 from its enclosing case does not in any way interfere with the performance of the control system. As this removal is effected, the self-sealing receptacles 107, 108 and 109 cut off escape of pressure fluid in the associated conduits 100, 103 and 104; and, while removal of the instrument eliminates from the system the normal means for quantitatively determining the regulated variable or the set point of the control, the apparatus will continue to operate as a "blind" controller performing all its regulatory functions in a normal manner.

It is to be understood that while the present invention is especially well suited for use in and has been described in connection with a pneumatically actuated system, many of its important advantages are attained when the invention is utilized with other types of apparatus. In particular, the electrically operated devices of an electrical system may be mounted on base-plate 33 in casing 32 and corresponding electrical connecting devices are then utilized in place of those shown.

In the operation of practically all automatic control installations there arise occasions where it becomes desirable that regulation of the variable be rendered subject to the command of manually actuable means. This is especially true at times of starting up and of shutting down a process; but such occasions may develop at any time, and should be fully provided for in the installation. When transfer is made from automatic to manual, or from manual to automatic, control, it is of course desirable that such transfer should be as nearly as possible "bumpless," i. e., that the main control valve should not be subjected to any influence tending to cause it to make an abrupt change in its position. In a pneumatic control system, which has been selected as best exemplifying the present invention, this bumpless characteristic requires that as control is transferred from automatic to manual, or vice versa, the fluid pressures reaching the motor element of the control valve under the respective conditions be mutually equal at the instant of transfer. The peculiar adaptability of the present apparatus to the fulfillment of this condition will be apparent from a consideration of the manner in which such transfers are effected.

It may first be assumed that the installation is performing normal control under a substantially steady-state condition, with the three-way valve 106 in the position

shown in Figure 3, this being indicated by the handle 85 pointing toward "Automatic" as in Figure 9 of the drawings. The spotter 62 is set at a value of 5.4 on the left-hand graduations (which might, for example, represent a temperature of 540 degrees); and the pointer 61 in following the normal variations of automatic control is shown at a point slightly below the spotter. It may now be assumed that it is desired to change from automatic to manual control. The three-way valve 106 is first set to the "Seal" position, as shown in Figure 4 and as indicated in Figure 10. This entraps the air in conduit 103 at its last-regulated pressure as indicated by the index 63 on the scale 50. In order that there be no abrupt change in pressure as manual control is introduced, it is essential that this pressure be not suddenly changed at that time. Thus, the pressure in the conduit 104 should be the same as that in the conduit 103 before communication between the same is established. To effect this condition, it is necessary only to adjust the former of said pressures by manipulation of the regulator 97 through the control knob 83. As the position of the spotter 62 is representative of said pressure, there is thus provided a means of comparing the two pressures prior to completing the transfer. By observing the position of the spotter 62, and, without regarding its scale reading, adjustment of the pressure in the conduit 104 may be effected until said spotter is in line with the index 63, as indicated in Figure 7, at which time the two pressures are matched, and the three-way valve 106 may be turned to the "Manual" position, as shown in Figure 5 and as indicated in Figure 11, without any change in pressure applied to the valve motor and without any "bump" in the control.

The degree of opening of the control valve 96 is now wholly subject to the pressure in the intercommunicating conduits 103 and 104, as regulated by the setting of the control knob 83; and this may be varied at will, so long as the valve 106 remains set in the "Manual" position. During such time the pointer 61 will continue to indicate, and the pen or stylus 60 to record, the value of the controlled variable, while the spotter 62 and the index 63 will remain in coincident positions indicating the pressure applied to the motor element of the control valve 96.

The procedure for effecting a transition from manual to automatic control is substantially the reverse of that set forth for introducing manual control. The valve 106 is first set to the "Seal" position, as shown in Figure 4 and as indicated in Figure 12, thus entrapping air in the motor element of the valve 96 and in the conduit 103 at a pressure as last established by the regulator 97. Assuming a reasonably steady-state condition, this pressure will be such as to cause the regulated variable to have a value as indicated by the pointer 61. By adjusting the regulator 97 until the spotter 62 assumes a position in coincidence with said pointer, the air pressure in the conduit 104, balancing in the control unit 98 that in the conduit 100, will cause the pressure in the conduit 105 to attain a pressure corresponding to that in the conduit 103, whereupon the valve 106 may be thrown to the position shown in Figure 3 and as indicated in Figure 13 without abrupt change of pressure in the motor element of the control valve 96, thus completing a "bumpless" re-establishment of automatic control.

The terms and expressions which I have employed are used as terms of description and not of limitation, and I have no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but recognize that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. Controlling and indicating apparatus for controlling and indicating the magnitude of a variable condition, comprising a control valve or regulating the admission

of a condition-affecting agent, a fluid-operated motor element coupled to said control valve, condition-sensitive means and means actuated thereby for producing a first fluid pressure representative of said magnitude, an adjustable regulator adapted to produce a second fluid pressure adjustable at will, pressure-sensitive control means responsive to said first and second fluid pressures for producing at an outlet thereof a third fluid pressure representative of the difference between said first and second pressures, a first conduit for carrying fluid at said first pressure and coupled to the input side of said pressure-sensitive control means, a second conduit for carrying fluid at said second pressure and coupled to the input side of said pressure-sensitive control means where said first and second fluid pressures are opposed one to the other, a third conduit communicating with said outlet, a fourth conduit coupled to said motor element, valve means for selectively coupling said fourth conduit with either of said second and third conduits, a casing, support means, releasable means quick detachably securing said support means in said casing in a fully mounted position and for automatically securing said support means in a predetermined partially withdrawn position relative said casing, exhibiting means on said support means and for independently indicating the magnitudes of said first and second fluid pressures as well as the fluid pressure in said fourth conduit, coupling means for connecting said exhibiting means in energy transfer relation with sources of said last mentioned respective fluid pressures and including quick disconnect means and yieldable connecting means on said support means for maintaining said exhibiting means in operative and in energy transfer relation with said sources of fluid pressure when said support means is in its fully mounted position relative to said casing and when said support means is at least partially withdrawn therefrom.

2. In combination with indicating apparatus including exhibiting means for indicating values of a variable condition and actuating means in a panel member for connection with said exhibiting means in energy transfer relation; mounting means for releasably securing said indicating apparatus in said panel member comprising guide means defining a predetermined path along which said indicating apparatus is movable into and out of said panel member through an intermediate partially withdrawn position, separable coupling means including one portion mounted on said panel member and another portion releasably connected thereto, means movably connecting said another portion of said separable coupling means to said indicating apparatus and adapted to allow limited movement of said another portion relative to said indicating apparatus, yieldable means coupling said another portion of said separable coupling means with said exhibiting means so that said indicating apparatus is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said portions of said separable coupling means remain engaged and maintain said exhibiting means and said actuating means in energy transfer relation, and means for automatically decoupling said separable coupling means in response to withdrawal of said indicating apparatus beyond said partially withdrawn position while maintaining said yieldable means substantially free of strain incident to said decoupling.

3. In combination with indicating apparatus including energy translating means for indicating values of a variable condition and a panel member having actuating means for connection with said energy translating means in energy transfer relation; mounting means for releasably securing said indicating apparatus in said panel member comprising guide means defining a predetermined path along which said indicating apparatus is movable into and out of said panel member through an intermediate partially withdrawn position, quick releasable latch means for automatically securing said indicating

apparatus in said partially withdrawn position, quick disconnect separable coupling means including one portion mounted on said panel member and another portion on said indicating apparatus, means movably connecting said another portion of said separable coupling means to said indicating apparatus and adapted to allow limited movement of said another portion relative to said indicating apparatus, yieldable means coupling said another portion of said separable coupling means with said energy translating means so that said indicating apparatus is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said portions of said separable coupling means remain engaged and maintain said energy translating means and said actuating means in energy transfer relation, and means for automatically decoupling said separable coupling means in response to withdrawal of said indicating apparatus beyond said partially withdrawn position while maintaining said yieldable means substantially free of strain incident to said decoupling.

4. In combination with indicating apparatus including exhibiting means for indicating values of a variable condition and actuating means in a panel member for connection with said exhibiting means in energy transfer relation; mounting means for releasably securing said indicating apparatus in said panel member comprising guide means defining a predetermined path along which said indicating apparatus is movable into and out of said panel member through an intermediate partially withdrawn position, separable coupling means including one portion mounted on said panel member and another portion releasably connected thereto, yieldable means coupling said another portion of said separable coupling means with said exhibiting means so that said indicating apparatus is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said portions of said separable coupling means remain engaged and maintain said exhibiting means and said actuating means in energy transfer relation, and means for automatically decoupling said separable coupling means in response to withdrawal of said indicating apparatus beyond said partially withdrawn position while maintaining said yieldable means substantially free of strain incident to said decoupling.

5. A quick releasable mounting for indicating apparatus having exhibiting means as well as energy translating means adapted for connection in energy transfer relation within a panel member with actuating means for the same, comprising support means, said exhibiting means and said energy translating means being supported by said support means and operatively connected one with the other, guide means defining a predetermined path along which said support means is movable into and out of said panel member through an intermediate partially withdrawn position in which at least said exhibiting means is accessible from outside said panel member, means for automatically releasably securing said support means in said partially withdrawn position, means for maintaining said actuating means and said energy translating means in energy transfer relation when said support means is withdrawn to at least said partially withdrawn position and including quick disconnect separable coupling means having one portion thereof mounted on said panel member and another portion thereof releasably connected thereto, yieldable means coupling said another portion of said separable coupling means with said energy translating means, whereby said support means with the exhibiting and energy translating means supported thereby is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said portions of said separable coupling means remain engaged and maintain said actuating means in energy transfer relation with said energy translating means, means for automatically decoupling said separable coupling means in response to withdrawal of said

support means beyond said partially withdrawn position while maintaining said yieldable means substantially free of strain incident to said decoupling.

6. A quick releasable mounting for indicating apparatus having exhibiting means as well as energy translating means adapted for connection in energy transfer relation within a panel member with actuating means for the same, comprising support means, said exhibiting means and said energy translating means being supported by said support means and operatively connected one with the other, guide means defining a predetermined path along which said support means is movable into and out of said panel member through an intermediate partially withdrawn position in which at least said exhibiting means is accessible from outside said panel member, quick releasable latch means for automatically securing said indicating apparatus in said partially withdrawn position, means for maintaining said actuating means and said energy translating means in energy transfer relation when said support means is withdrawn to at least said partially withdrawn position and including quick disconnect separable coupling means having one portion thereof mounted on said panel member in a predetermined position relative to said path and another portion thereof supported by and movable relative to said support means, aligning means orienting said another portion of said separable coupling means relative to said path and said predetermined position whereby said portions are aligned for engagement one with the other as said support means is inserted in said panel member, yieldable means coupling said another portion of said separable coupling means with said energy translating means whereby said support means is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said portions of said separable coupling means remain engaged and maintain said actuating means and said energy translating means in energy transfer relation, and means for automatically decoupling said separable coupling means in response to withdrawal of said support means beyond said partially withdrawn position while maintaining said yieldable means substantially free of strain incident to said decoupling.

7. A quick releasable mounting for indicating apparatus having exhibiting means as well as energy translating means adapted for connection in energy transfer relation within a panel member with actuating means for the same, comprising support means, said exhibiting means and said energy translating means being supported by said support means and operatively connected one with the other, guide means defining a predetermined path along which said support means is movable into and out of said panel member through an intermediate partially withdrawn position in which at least said exhibiting means is accessible from outside said panel member, means for automatically releasably securing said support means in said partially withdrawn position, means for maintaining said actuating means and said energy translating means in energy transfer relation when said support means is withdrawn to at least said partially withdrawn position and including quick disconnect separable coupling means having members forming opposite sides thereof coupled respectively with said actuating means and said energy translating means, means movably supporting one of said members and orienting the same relative to the other of said members, yieldable means coupling the movable one of said members with the respective means associated therewith, whereby said support means is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said members of said separable coupling means remain engaged and maintain said actuating means and said energy translating means in energy transfer relation and said movable member is automatically oriented with and couples with the other member of said separable coupling means when said indicating

apparatus is inserted into said panel member for connection in energy transfer relation, and means for automatically decoupling said separable coupling means in response to withdrawal of said support means beyond said partially withdrawn position while maintaining said yieldable means substantially free of strain incident to said decoupling.

8. A quick releasable mounting for indicating apparatus having exhibiting means as well as energy translating means adapted for connection in energy transfer relation within a panel member with actuating means for the same, comprising support means, said exhibiting means and said energy translating means being supported by said support means and operatively connected one with the other, guide means defining a predetermined path along which said support means is movable into and out of said panel member through an intermediate partially withdrawn position in which at least said exhibiting means is accessible from outside said panel member, means for maintaining said actuating means and said energy translating means in energy transfer relation when said support means is withdrawn to at least said partially withdrawn position and including quick disconnect separable coupling means having members forming opposite sides thereof coupled respectively with said actuating means and said energy translating means, means movably supporting one of said members and orienting the same relative to the other of said members, yieldable means coupling the movable one of said members with the respective means associated therewith, quick releasable latch means for automatically securing said support means in said partially withdrawn position, and means for automatically decoupling said separable coupling means in response to withdrawal of said support means beyond said partially withdrawn position while maintaining said yieldable means substantially free of strain incident to said decoupling.

9. A quick releasable mounting for indicating apparatus having exhibiting means as well as energy translating means adapted for connection in energy transfer relation within a panel member with actuating means for the same, comprising a plate-like support member, said exhibiting means being supported on said plate-like member adjacent to one end thereof, said energy translating means being supported on said plate-like member adjacent to the opposite end thereof, means operatively linking said exhibiting means and said energy translating means, mounting means including a pair of elongated guide rails supported in said panel member in spaced parallel relation and defining a predetermined path, said plate-like member having opposite side portions thereof disposed for sliding engagement with said guide rails whereby said plate-like member may be inserted into and withdrawn from said panel member through an opening formed therein along said path with said plate-like member passing through an intermediate partially withdrawn position, latch means for quick releasably locking said plate-like member in said partially withdrawn position in which at least said exhibiting means is accessible from outside said panel member, mating quick disconnect coupling members one mounted on said panel member and coupled to said actuating means, means for automatically sealing said one coupling member when the other coupling member is removed from mating engagement therewith, an elongated rod slidably mounted and movable between two extreme positions on said plate-like member and having one end thereof presented toward said opposite end of said plate-like member, said rod being connected to and movably supporting the other of said coupling members adjacent to said opposite end of said plate-like member, means for orienting said other coupling member with said one coupling member, yieldable means coupling said other coupling member with said energy translating means, whereby said plate-like mem-

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ber is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said coupling members remain engaged and maintain said actuating means and said energy translating means in energy transfer relation, and means for automatically disengaging said coupling members one from the other and operative when said latch means is released and said plate-like member withdrawn from said panel member.

10. A quick releasable mounting for indicating apparatus having exhibiting means as well as energy translating means adapted for connection in energy transfer relation within a panel member with fluid-pressure-actuating means for the same, comprising a plate-like support member, said exhibiting means being supported on said plate-like member adjacent to one end thereof, said energy translating means being supported on said plate-like member adjacent to the opposite end thereof, means operatively linking said exhibiting means and said energy translating means, mounting means including a pair of elongated guide rails supported in said panel member in spaced parallel relation and defining a predetermined path, said plate-like member having opposite side portions thereof disposed for sliding engagement with said guide rails whereby said plate-like member may be inserted into and withdrawn from said panel member through an opening formed therein along said path with said plate-like member passing through an intermediate partially withdrawn position, latch means for quick releasably locking said plate-like member in said partially withdrawn position in which at least said exhibiting means is accessible from outside said panel member, mating quick disconnect fluid coupling members one mounted on said panel member and coupled to said actuating means, means for automatically sealing said one coupling member when the other coupling member is removed from mating engagement therewith, an elongated rod slidably mounted for movement between two extreme positions on said plate-like member and having one end thereof presented toward said opposite end of said plate-like member, said rod being connected to and movably supporting the other of said coupling members adjacent to said opposite end of said plate-like member, means for orienting said other coupling member with said one coupling member, flexible fluid conduits for transmitting fluid pressure from said actuating means to said energy translating means and connected to said other coupling member and to said energy translating means, whereby said plate-like member is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said coupling members remain engaged and maintain said actuating means and said energy translating means in energy transfer relation, and means on said rod and said plate-like member for automatically disengaging said coupling members one from the other and operative when said latch means is released and said plate-like member withdrawn from said panel member.

11. A quick releasable mounting for indicating apparatus having exhibiting means as well as energy translating means adapted for connection in energy transfer relation within a panel member with fluid-pressure-actuating means for the same, comprising a plate-like support member, said exhibiting means being supported on said plate-like member adjacent to one end thereof, said energy translating means being supported on said plate-like member adjacent to the opposite end thereof, means operatively linking said exhibiting means and said energy translating means, mounting means including a pair of elongated guide rails supported in said panel member in spaced parallel relation and defining a predetermined path, said plate-like member having opposite side portions thereof disposed for sliding engagement with said guide rails whereby said plate-like member may be in-

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serted into and withdrawn from said panel member through an opening formed therein along said path with said plate-like member passing through an intermediate partially withdrawn position, latch means for quick releasably locking said plate-like member in said partially withdrawn position in which at least said exhibiting means is accessible from outside said panel member, mating quick disconnect fluid coupling members one mounted on said panel member and coupled to said actuating means, means for automatically sealing said one coupling member when the other coupling member is removed from mating engagement therewith, an elongated rod slidably mounted for movement between two extreme positions on said plate-like member and having one end thereof presented toward said opposite end of said plate-like member, said rod being connected to and movably supporting the other of said coupling members adjacent to said opposite end of said plate-like member, means for orienting said other coupling member with said one coupling member, flexible fluid conduits for transmitting fluid pressure from said actuating means to said energy translating means and connected to said other coupling member and to said energy translating means, said fluid-pressure-actuating means including a three-position valve for selectively setting said actuating means for either automatic or manual adjustment and operative when said plate-like member is in said partially withdrawn position as well as when said plate-like member is in its fully inserted position, whereby said plate-like member is movable along said path from its inserted position in said panel member to at least said partially withdrawn position while said coupling members remain engaged and maintain said actuating means and said energy translating means in energy transfer relation, and means on said rod and said plate-like member for automatically disengaging said coupling members one from the other and operative when said latch means is released and said plate-like member withdrawn from said panel member.

12. In a pressure-fluid-actuated apparatus for controlling the magnitude of a variable condition and of the type comprising a control valve for regulating the admission of a condition-affecting agent and having a fluid-operated motor element, condition-sensitive means and means actuated thereby for producing a first fluid pressure representative of said magnitude, an adjustable regulator adapted to produce a second fluid pressure adjustable at will, a control device sensitive to said first and second fluid pressures and having a fluid outlet and responsive to the difference of said pressures to produce at said outlet a third fluid pressure representative of said difference, a first conduit adapted to carry fluid at said first pressure and to admit the same to said control device, a second conduit adapted to carry fluid at said second pressure and to admit the same to said control device to be pressure-wise opposed to said first fluid, a third conduit communicating with the outlet of said device, and a fourth conduit adapted to apply pressure fluid to the motor element of said control valve to operate the same, a three-position valve connected to said second, third and fourth conduits and having a first position providing communication between said third and fourth conduits, a second position wherein said second, third and fourth conduits are mutually isolated and a third position providing communication between said second and fourth conduits, individual pressure-responsive deflectable elements connected to said first, second and fourth conduits respectively and having discrete exhibiting members deflectable in proportion to the respective pressures therein, said exhibiting members in their excursions following substantially a common path whereby at any portion of said path their deflected positions may be compared and matched.

13. In a pressure-fluid-actuated apparatus for controlling the magnitude of a variable condition having a control valve with a fluid-operated motor element for regulating the admission of a condition-affecting agent, con-

dition-sensitive means and means actuated thereby for producing a first fluid pressure representative of said magnitude, an adjustable regulator adapted to produce a second fluid pressure adjustable at will, a control device sensitive to said first and second fluid pressures and having a fluid outlet and responsive to the difference of said pressures to produce at said outlet a third fluid pressure representative of said difference, a first fluid conduit for carrying fluid at said first pressure and connected between said second mentioned means and the inlet side of said control device, a second fluid conduit for carrying fluid at said second pressure and connected between said adjustable regulator and the inlet side of said control device wherein said second fluid pressure is pressure-wise opposed to said first fluid pressure, a third fluid conduit communicating at one end thereof with the outlet of said control device, a fourth conduit connected to the motor element of said control valve for applying fluid under pressure thereto for operating the same, a three-position valve coupled to said second, third and fourth conduits and having a first position providing communication between said third and fourth conduits while isolating the second conduit therefrom, a second position wherein said second, third and fourth conduits are mutually isolated and a third position providing communication between said second and fourth conduits while isolating said third conduit therefrom, pressure-responsive energy translating means coupled to each of said first, second and fourth conduits, a plurality of deflectable elements one for each of said first, second and fourth conduits connected to said energy translating means and each deflectable thereby in proportion to the pressure in the respective conduits, said deflectable elements being mounted to sweep closely adjacent paths, the deflectable element associated with said second conduit being alignable with either of the remaining deflectable elements so that said second pressure may be matched with either said first pressure or the pressure in said fourth conduit while said three-position valve is in said second position in accordance with whether the apparatus is being switched to automatic or manual operation.

14. In a pressure-fluid-actuated apparatus for controlling the magnitude of a variable condition and having a

control valve with a fluid-operated motor element for regulating the admission of a condition-affecting agent, condition-sensitive means and means actuated thereby for producing a first fluid pressure representative of said magnitude, an adjustable regulatory means for producing a second fluid pressure adjustable at will, control means sensitive to said first and second fluid pressures and responsive to the difference of said pressures to produce a third fluid pressure, means for selectively coupling said second or third fluid pressure with the motor element of said control valve and including a three-position valve, said three-position valve having a first position coupling said control means to said motor element, a second position isolating said motor element and a third position coupling said regulatory means to said motor element, and a plurality of individual pressure-responsive deflectable means connected respectively to sources of said first and second fluid pressures and to the input side of said motor element, said deflectable means each including an exhibiting member and for providing a comparison of the first and second fluid pressures and the pressure on the input side of said motor element, whereby said second fluid pressure may be readily adjusted to correspond with either said first fluid pressure or the fluid pressure on the input side of said motor element when said three-position valve is in its second position in accordance with whether the apparatus is being switched to automatic or manual operation.

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