

July 11, 1950

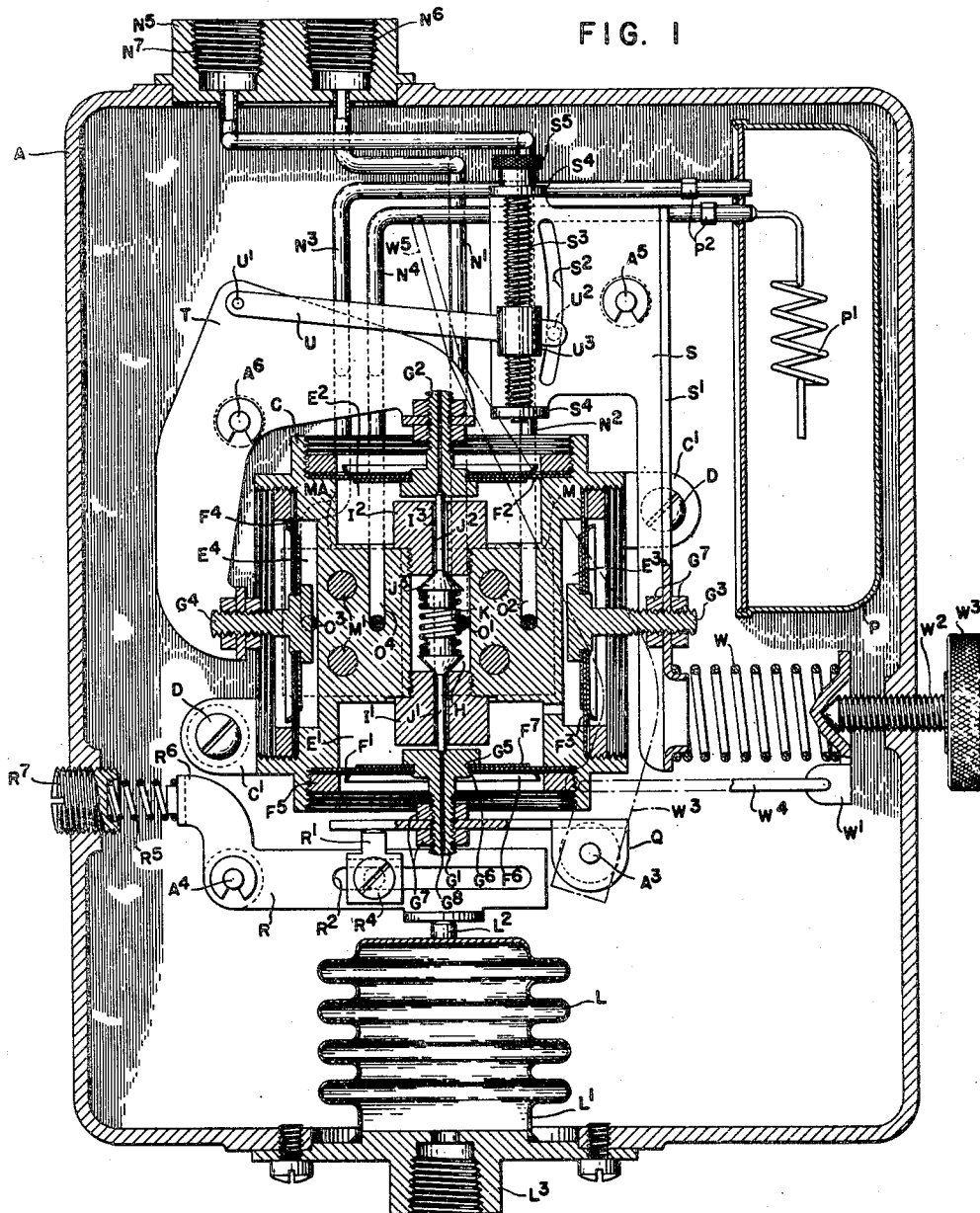
D. P. ECKMAN
CONTROL INSTRUMENT

2,514,445

Filed April 20, 1946

3 Sheets-Sheet 1

FIG. 1



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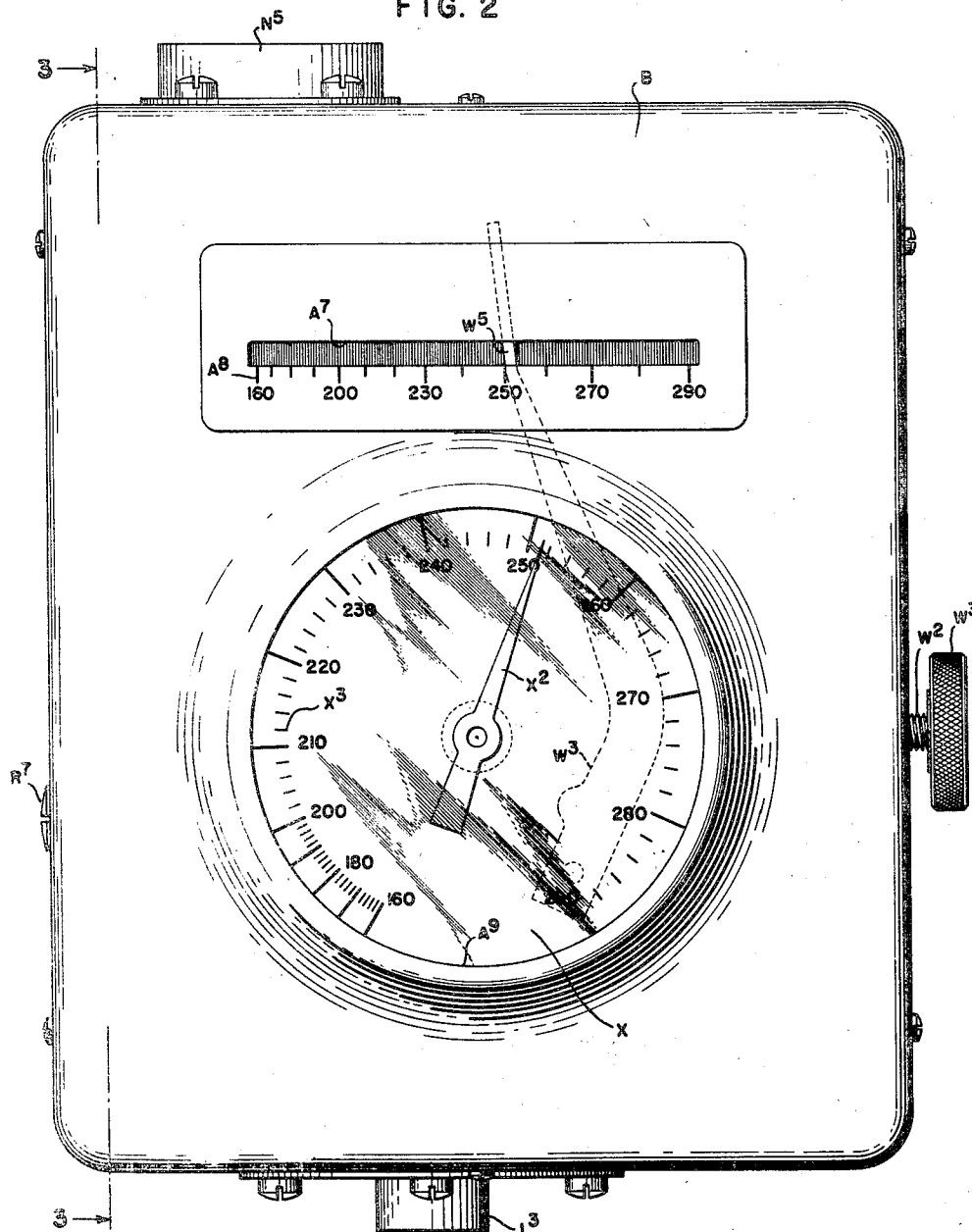
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3 Sheets-Sheet 2

FIG. 2



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3 Sheets-Sheet 3

FIG. 3

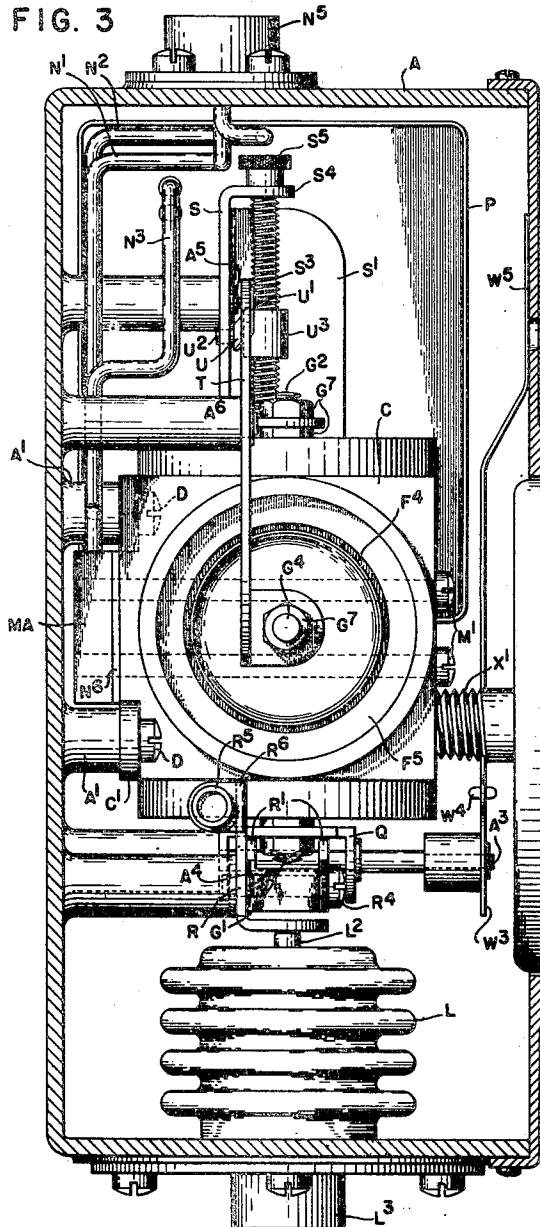


FIG. 5

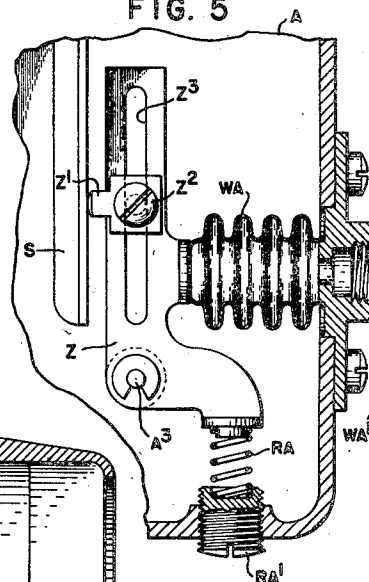
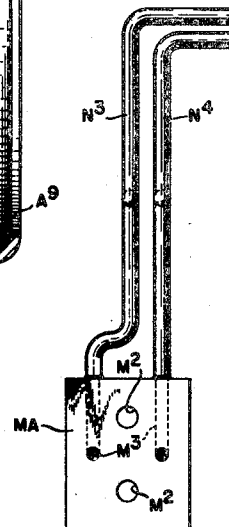


FIG. 4



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UNITED STATES PATENT OFFICE

2,514,445

CONTROL INSTRUMENT

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14 Claims. (Cl. 137—153)

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The present invention relates to air control instruments of the general type including mechanism which is actuated by a variable controlling force to automatically maintain a control air pressure which varies on and in proportion to variations in said controlling force, and which is further varied more or less slowly following a variation in said controlling force by the action of an automatic reset or compensating mechanism included in the instrument. The control pressure maintained is customarily transmitted to and actuates a diaphragm valve or other regulating device.

Various forms of air control instruments of the above mentioned general type are well known and in extensive use. Such of those instruments as have the accuracy, sensitivity and capacity for adjustment required for most uses for which such instruments have been employed, include some relatively delicate parts and are relatively heavy and bulky and inherently expensive to manufacture.

The general object of the present invention is to provide an air control instrument which has the essential operating characteristics of instruments of the above mentioned type now in general use but which is substantially simpler in structure and smaller in bulk, though desirably rugged, and less expensive to manufacture.

My improved instruments have ample accuracy and sensitivity to adapt them for use in various fields in which extensive use of the larger and more expensive instruments is now being made. Moreover, the reduced cost, weight and bulk of instruments embodying my invention make them practically available and desirable for use in fields in which the use of the prior instruments is practically precluded by their bulk, weight and high inherent cost of manufacture.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages, and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described preferred embodiments of the invention.

Of the drawings:

Fig. 1 is an elevation in section of an air controller instrument;

Fig. 2 is a front elevation of the instrument;

Fig. 3 is a section of the instrument casing taken on the line 3—3 of Fig. 2, with some mechanism parts shown in outline and others omitted;

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Fig. 4 is a front elevation of a channelled conduit connector; and

Fig. 5 is a partial section taken similarly to Fig. 1 and illustrating a modification.

The instrument shown in Figs. 1-4 comprises a casing A with a removable cover B and enclosing an air controlling mechanism unit comprising a chambered metallic body C secured to the casing A by bolts D. The body is formed with four pressure chambers E', E², E³ and E⁴, each having a movable outer diaphragm wall F', F², F³ and F⁴, respectively. The body C also includes a valve chamber H connected to a source of air under pressure, and valves J' and J² actuated by movements of the diaphragm walls F' and F² to pass air from the valve chamber to the pressure chambers E' and E² as required to maintain the pressures therein required by operating conditions. The pressure maintained in the chamber E' is proportional to, and constitutes a measure of, a controlling force which acts against the outer wall of the diaphragm F'. As shown the controlling force is the fluid pressure within a bellows element L.

The chambers E' and E³ are in free communication, and the force measuring pressure maintained in the chamber E', when transmitted to the chamber E³, constitutes an actuating pressure which acts through the diaphragm F³ on a leverage system, hereinafter described, through which any movement of any one of the diaphragm walls F², F³ and F⁴ tends to cause movement in a predetermined direction of each of the two other walls. The overall operation of the diaphragms F², F³ and F⁴, and the associated leverage system is to maintain a control pressure in the chamber E² which is proportional, directly or inversely, to the measuring pressure in the chambers E' and E³. On any change in the measuring pressure, the diaphragm wall F³ actuates the diaphragm wall F² to produce a corresponding pressure change in the chamber E². That pressure change moves the diaphragm F² and thereby produces proportional, or follow-up modification of the pressure in the chamber E². Thereafter the diaphragm F⁴ effects a reset, or compensating, adjustment of the pressure in the chamber E², tending to neutralize the preceding follow-up adjustment of that pressure. That reset adjustment is the direct result of flow through a restricted, pressure equalization flow path which connects the chambers E² and E⁴, and which in the form shown, includes a tank or capacity chamber P.

In the preferred instrument form of construction shown in Figs. 1-4, the body or device C, is a casting of brass, or other suitable metal, of rec-

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tangular outline. The body C is secured to lugs or projections A' from the back wall of the casing A, by the clamping bolts D which extend through lateral ear portions C' of the body C. Each of the four chambers E', E², E³ and E⁴ is in the form of a recess in a corresponding one of the four sides of the body C. The chambers E' and E² are at opposite sides of the body C and coaxial. The flexible diaphragms F', F², F³ and F⁴, respectively forming the outer walls of the chambers E', E², E³ and E⁴, have elongated central stem or abutment members G', G², G³ and G⁴, respectively.

As shown, the diaphragm F' is a thin disc of flexible material, such as the artificial rubber known as neoprene, and has a central orifice through which its stem or elongated abutment member G extends. A clamping ring F⁵ holds an annular peripheral edge portion of the neoprene disc F' against a rabbeted seat in the casing C. The ring F⁵ is in threaded engagement at its periphery with the member C.

Except for a relatively small annular portion adjacent the inner edge of the clamping ring F⁵, the outer side of the neoprene disc F' is reinforced and held against flexure, by metallic disc F⁶ surrounding the stem G'. As shown, the stem G' is formed with a circumferential seat G⁵ for annular portions of the neoprene diaphragm F', the disc F⁶, and an annular portion of a reinforcing disc F⁷ at the inner side of the disc F'. As shown, the wall of said recess G⁵ is upset as indicated at G⁶, to snugly secure the parts F', F⁶ and F⁷ to the stem G'. The reduced stem G' is externally threaded to receive abutment nuts G⁷ and is formed with an axial vent port G³. The diaphragm F² is shown as a counterpart of diaphragm F', and the diaphragms F³ and F⁴ need differ from diaphragm F' only in that their stem or abutment members G³ and G⁴ respectively, are not formed with axial ports. To facilitate its connection to the leverage system hereinafter described, the stem member G³ of the diaphragm F³ is made longer than the stem members of the other diaphragms.

As shown, the device L is an expansible bellows element having its stationary lower end L' supported by the bottom wall of the casing A. The movable upper end of the bellows L terminates in a thrust transmitting part L² which acts on the stem G' of the diaphragm F' through the lever arrangement hereinafter described. The controlling pressure transmitted to the bellows L by a pipe (not shown) threaded into the inlet socket L³ in the lower end L' of the bellows L may come from any one of various sources. For example, it may be the bulb pressure of a fluid pressure thermometer, or it may be a fluid pressure due to a fluid rate of flow, or to the height of the liquid level in a tank, or to a centrifugal or gravitational force.

The air controller includes conduit connections external to the body C through which the chamber E² is connected to the chamber E⁴ and to apparatus external to the air controller. Those conduit connections comprise two channelled block-like parts M and MA which are secured against the back wall of the member C by bolts M' passing through the member C and threaded into tapped openings M² in the members M and MA. The two members M and MA are identical in construction, each being formed with two side-by-side L-shaped passages M³. The two passages M³ in the member M are respectively connected at the top of the latter to flexible pipes or tubes

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N' and N². The two channels M³ in the part MA are similarly connected to flexible pipes or tubes N³ and N⁴. The passage M³ in the member M which is connected at one end to the tube N' has its other end open at the face of the part M adjacent the member C, and in register with a channel O' in the latter which opens into the valve chamber H. Similarly the passage M³ in the member M which is connected at one end to pipe N², has its other end in register with a channel O² in member C which opens into the control pressure chamber E². The channels M³ in the member MA have their upper ends respectively connected to the pipes N³ and N⁴, and have their other ends in register with channels O³ and O⁴ formed in the member C and opening into the chambers E⁴ and E³, respectively. To avoid leakage, a gasket N⁶ may well be clamped between each of the members M and MA and the member C, each gasket being forced with apertures in register with the corresponding channels O' and O² or O³ and O⁴, respectively.

The ends of the tubes N' and N² remote from the part M are connected to a connection or conduit coupling part N⁵ normally mounted in and extending through the top wall of the casing A. The part N⁵ is formed with threaded sockets N⁶ and N⁷ opening externally of the casing and into which the tubes N' and N² respectively open. Air from a source of air at a constant pressure may be supplied to the valve chamber H, and the pressure in the control pressure chamber E² may be transmitted to a diaphragm valve or other fluid pressure regulating device, by pipes (not shown) threaded into the socket N⁶ and N⁷, respectively. The ends of the tubes N³ and N⁴ remote from the block MA are connected through the tank or capacity P and a capillary tube P', to thereby establish the previously mentioned restricted, pressure equalizing, flow path between the chambers E² and E⁴. As shown, the tube N³ establishes free connection between the chamber E⁴ and the interior of a tank or chamber P which is replaceably mounted in the casing A, and the tube N⁴ establishes a restricted connection between the chamber E² and said tank or chamber P through the capillary tube P'.

The pipes N³ and N⁴ are shown as connected to the tank P and capillary tube P', respectively, through unions or other readily separable connectors P² so as to permit the ready replacement of one tank P by another which may differ from the first in various ways. In particular, the two tanks may differ in volumetric capacity or in the resistance to flow of their respective capillary pipes P', or in both respects. By the interchangeable use of such tanks, the air controller may be readily adapted to provide the particular reset action made desirable by any particular industrial process or operation, with which the instrument is used. Thus, for example, the set of tanks P and associated capillaries P', provided for interchangeable use with an air controller, may be of a character to adapt the air controller for use in controlling so-called two, five, ten and thirty minute processes.

The valve chamber H is in the form of an open ended passage in the body C coaxial with and extending between the chambers E' and E². The ends of the passage H are internally threaded to receive threaded valve seat members I' and I², which have head portions in the chambers E' and E², respectively. Each of the valve members I' and I² is formed with an axial passage or port I³. Extending through but not filling the axial pas-

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sages I³ in the valve members I' and I², are the elongated stem portions of valve members J' and J², respectively. The portion of each of the valve members J' and J² within the chamber H is an enlarged conical head J³ constituting a valve or stopper part which closes the passage I³ in the corresponding valve seat member I' or I², when in engagement with the latter. Each valve portion J³ is biased for closing movement by a helical spring K extending between the enlarged inner heads of the two valves J' and J² and surrounding spring centering portions of those valves. Ordinarily, also, the air pressure in the chamber H exceeds the air pressure in each of the diaphragm chambers E' and E and tends to hold each of the valve members J' and J² in engagement with the corresponding valve seat member.

Whether the end portion J³ of the valve member J' is or is not in position to close the passage I³ in the valve seat member I', the other end of the valve member ordinarily extends into engagement with the diaphragm abutment member G' and closes the axial passage G³ therein. However, when the controlling force exerted by the device L on the diaphragm F' decreases relative to the opposing force due to the air pressure in the chamber E', the diaphragm F' moves its member G' out of engagement with the valve member J'. This permits air to vent to the atmosphere through the vent port G³, until the forces acting on the opposite sides of the diaphragm are again equalized. When the force on the diaphragm F' due to the member L exceeds that due to the air pressure in the chamber E', the diaphragm F' moves inward. That movement forces the head J³ of the valve member J' away from the valve seat member I' and opens the corresponding passage I³. Air then passes from the valve chamber H into the chamber E' as required to restore the normal condition in which the ports in the member I' and G' are both closed.

The diaphragm F² acts similarly on the valve J² to make the pressure in the chamber E² that required to balance the force acting against the outer side of the diaphragm F² by the hereinafter described lever T.

The required axial movement of each of the diaphragms F, F², F³ and F⁴ is extremely small, ordinarily being of the order of one or two thousandths of an inch. In consequence, the external force supplying or transmitting connection to each diaphragm may be and in the construction shown is in the form of a lever mounted on a pivot transverse to and laterally displaced from the axis of the diaphragm, and having an arm rigidly connected to the diaphragm stem. As shown the lever arm so attached to each diaphragm is formed with an aperture through which the threaded end of the diaphragm stem extends, so that the lever arm may be clamped between the nuts G⁷ threaded on the diaphragm stem. A lever Q mounted on a pivot pin A³ secured to the back wall of the casing A, is connected as just described to the stem of the diaphragm F'. The thrust of the bellows L is transmitted to the lever Q and thereby to the diaphragm F' through a second lever R and an adjustable thrust member R'. The lever R is shown as mounted on a pivot A⁴ carried by the back wall of the casing A, and at the opposite side of the stem G' from the pivot A³. The thrust transmitting element R' is mounted on the lever R for adjustment longitudinally of the latter. To this end, the lever R is formed with a longitudinal slot R² through which passes a clamping screw R⁴ for securing

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the thrust part R' to the lever R in any desired adjustment. The purpose of this adjustment of the thrust block is to vary the leverage with which the element L acts on the diaphragm E', and thereby vary the ratio between the pressures normally maintained in the bellows L and chamber E'.

For zero calibration purposes, a compression spring R⁵ is interposed between an arm R⁶ of the lever R and an adjustable abutment R⁷. As shown, the latter is a short bolt mounted in a threaded aperture in the side wall of the casing A. Ordinarily, the parts are so arranged and adjusted that under the condition in which the pressure in the chamber E' should be at a minimum and equal to the pressure of the atmosphere, the stem G' will occupy the position in which the head of the valve member J' closes the passage J³ in the valve seat member I' and the other end of the valve member J' closes the vent port G³ in the stem G'. To facilitate zero calibration, the parts are so proportioned that with the abutment R⁷ in an inoperative position the resiliency of the bellows L will prevent the valve J from closing the passage I³ in the valve seat member I' when the fluid pressures in the chamber E' and in the bellows L are at their minimum values. With the parts so arranged, the zero adjustment is effected by rotating the bolt R⁷ until the valve J' closes the passage I³ in the valve seat member I'.

The illustrated leverage system associated with the diaphragms F², F³ and F⁴ comprises a lever S connected to the stem of the diaphragm F³, a bell crank lever T having one arm connected to the diaphragm F² and a second arm connected to the diaphragm F⁴, and a connection including a link U between the levers S and T. As shown, the lever S is mounted on a pivot pin A⁵ at a level above the top of the member C. The depending arm of the lever S is shown as L-shaped with the diaphragm stem G³ extending through an aperture in the web portion S' of the arm, said web portion being clamped between the corresponding pair of nuts G⁷. The bell crank lever T is mounted on a pivot pin A⁶ carried by the back wall of the casing and so positioned that a clockwise movement of the lever T, as seen in Fig. 1, will be attended by an in and out movement of the diaphragms F² and F⁴, respectively.

The link U has one end connected to the lever T by a pivot pin U' so located that in all operative positions the link U is at one side of the pivot A⁶. The second end of the link U is adjustably connected to the lever S so that a given angular adjustment of the lever S may cause either a clockwise, or a counterclockwise adjustment of the bell crank lever T. With such adjustment capacity, the control pressure in the chamber E² may be caused to vary in direct proportion, or in reverse or inverse proportion to the controlling pressure transmitted from the measuring chamber E' to the receiver or actuating chamber E.

Advantageously and as shown, the connection between the link U and lever S may also be adjusted to vary the proportional control band or "throttling range" of the air controller, said proportional control band or throttling range adjustment, is an adjustment of the extent of change in the controlling pressure required to vary the control pressure in the control chamber E² through a given range, for example, the range required for the adjustment of an associated diaphragm regulator valve between its wide open and fully closed positions.

The means shown for adjustably connecting the link U to the lever S comprises a transverse pivot pin U² carried by the adjustable end of the link U and extending through a slot S² formed in the lever S. The slot S² shown is a circular arc which is substantially concentric with the pivot pin U¹ and has its opposite ends at approximately equal distance from the plane including the axes of the pivot pins U¹ and U². Swivelled on the lever U adjacent the pivot U² is a nut U³ through which is threaded a shaft S³. The latter has its ends journaled in bracket portions S⁴ of the lever S, and is provided at one end with a knob S⁵. By rotating the threaded shaft S³ the pivot pin U² may be adjusted longitudinally of the shaft into the operative position in which a given extent of angular adjustment of the lever S, will produce the angular adjustment of the lever T required for direct or inverse regulation with the desired throttling range.

In order that different predetermined pressures in the actuating chamber E³ may maintain the control pressure diaphragm F² in its intermediate or neutral position in which the air inlet to, and vent from the chamber E² are both closed, the instrument is provided with so-called control point adjusting means. Such means, in the form shown in Fig. 1, comprises a bias or loading spring W acting on the lever S in opposition to the thrust of the diaphragm F³. The spring W acts between the lever and an adjustable abutment W'. The latter is carried by a threaded spindle W² passing through a threaded aperture in the side wall of the casing A. The outer end of the spindle W² carries a knob W³ which is rotated to vary the control point adjustment of the instrument. In effect the spring W is a resilient strut opposing out movement of the diaphragm with a yielding force regulated by rotation of the spindle W². As shown in Figs. 1 and 2, the existing control point adjustment is indicated by the angular adjustment of a lever W³ which has one end pivoted on the pivot pin A³ and which is connected by a link W⁴ to the abutment W'. As shown in Fig. 2, the end W⁵ of the lever W³ remote from the pivot A³ extends behind a slot A⁷ in the casing cover member B and forms an index cooperating with scale marks A⁸ on the cover B to show the existing control point adjustment.

As previously stated, the pressure maintained in the chamber E' is a measure of the controlling quantity giving rise to and varying with the pressure in the bellows L. For some uses of the air controller, the latter is advantageously provided with gauge means for exhibiting the varying values of the measuring pressure. When such exhibiting means are required they may advantageously take the form of a pressure gauge X as illustrated. The pressure gauge X is attached to the controller body C by screwing a threaded nipple extension X' of the gauge X into a threaded opening in the portion of the body C forming the front wall of the measuring chamber E'. The pressure gauge X may be of any usual or suitable form adapted for use in measuring the relatively low pressures in the chamber E'. Ordinarily, the pressure in the chamber E' may vary from zero up to a maximum which ordinarily will be a few pounds per square inch. As shown, the gauge X is circular in form and comprises an index arm X² deflecting along a suitably graduated scale X³. As shown, the circular gauge X has its outer portion extending

through and snugly received in a circular opening A⁹ in the casing cover B. With the described arrangement, the index X² and dial markings X³ may be of such character as to be easily read by a person in front of and at an appreciable distance from the controller, notwithstanding the relatively small size of the latter. The air controller shown in Figs. 1, 2 and 3, operates to create a control air pressure in the chamber E² which may be transmitted through the pipe N² and nozzle N⁵ to an external diaphragm valve or other fluid regulating device, for actuation of the latter in accordance with variations in a controlling quality or force transmitted to the diaphragm F' through the lever R from a source of pressure or device external to the air controller. As shown, the controlling force is the fluid pressure in the bellows L which is normally balanced by the air pressure in the chamber E'. On an increase or decrease in the controlling bellows pressure, the diaphragm F' and valve member J' cooperate to respectively supply air under pressure from the valve chamber H to the chamber E' and thereby increase the pressure in the last mentioned chamber, or to discharge air to the atmosphere through the axial passage G⁸ in the abutment member G' and thereby lower the pressure in the chamber E'. The valve chamber H is connected through piping which includes the pipe N', to an external source (not shown) of air under pressure.

The pressure in the chamber E' is proportional to and constitutes a measure of the controlling force impressed on the lever R by the bellows L. The chambers E' and E³ are in free communication, and in the chamber E³ the measuring pressure serves as an actuating pressure operating through the diaphragm F³ and force transmitting means comprising the levers S, and T and link U, to increase and decrease the control pressure in the chamber E² as the pressure in the chamber E³ increases and decreases. The pressure in the chamber E² is directly controlled by the diaphragm F² forming the outer wall of that chamber. On an increase in the pressure in the chamber E³, the diaphragm F³ operates through the levers S and T and link U to force the diaphragm F² inward and thus give the valve member J² an opening adjustment which permits air under pressure to pass from the valve chamber H into the chamber E² and thereby increase the pressure in the latter. Conversely, on a decrease in the pressure in the chamber E³, the levers S and T and link U permit outward movement of the diaphragm F² and abutment member G² with the result that the axial channel in the member G² is opened so that air may bleed to the atmosphere through said channel and thereby reduce the pressure in the chamber E².

An initial change in the pressure in the chamber E², directly resulting from a movement of the diaphragm F³, is normally followed by an automatic reset pressure change in the same direction. That reset change is due to an adjustment of the valve J² resulting directly from a pressure change in the reset chamber E⁴. That pressure change is due to the slow leakage of air between the chamber E² and the tank or chamber P through the conduit connection including the capillary tube P', accompanied by the action of the pipe N³ in equalizing the pressures in the chambers E⁴ and P'. On each such retarded increase or decrease in the pressure in the chamber E, the diaphragm F⁴ acts through the lever T to adjust the valve J² in the direction to re-

spectively increase or decrease the control pressure in the chamber E^2 .

As has been explained, zero calibration of the air controller is effected by rotating the threaded abutment R^7 and thus varying the tension of the spring R^5 . The adjustment of the pivot U^2 to the upper or lower side of the plane including the axes of the pivots U^1 and A^5 , determines whether the proportion maintained between the pressures in the chambers E^3 and E^2 is direct or inverse, respectively. The distance between said plane and the pivot U^2 determines the extent of throttling range or band of the air controller. An adjustment of the screw W^2 which increases or decreases the tension of the spring W , constitutes a control point adjustment of the controller.

In some cases, the character of use to which the controller may be put, will be such as to make any indication of the value of the measuring pressure unnecessary, and the inherent cost of producing the controller may then be reduced by omitting the pressure gauge X . In such case, the casing cover B shown in the drawings may be replaced by a casing cover differing from the one shown, only in the omission of the aperture A^9 . The threaded opening in the front wall of the chamber E^1 closed in the illustrated construction by the nipple X' , may then be closed by a screw plug. The mere removal of the gauge X will not alter the operation of the air controller shown but will convert it from an indicating measuring instrument to a so-called blind measuring instrument.

When, as may sometimes be desirable, the air controller shown is employed to create a control pressure varying in accordance with a controlling pressure established externally of the air controller, no use need be made of the diaphragm F^1 and valve member J' . In such case, the diaphragm F may be replaced by a rigid closure for the outer end of the chamber recess E' . Said closure may be provided with a socket, like the socket L^2 , carried by the bottom wall of the bellows member L , for connection to a pipe transmitting the controlling pressure to the air controller. When the valve J' is thus made unnecessary, that valve member may be removed and the valve seat member I' may be replaced by a plug having an inner end which forms a suitable abutment for the spring K . As will be apparent when the pressure gauge X is not included in the instrument, the nipple X' may be replaced by a pipe leading to an external indicating or recording pressure gauge.

In the modification shown in Fig. 5, the loading spring W of the construction previously described is replaced by an expansible bellows element WA acting between the depending end of the lever S and the adjacent side wall of the casing A . As shown, the rigid end wall of the bellows engaging the casing is formed with a threaded inlet socket portion WA' which extends through the casing side wall. With this arrangement a pipe threaded into the socket WA' may be employed to transmit a fluid pressure to the bellows from some external source of regulable pressure. A variation in the pressure thus transmitted to the bellows WA makes possible an automatic control point adjustment effect, analogous to the effect obtained by the manual rotation of the threaded spindle W' to regulate the tension of the spring W . The remote control pressure transmitted to the bellows WA may be varied by means external to the instrument and actuated either

manually or automatically. For example, the pressure in the bellows may be varied by external means responsive to changes in fluid pressure developed by other apparatus. Thus such an air controller as is shown in Figs. 1-4, may have its control pressure or its measuring pressure transmitted to the inlet WA' of the bellows WA .

As shown in Fig. 5, the control point setting may be adjusted manually at the instrument, as well as by remote control of the pressure transmitted to the bellows WA . Such manual adjustment at the instrument of the control point setting is effected by varying the leverage with which the bellows WA acts on the lever S . To this end, a lever Z , for which the instrument pivot pin A^3 forms a fulcrum, is interposed between the bellows WA and the lever S . Mounted on and adjustable longitudinally of the lever Z is a thrust member Z' through which the lever Z and thereby the bellows WA acts on the lever S at a distance from its supporting pivot A^3 which varies with the adjustment of the thrust part Z along the length of the lever Z . As shown, the part Z' is adjustably secured to the lever Z by a clamping screw Z^2 extending through a longitudinal slot Z^3 in the lever Z .

As will be apparent, the control point adjustment obtainable with the apparatus shown in Fig. 5 is generally like that obtainable with the arrangement shown in Fig. 1, in that it serves to vary the pressure in the actuating chamber E^3 in which the position of the lever S is such as to permit the control pressure diaphragm E^2 to occupy its intermediate or normal position in which the air inlet port to the chamber E^2 and the diaphragm vent outlet from that chamber are both closed when the pressure in the reset chamber E^4 is equal to the pressure in the chamber E^2 .

What may be called a zero point calibration of the control point adjusting apparatus shown in Fig. 5 is obtainable by means of a spring RA acting between the lever Z and an adjustable abutment RA' . As shown, the abutment RA' is in the form of a short bolt threaded through the bottom wall of the casing A . The practical effect of the adjustment of the abutment RA' is to vary the position of the diaphragm F^3 at which a given pressure in the chamber F^3 will permit the control pressure diaphragm F^2 to occupy its neutral or intermediate position.

While in accordance with the provisions of the statutes, I have illustrated and described the best forms of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the forms of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. An air controller comprising a body formed with three recesses extending into the body from different portions of its outer surface with their outer ends facing in respectively different directions and a separate flexible diaphragm extending across the outer end of each recess, said recesses and associated diaphragms forming separate actuating, control pressure, and reset chambers, means for maintaining an actuating pressure in said actuating chamber, a leverage

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system comprising separate arms respectively engaging the three diaphragms and so connected that axial movement of one diaphragm causes axial movements of each of the other two diaphragms, valve means actuated by the diaphragm of the control pressure chamber for admitting air to, and exhausting air from that chamber as required to minimize axial movement of its diaphragm by said leverage system on a change in said controlling pressure, and a restricted, pressure equalizing, flow path connecting said reset and control pressure chambers.

2. An air controller as specified in claim 1, including a casing in which said body is mounted with the lever arm engaging the actuating chamber diaphragm between said diaphragm and a side wall of the casing and means for impressing a regulable bias force on said lever arm comprising a strut connection between said side wall and lever arm which includes an expansible strut portion under a tension tending to elongate such portion and including a strut portion adjustable to vary the length of said strut connection when the expansible portion thereof is under a given tension.

3. An air controller as specified in claim 1, including a casing in which said body is mounted with the lever arm engaging the actuating chamber diaphragm between said diaphragm and a side wall of the casing, and means for impressing a regulable bias force on said lever arm comprising a threaded member extending through a threaded passage in said side wall and an expansible strut acting between said threaded member and lever and subjecting the latter to a yielding force opposing outward movement of said diaphragm.

4. An air controller as specified in claim 1 including a casing in which said body is mounted with the lever arm engaging the actuating chamber diaphragm between said diaphragm and a side wall of the casing and means for impressing a regulable bias force on said lever arm comprising a bellows element interposed between said side wall and lever arm and subjecting the latter to a yielding force which opposes out movement of the actuating chamber diaphragm and varies with the pressure in said bellows, said bellows having an inlet for the transmission of a fluid under a pressure regulated externally at the bellows.

5. An air controller as specified in claim 1 including a casing in which said body is mounted with the lever arm engaging the actuating chamber diaphragm between said diaphragm and a side wall of the casing and means for impressing a regulable bias force on said lever arm comprising a strut connection between said side wall and lever arm including a bellows element having an inlet for the transmission of fluid pressure to the bellows and a thrust transmitting means interposed between the bellows and the lever arm and adjustable to vary the ratio between the pressure in the bellows and the yielding force impressed by the bellows on the lever arm by a given fluid pressure in said bellows.

6. An air controller comprising a body formed with three recesses extending into the body from different portions of its outer surface with their outer ends facing in respectively different directions and a separate flexible diaphragm extending across the outer end of each recess whereby said recesses and associated diaphragms form separate actuating, control pressure, and reset chambers, the control pressure diaphragm being

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formed with a central vent port, means for maintaining a controlling pressure in said actuating chamber, a leverage system comprising separate arms respectively engaging the three diaphragms and so connected that an axial movement of one diaphragm causes axial movements of each of the other two diaphragms, valve means actuated by the diaphragm of the control pressure chamber for admitting air to valve means controlling the admission of air under pressure to the control pressure chamber and comprising a valve member biased to a closed position and engaged and moved to an open position by said diaphragm and closing said vent port when the diaphragm moves inward from an intermediate position and being permitted to move to its position and to open said vent port when the diaphragm moves outwardly into and through its intermediate position.

7. An air controller comprising a body formed with three recesses extending into the body from different portions of its outer surface with their outer ends facing in respectively different directions and a separate flexible diaphragm extending across the outer end of each recess whereby said recesses and associated diaphragms form separate actuating, control pressure, and reset chambers, said body being formed with a valve chamber having an inlet for air under pressure and an outlet port opening centrally into said control pressure chamber and the control pressure diaphragm being formed with a central vent port, means for maintaining an actuating pressure in said actuating chamber, a leverage system comprising separate arms respectively engaging the three diaphragms and so connected that an axial movement of one diaphragm causes axial movements of each of the other two diaphragms, a movable valve member mounted in said body for actuation by the diaphragm of the control pressure chamber to open said outlet port and close said vent port as the diaphragm moves inward through an intermediate position and closes said outlet port and opens said vent port as the diaphragm moves outward through said intermediate position.

8. An air controller comprising a body recessed at three sides and a separate flexible diaphragm extending across the outer end of each recess whereby said recesses and associated diaphragms form separate actuating, control pressure, and reset chambers, a leverage system comprising a bell crank lever having one arm engaging the diaphragm of said reset chamber and a second arm engaging the diaphragm of said control pressure chamber and pivoted so that turning movement of the lever in either direction produces an in movement of one, and permits an out movement of the other of the two diaphragms engaged by said arms, a second lever having an arm engaging the actuating chamber diaphragm and pivoted to turn about an axis laterally displaced from the axis of the last mentioned diaphragm, and a link connection between said levers whereby axial movement of the actuating chamber diaphragm produces an in movement of one and an out movement of the other of said reset and control pressure chamber diaphragms, means for maintaining an actuating pressure in said actuating chamber, valve means actuated by the diaphragm of the control pressure chamber to admit air to, and exhaust air from that chamber as required to minimize axial movement of its diaphragm on a change in said controlling pressure, and a restricted pressure equalizing

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flow path connecting said reset and control pressure chambers.

9. An air controller comprising a body recessed at four sides and a flexible diaphragm extending across the outer end of each recess whereby said recesses and associated diaphragms form measuring, actuating, control pressure and reset chambers, valve mechanism actuated by movement of the measuring chamber diaphragm to admit air to, and vent air from the measuring chamber as required to maintain an air pressure in said chamber proportional to a controlling force acting against the outer side of the last mentioned diaphragm, said measuring and actuating chamber being in free communication, a lever system associated with the diaphragms of the actuating, control pressure and reset chambers whereby movement of any one of the last mentioned diaphragms tends to produce movement of each of the others, valve means through which the movement of the diaphragm of the control pressure chamber admits air to, or vents air from that chamber when the pressure in the control pressure chamber changes in one direction or in the opposite direction, means for connecting the control pressure chamber to a regulating device controlled by the pressure in that chamber, and a restricted flow equalizing connection between said follow-up and reset chambers.

10. An air controller comprising a body recessed at four side and a flexible diaphragm extending across the outer end of each recess to form a pressure chamber, two of the pressure chambers so formed being coaxial and serving as measuring and control pressure chambers and the other two serving as actuating and reset chambers, a lever system engaging the diaphragms of the actuating control pressure and reset chambers whereby movement of any one of the three corresponding diaphragms produces movement of each of the other two of those diaphragms, said body being formed with a valve chamber between said measuring and control pressure chambers and supply ports respectively connecting the valve chamber to the measuring and pressure control chambers, said measuring chamber and control pressure chamber diaphragms being each formed with a vent port, valve means actuated by movements of the measuring chamber diaphragm to open and close the measuring chamber supply and vent ports as required to maintain an air pressure in said chamber proportional to a controlling force acting against the outer side of the last mentioned diaphragm, said measuring and actuating chamber being in free communication, valve means actuated by movements of the control pressure chamber diaphragm to open and close the control pressure chamber supply and vent ports as required to maintain that diaphragm in an approximately constant intermediate position, means for connecting the control pressure chamber to a regulating device controlled by the pressure in that chamber and a restricted flow equalizing connection between said control pressure and reset chambers.

11. An air controller as specified in claim 10, in which said body is mounted in a box-like casing having a removable cover formed with an aperture and including a pressure gauge extending through said aperture and comprising a pressure inlet portion within said casing and detach-

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ably connected to said body for transmitting the pressure in said measuring chamber to said gauge.

12. An air controller comprising a body formed with three recesses extending into the body from different sides of the latter and a separate flexible diaphragm extending across the outer end of each recess, said recesses and associated diaphragms forming separate actuating, control pressure, and reset chambers, means for maintaining an actuating pressure in said actuating chamber, a leverage system comprising separate arms respectively engaging the three diaphragms and so connected that axial movement of one diaphragm causes axial movement of each of the other two diaphragms, said body being formed with a valve chamber, valve means actuated by the diaphragm of the control pressure chamber for admitting air from said valve chamber to, and for venting air from the control pressure chamber, as required to minimize axial movement of its diaphragm by said leverage system on a change in said controlling pressure, a casing in the form of a box having a removable front cover, means including spacer parts between the back wall of the casing and rear side of said body for connecting the latter to said casing with a space between said body and back wall, channelled connection parts located in said space and secured to the rear side of said body, each of said connection parts being formed with two channels and said body being formed with channels through which the two channels in one of said parts are connected with said valve chamber and control pressure chambers, respectively, and with two other channels through which said reset chamber and pressure control chamber are respectively connected to the two channels of the second connection part, flexible pipes adapted to connect the channels in said one connection part to pipes external to the casing and respectively supplying air under pressure and connected to a device to be regulated by the pressure in the control chamber, means including a capacity tank within said casing and flexible pipes separately connecting the two channels in said second connection part to said capacity tank to provide a restricted, pressure equalizing, flow path connecting said reset and control pressure chambers.

13. An air controller as specified in claim 12 in which a capillary tube forms a portion of said pressure equalizing flow path.

14. An air controller as specified in claim 12 in which the flexible pipes connected to said one connection part have their opposite ends connected to a part adapted to be mounted in and extend through a wall of said casing and formed with threaded sockets having open ends outside said casing and into the other ends of which said flexible pipes open.

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