Sept. 20, 1960 T. W. CLEMENTS 2,953,657

PNEUMATIC-ELECTRIC RELAY

Filed March 12, 1957 2 Sheets-Sheet 1

Fig. 1.

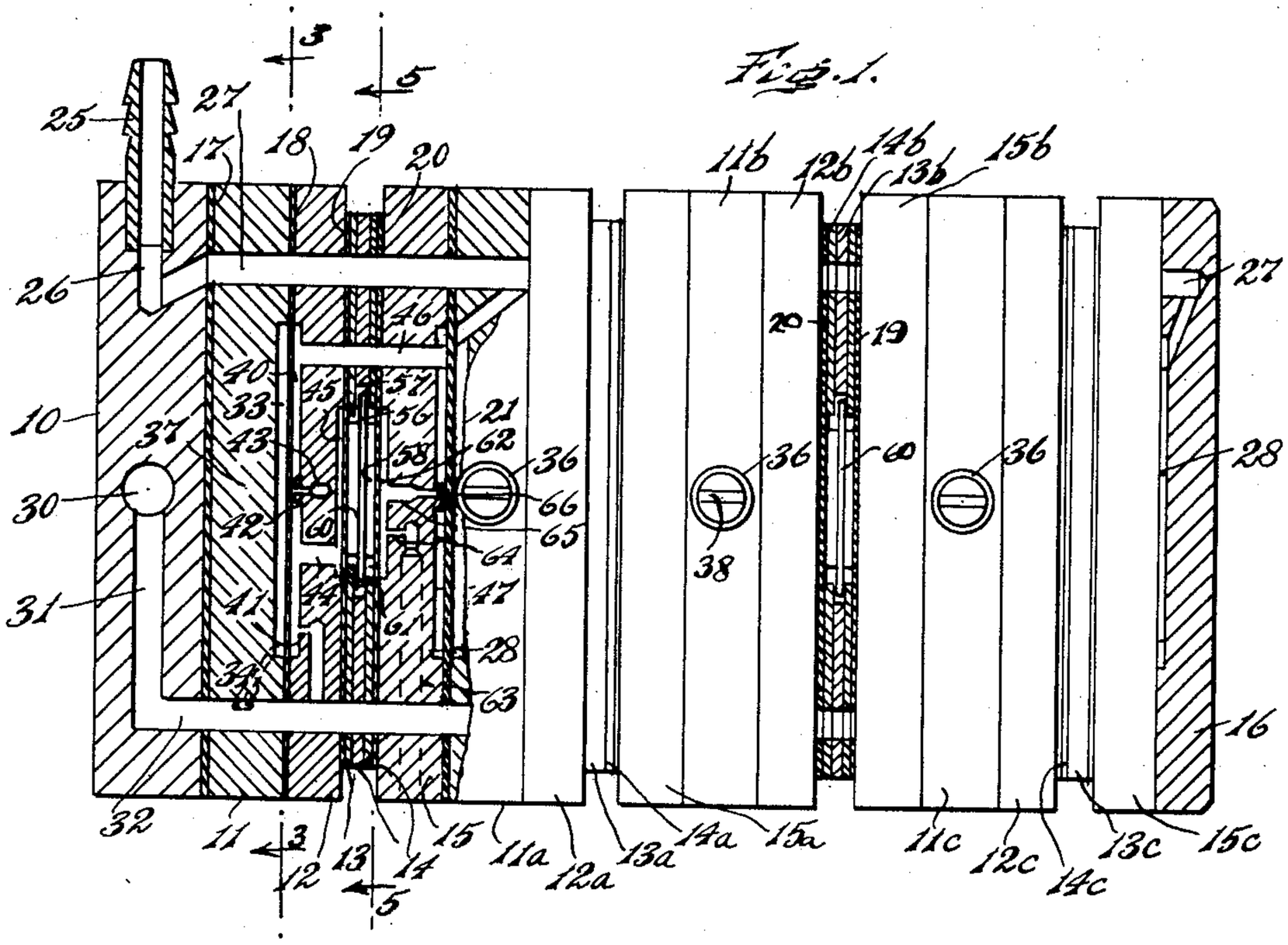

Fig. 2.

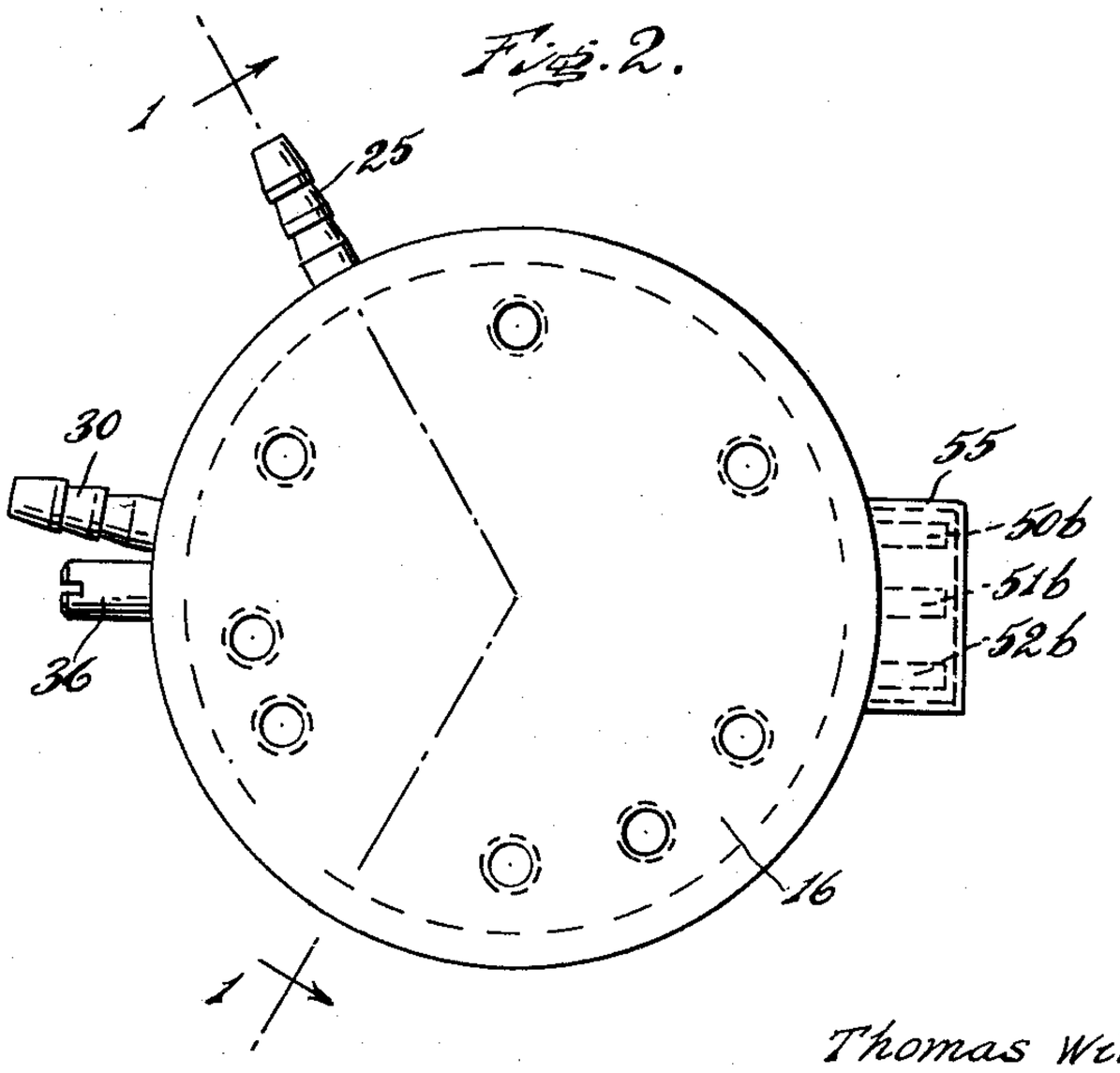

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Fig. 4.

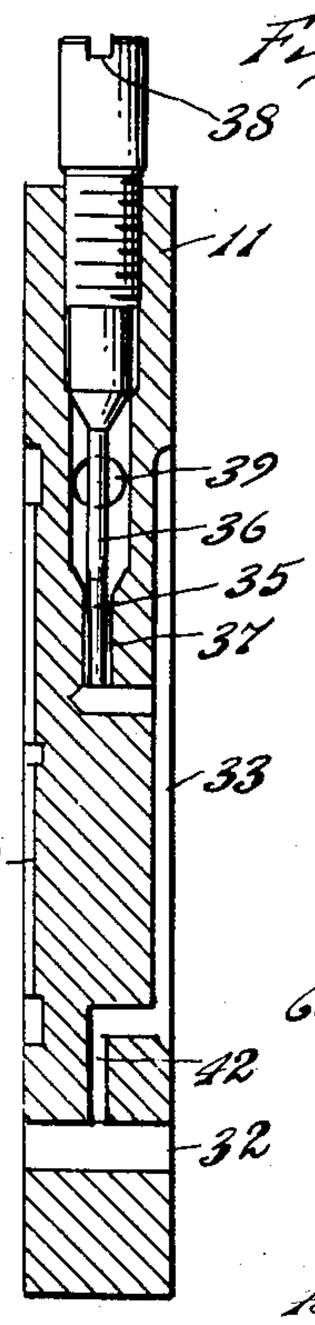


Fig. 3.

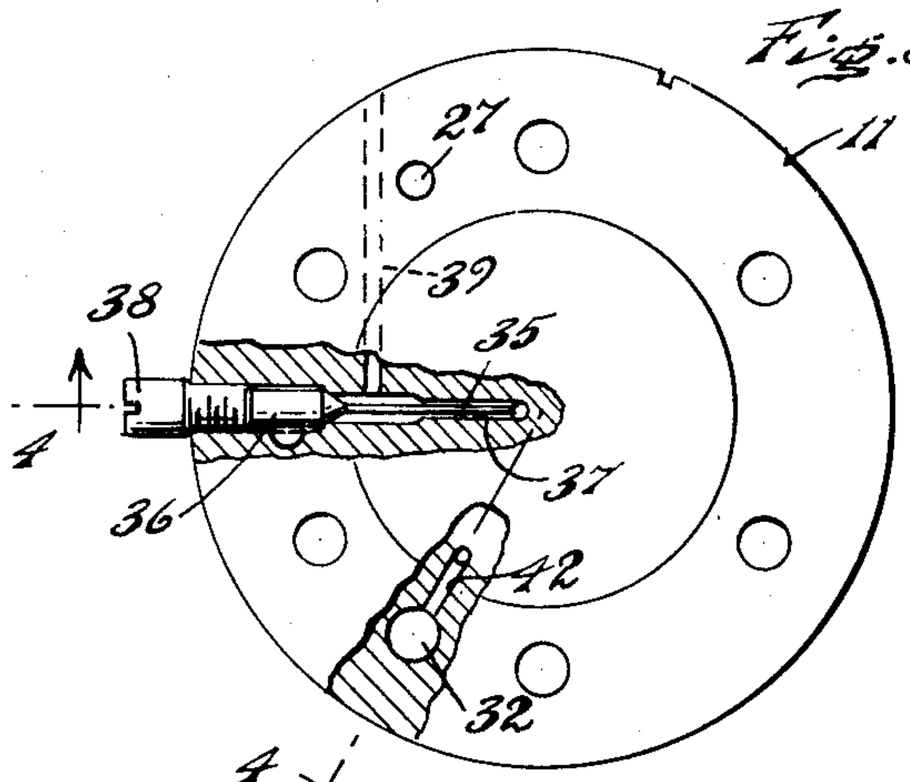


Fig. 6.

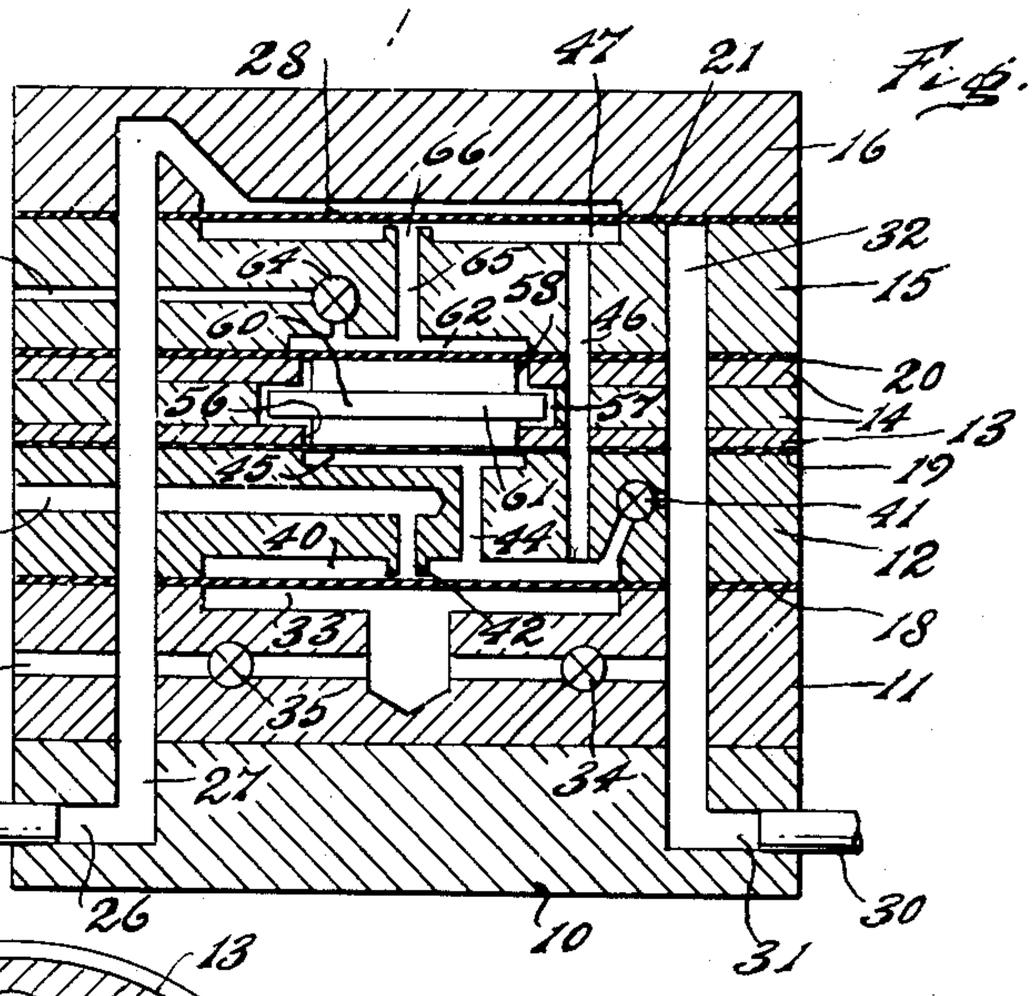
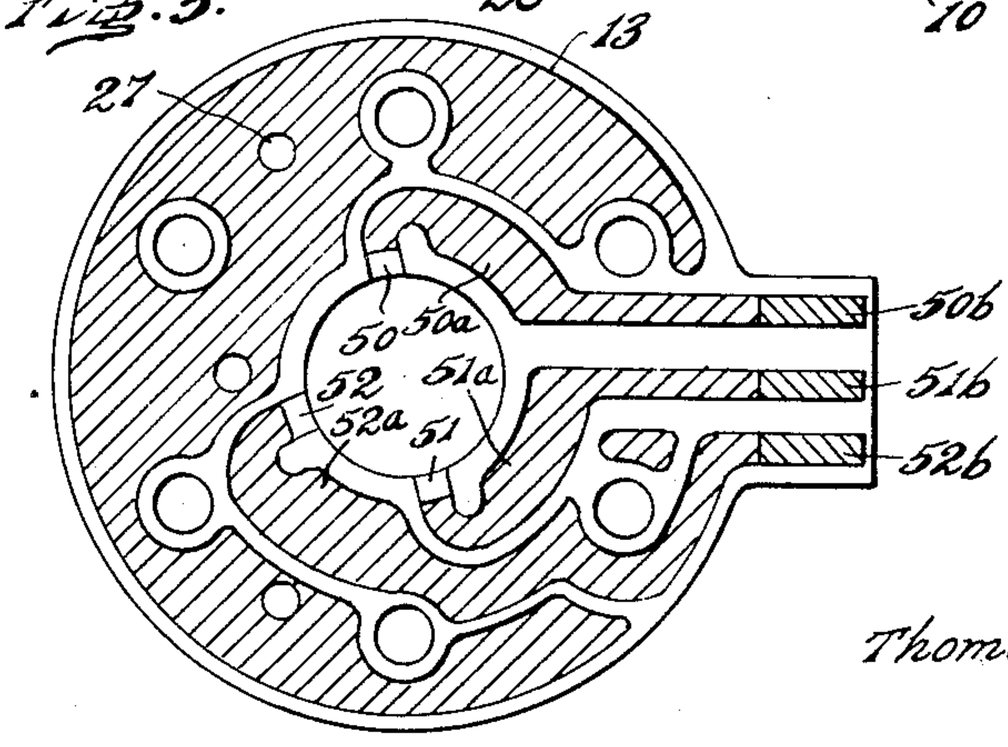


Fig. 5.



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PNEUMATIC-ELECTRIC RELAY

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13 Claims. (Cl. 200—81)

This invention relates to pneumatically actuated electric relays.

It is the principal object of the present invention to provide a pneumatically operated relay in which a control pressure is balanced against a measured or set pressure for controlling electrical contacts.

It is a further object of the present invention to provide a pneumatically operated relay of the character aforesaid in which the set pressure can be varied as desired.

It is a further object of the present invention to provide a pneumatically operated relay for controlling electrical contacts in which the components are disposed in a compact and concentric arrangement.

It is a further object of the present invention to provide a pneumatically operated relay for controlling electrical contacts in which the components include a limit setting regulator, a pneumatic-electric switch and a pneumatic limit device.

It is a further object of the present invention to provide a pneumatically operated relay for controlling electrical contacts in which the unit has one or more pneumatically operated switch elements which respond to predetermined levels of a pressure, such as a gaging pressure, supplied to one connection.

Other objects and advantageous features of the invention will be apparent from the description and claims.

The nature and characteristic features of the invention will be more readily understood from the following description, taken in connection with the accompanying drawings forming part thereof, in which:

Figure 1 is a view of the relay in accordance with the invention partly in elevation and partly in section taken on the line 1—1 of Fig. 2;

Fig. 2 is an end elevational view of the relay shown in Fig. 1;

Fig. 3 is a sectional view taken approximately on the line 3—3 of Fig. 1 and with parts broken away to show details of construction;

Fig. 4 is a sectional view, enlarged, taken approximately on the line 4—4 of Fig. 3;

Fig. 5 is a sectional view taken approximately on the line 5—5 of Fig. 1; and

Fig. 6 is a schematic cross sectional view of one of the switch elements.

It should, of course, be understood that the description and drawings herein are illustrative merely, and that various modifications and changes can be made in the structure disclosed without departing from the spirit of the invention.

Like numerals refer to like parts throughout the several views.

Referring now more particularly to the drawings, a plurality of discs or rings are provided, arranged in a stack and suitably clamped together, with fluid pressure input connections and with electrical conductors preferably brought together at a separable plug connection.

The relay in accordance with the invention preferably includes a connection ring **10**, a pressure divider ring **11**,

a regulator ring **12**, a composite contact ring **13**, a spacer ring **14**, a relay ring **15** and a cover ring **16**. For each additional switch section, additional stacks of discs or rings **11** to **15**, inclusive, are provided, identified on additional sections as **11***a* to **11***c*, **12***a* to **12***c*, **13***a* to **13***c*, **14***a* to **14***c*, and **15***a* to **15***c*, respectively. Only one cover ring **16** is required and is disposed at the end of the stack opposite the connection ring **10** when all the other rings have been assembled, and diaphragms interposed and clamped with respect to the rings are provided, as follows: a sealing ring **17** between the rings **10** and **11**, a regulator diaphragm **18** between the rings **11** and **12**, a switch loading diaphragm **19** between the rings **12** and **13**, a switch actuating diaphragm **20** between the rings **14** and **15**, and a relay diaphragm **21** between the ring **15** and the ring therebeyond whether this is a ring **11***a* or a ring **16**. The diaphragms **17**, **18**, **19**, **20** and **21** can be of any desired thin flexible impervious material.

The ring **10** is provided with a pressure connection **25** for the application of the gaging or measured pressure to an interior passageway **26** from which a longitudinal passageway **27** extends through the rings **11**, **12**, **13**, **14** and **15** of each section and to the ring **16**, for application in a chamber **28** in the ring **11***a* or **16** against the upper face of the diaphragm **21**.

The ring **10** is also provided with a supply pressure connection **30** for the introduction of a supply pressure from any suitable source of pressure regulated fluid, such as air, and which serves as a source of setting pressure and as a source of energy for switch actuation as hereinafter pointed out. The supply connection **30** is connected to an interior passageway **31** and thence to a longitudinal passageway **32** extending through the rings **11**, **12**, **13**, **14** and **15** of each section and is closed by the cover ring **16**.

The ring **11** is provided with a chamber **33** in communication with one side of the diaphragm **18** and which is in communication with the passageway **32** through a restriction **34** and vented to the atmosphere through an adjustable restriction **35** comprising a threaded stem **36** with an elongated tapered end movable with respect to a port **37** in the ring **11**. The outer end of the stem **36** has a screw slot **38** for adjustment from the exterior. A vent port **39** to atmosphere is provided in the ring **11**.

The ring **12** is provided with a chamber **40** in communication with the opposite side of the diaphragm **18** and the chamber **40** is in communication with the passageway **32** through a restriction **41**. A nozzle **42** is provided in the chamber **40** and facing the diaphragm **18** for engagement thereby by which the flow therethrough to an exhaust passageway **43** to atmosphere is controlled. The chamber **40** has a passageway **44** extending therefrom to a chamber **45** on the opposite face of the ring **12** and bounded by the diaphragm **19**. A passageway **46** is also provided extending between the chamber **40** and a chamber **47** in the ring **15** on the opposite face of the diaphragm **21** from the chamber **28**.

The rings **13** and **14** can be made from a plurality of discs, laminated if desired, and with contacts therein in any preferred manner. One suitable arrangement of contacts **50**, **51** and **52** will be seen in Fig. 5, which can employ printed circuits with connectors **50***a*, **51***a*, and **52***a* to exterior contacts **50***b*, **51***b*, and **52***b*, in a connector block **55** on the exterior of the stack of rings.

The rings **13** and **14** can be as shown at **13** and **14**, **13***a* and **14***a*, or reversed as at **13***b* and **14***b*, **13***c* and **14***c*, in accordance with the desired positioning of the contacts **50**, **51**, and **52**, i.e., whether they are to be employed normally closed or normally open.

The ring **13** has a chamber **56** formed therein and bounded by the diaphragm **19** and a communicating enlargement **57** therebeyond in the ring **14** and the ring **14**

has a communicating chamber 58 therein bounded by the diaphragm 20 and preferably of a larger effective area than the chamber 56.

The diaphragms 19 and 20 preferably have a conducting contact disc 60 interposed therebetween and secured thereto for movement together, the contact disc 60 having a rim 61 for engagement and disengagement with the contacts 50, 51 and 52 in accordance with its positioning by the pressures on the diaphragms 19 and 20.

The ring 15 has a chamber 62 therein bounded by the diaphragm 20 and a vent passageway 63 connected thereto and to the atmosphere has a restriction 64 therein. The chamber 62 has a passageway 65 extending thereto from the chamber 47, the passageway 65 at its entrance end having a nozzle 66 controlled by the positioning of the diaphragm 21 with respect thereto.

The mode of operation will now be pointed out.

Fluid under pressure from a pressure regulated source is supplied through the supply connection 30 and is available through the passageway 31 to the passageway 32 and therefrom to the chamber 33 through the restriction 34 and to the chamber 40 through the restriction 41. From the chamber 40 fluid under pressure is supplied to the chamber 47 through the passageway 46, and to the chamber 45 through the passageway 44.

The gaging pressure or measured pressure is supplied through the fluid connection 25 and the passageways 26 and 27 to the chamber 28.

Whenever the pressure in the chamber 28 exceeds that in the chamber 47 the diaphragm 21 is depressed against the nozzle 66. The pressure in the chamber 33 is determined by the relative size of the restrictions 34 and 35 and can be manually adjusted by adjustment of the stem 36.

The restriction 41, as previously indicated supplies fluid, from the passageway 32 to the chamber 40 from which it is exhausted to the atmosphere through the nozzle 42 and passageway 43. Whenever the pressure in the chamber 40 exceeds the pressure in the chamber 33 the nozzle 42 will be open causing the pressure in the chamber 40 to fall since fluid can be exhausted through the nozzle 42 faster than it can be supplied through the restriction 41.

Conversely, whenever the pressure in the chamber 40 is lower than that in the chamber 28 the diaphragm 18 will be forced against the nozzle 42, thus preventing the escape of fluid through the nozzle 42 and causing the pressure in the chamber 40 to increase. As a result the pressure in the chamber 40 will come to equilibrium at a value substantially equal to that in the chamber 33 with the nozzle 42 partially closed by the diaphragm 18.

The pressure in the chamber 40 is a "live" pressure in that a small additional flow to or from the chamber 40 will not materially affect its pressure but merely cause the diaphragm 18 to reposition slightly with respect to the nozzle 42 as required to maintain the pressure in the chamber 40 in equilibrium with the pressure in the chamber 33.

The chamber 40 thus serves to furnish pressure fluid to the chamber 47 for balancing against the gaging pressure exerted in the chamber 28, as well as for additional purposes.

Fluid pressure from the chamber 40 is also supplied through the passageway 44 to the chamber 45 for loading the diaphragm 19 in an upward direction, thus moving the switch contact disc 60 upwardly and out of contact with the contacts 50, 51 and 52.

The pressure manually set in the chamber 33 by adjustment of the restriction 35 and which is reproduced in the chambers 33 and 47 is the set pressure and determines the firing point of the unit.

Whenever the gaging pressure in the chamber 28 is lower than the set pressure in the chamber 47 the diaphragm 21 will be in its upper position and fluid from the chamber 47 will flow through the nozzle 66 to the chamber 62 and thence to the atmosphere through the restriction 64. The size and pressure relations of the restrictions 64 and 41 are made such that fluid will be supplied through the restriction 41 faster than it can be exhausted to the atmosphere through the restriction 64. The excess fluid will be exhausted through the nozzle 42 and the pressure in the chamber 40 and hence in the chamber 62 will remain substantially in balance and equal to the set pressure in the chamber 33.

The pressure in the chamber 62 exerts a downward force on the diaphragm 20 and opposes the force of the same pressure exerted in the chamber 45 against the diaphragm 19.

The diameter of the switch contact disc 60 adjacent the diaphragm 20 is greater than the diameter of that portion of the disc 60 which is in contact with the diaphragm 19 so that the downward force will exceed the upward force and the contact disc 60 will be forced against the contacts 50, 51 and 52, closing the electrical circuit.

When the gaging pressure increases and exceeds the set pressure in the chamber 47 the diaphragm 21 will be forced against the nozzle 66, shutting off access of fluid from the chamber 47 to the chamber 62. The fluid in the chamber 62 will exhaust to the atmosphere through the restriction 64 and will no longer exert a downward force on the diaphragm 20. The pressure in the chamber 45 will act against the diaphragm 19 in an upward direction moving the contact disc 60 away from contacts 50, 51 and 52 and opening the electrical circuit.

While the operation has been described in detail as to a single electric switch unit it will be clear that the set pressure in each unit can be adjusted as described and in accordance with the particular control to be effected.

I claim:

1. Pneumatic control apparatus comprising a first connection to a supply of fluid under pressure, a second connection to a source of measured pressure, a chamber having a diaphragm therein to which said second connection is connected for applying said measured pressure against said diaphragm in one direction, means for applying a control pressure against said diaphragm in the opposite direction, said means including a second chamber having a movable member therein, said second chamber having a vent nozzle therein in communication with the atmosphere controlled by said movable member, said second chamber having a connection through a restriction to said first connection, electrical contacts, and members for controlling said contacts including a pressure actuated member controlled by said control pressure.

2. Pneumatic control apparatus comprising a first connection to a supply of fluid under pressure, a second connection to a source of measured pressure, a chamber having a diaphragm therein to which said second connection is connected for applying said measured pressure against said diaphragm in one direction, and means for applying a control pressure against said diaphragm in the opposite direction, said means including a second chamber having a movable member therein, said second chamber having a vent nozzle therein in communication with the atmosphere controlled by said movable member, said second chamber having a connection through a restriction to said first connection.

3. Pneumatic control apparatus as defined in claim 2 in which members are provided for applying another pressure on said movable member, said other pressure applying members including a connection to said first connection having two restrictions therein in series and a takeoff therein between said restrictions for applying said other pressure on said movable member.

4. Pneumatic control apparatus comprising a first chamber, a fluid pressure responsive diaphragm bounding said first chamber, a second chamber, a second fluid pressure responsive diaphragm bounding said second chamber, a contact disc movable with said second diaphragm, electrical contacts for engagement and disengagement by said

contact disc, and members for controlling the positioning of said second diaphragm including a connection from a control pressure to said first chamber, a second connection from said first chamber to said second chamber, and a nozzle in said second connection controlled by the positioning of said first diaphragm with respect thereto.

5. Pneumatic control apparatus comprising a first chamber, a fluid pressure responsive diaphragm bounding said first chamber, a second chamber, a second fluid pressure responsive diaphragm bounding said second chamber, a member movable with said second diaphragm, and members for controlling the positioning of said second diaphragm including a connection from a control pressure to said first chamber, a second connection from said first chamber to said second chamber, a nozzle in said second connection controlled by the positioning of said first diaphragm with respect thereto, and a vent through a restriction connected to said second chamber.

6. Pneumatic control apparatus comprising a chamber, a fluid pressure responsive diaphragm bounding said chamber, a contact disc movable with said diaphragm, electrical contacts for engagement and disengagement by said contact disc, and members for controlling the positioning of said diaphragm including a connection from a control pressure to said chamber, and a vent connected to said chamber and to atmosphere and having a fixed restriction therein, said vent providing continuous communication between said chamber and the atmosphere.

7. Pneumatic control apparatus comprising a pair of spaced diaphragms, a contact member interposed between and movable with said diaphragms, said contact member retaining said diaphragms in spaced relation, fixedly mounted electrical contacts for engagement and disengagement by said movable contact member, and means for applying different fluid pressures against said diaphragms in opposed directions for positioning said diaphragms and said contact member, said diaphragms having unequal effective areas.

8. Pneumatic control apparatus comprising a first connection to a source of measured pressure, a chamber having a pressure responsive diaphragm therein, a connection from said first connection to said chamber for applying the measured pressure against said diaphragm in one direction, members for applying an opposing force against said diaphragm, a nozzle controlled by the positioning of said diaphragm with respect thereto, a fluid connection from said nozzle, and pressure controlled electrical contact members controlled by the pressure in said last connection determined by said nozzle.

9. Pneumatic control apparatus comprising a first connection to a source of measured pressure, a chamber having a pressure responsive diaphragm therein, a connection from said first connection to said chamber for applying the measured pressure against said diaphragm in one direction, members for applying a set pressure in said chamber and against said diaphragm in the opposite direction, a nozzle in said chamber having a discharge connection with the pressure therein controlled by the positioning of said diaphragm with respect to said nozzle, and pressure controlled electrical contact members controlled by the pressure at said discharge connection.

10. Pneumatic control apparatus comprising a plurality of rings in coaxial arrangement, one of said rings having a first connection to a supply of fluid under pressure, one of said rings having a second connection to a source of measured pressure, certain of said rings having spaced diaphragms with a coaxial contact disc therebetween and electrical contacts for engagement and disengagement by said contact disc, others of said rings having a limit setting regulator therein for delivering a regulated fluid pressure and with which said first connection is in communication, and others of said rings having a pressure responsive sensing device therein to which said second connection is connected, said sensing device controlling the pressure effective on one of said diaphragms, and a fluid connection for delivering said regulated fluid pressure against another of said diaphragms.

11. Pneumatic control apparatus comprising a first connection to a supply of fluid under pressure, a second connection to a measured pressure, a fluid pressure responsive member to which said second connection is connected, electric contact members, a second fluid pressure responsive member for controlling said electric contact members, members connected to said first connection for supplying a setting fluid pressure, members for applying said setting fluid pressure at said first fluid pressure responsive member in opposition to said measured pressure, and members for applying said setting fluid pressure against said second fluid pressure responsive member for controlling said contact members.

12. Pneumatic control apparatus as defined in claim 11 in which said setting pressure fluid applying members include portions for applying said setting fluid pressure against opposed areas of said second fluid pressure responsive member.

13. Pneumatic control apparatus comprising a differential fluid pressure responsive member, a connection for applying a measured fluid pressure against said member in one direction, a control pressure setting member for applying a fluid pressure against said pressure responsive member in the opposite direction, a valve member having a port controlled by the positioning of said pressure responsive member, a fluid pressure operated switching member, and a fluid connection between said port and said switching member for controlling said switching member in response to a pressure controlled by said valve member.

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