Nov. 2, 1965 J. E. BASS, JR., ETAL 3,215,158

STACK VALVE ASSEMBLIES WITH INTERCHANGEABLE COMPONENTS

Filed Oct. 9, 1963 5 Sheets-Sheet 1

Fig-1

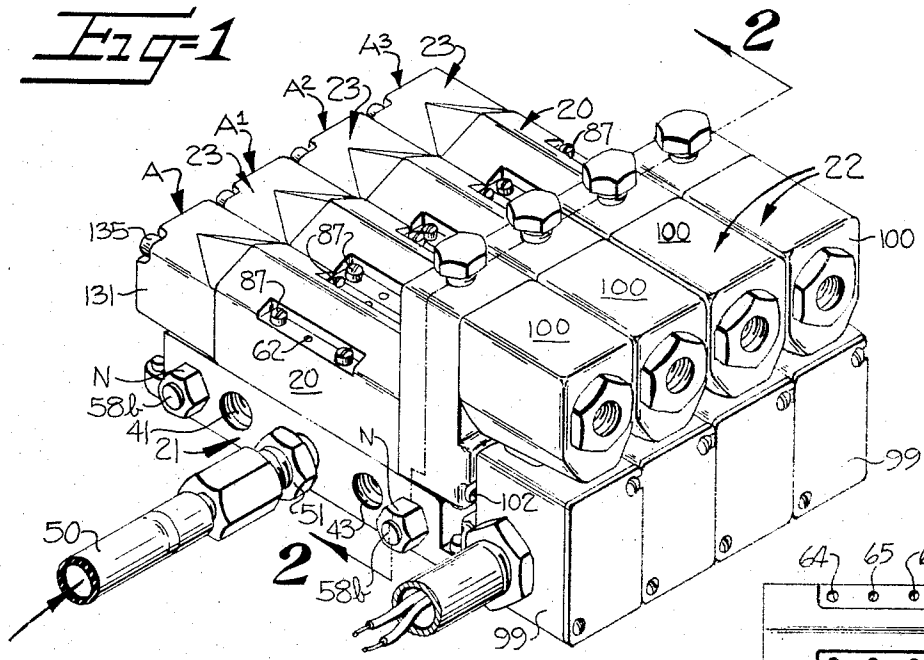

Fig-1A

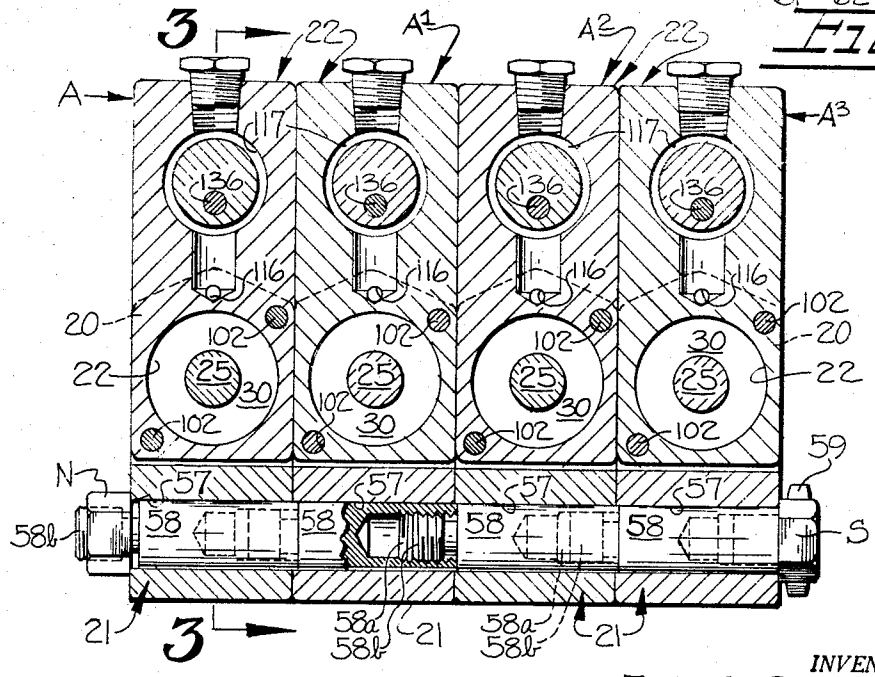

Fig-2

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STACK VALVE ASSEMBLIES WITH INTERCHANGEABLE COMPONENTS

Filed Oct. 9, 1963 5 Sheets-Sheet 2

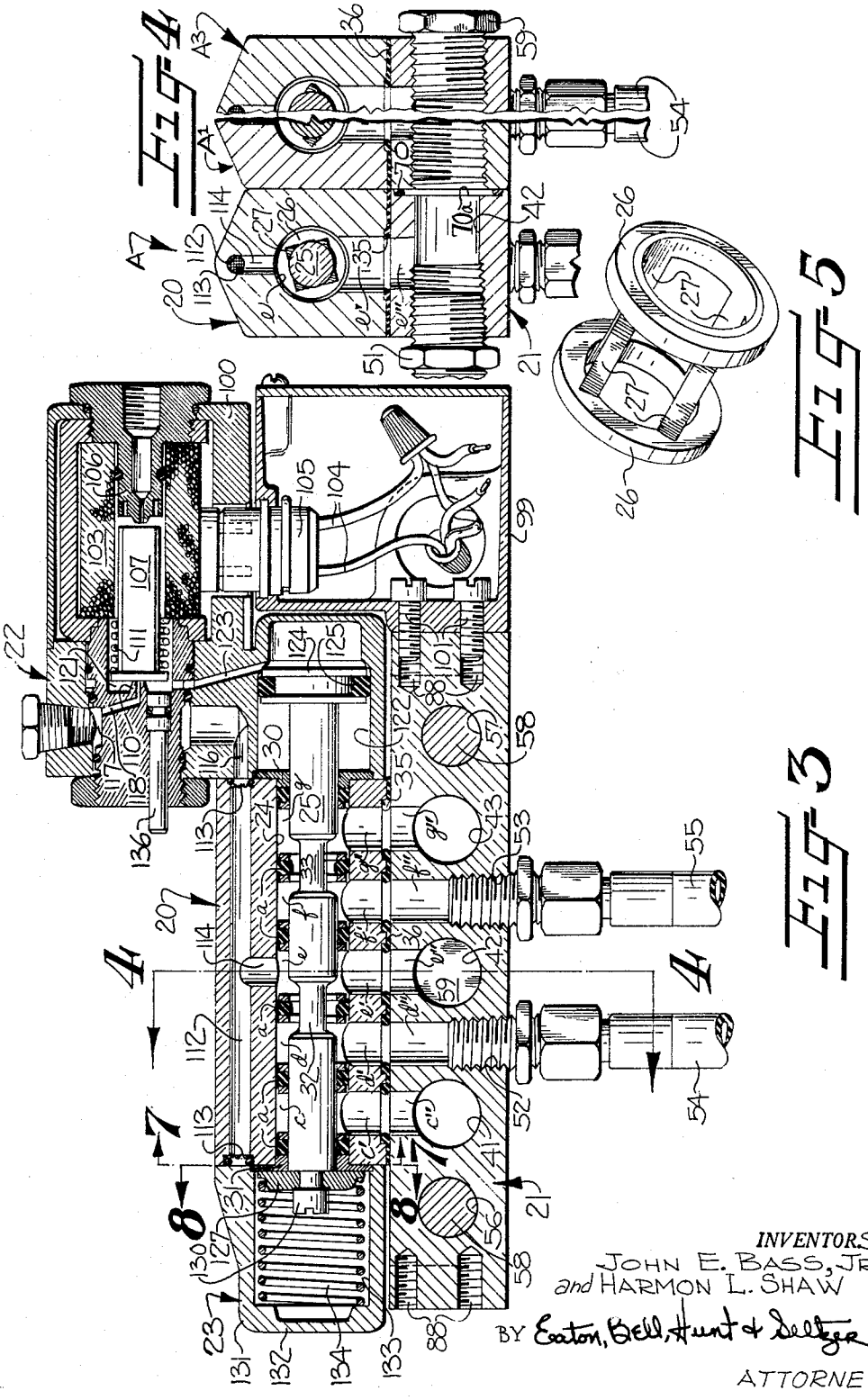

Fig. 4

Fig. 5

Fig. 3

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STACK VALVE ASSEMBLIES WITH INTERCHANGEABLE COMPONENTS

Filed Oct. 9, 1963 5 Sheets-Sheet 3

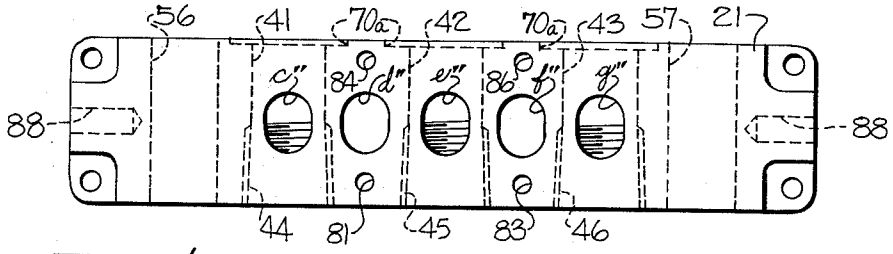

Fig-6

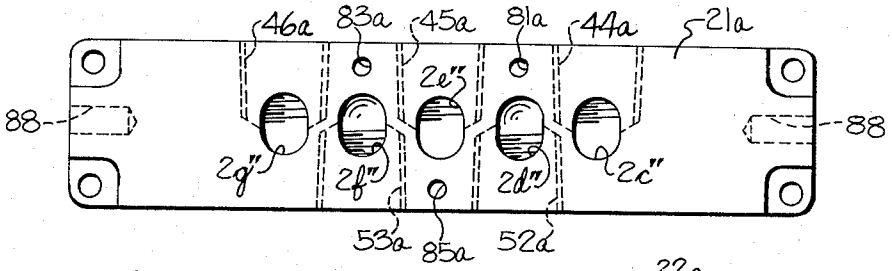

Fig-10

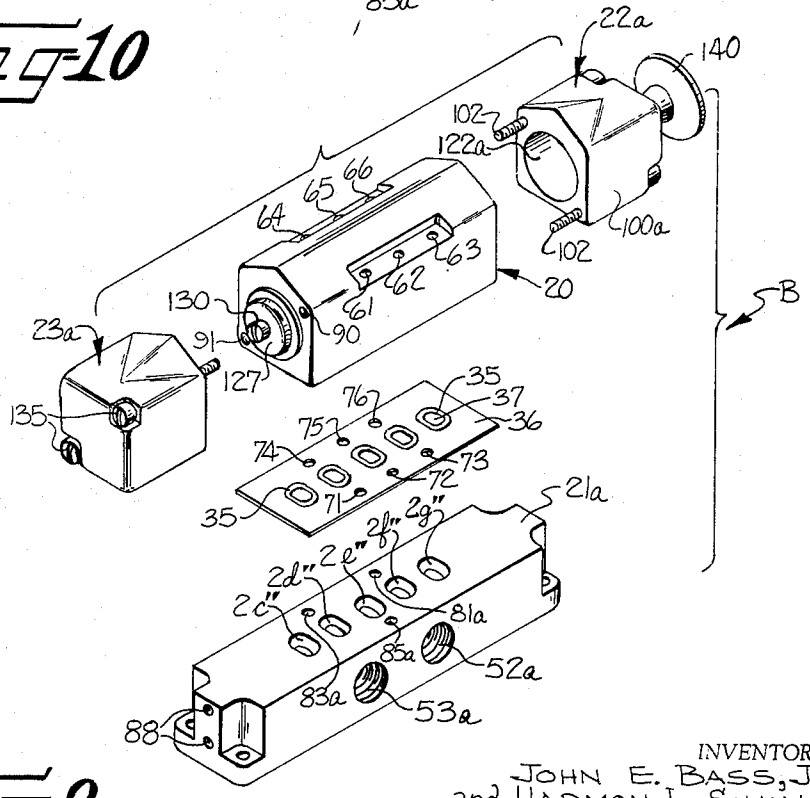

Fig-9

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STACK VALVE ASSEMBLIES WITH INTERCHANGEABLE COMPONENTS

Filed Oct. 9, 1963 5 Sheets-Sheet 4

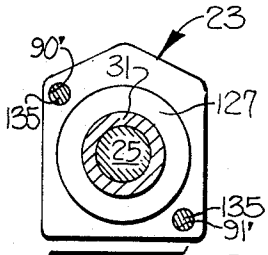

Fig-8

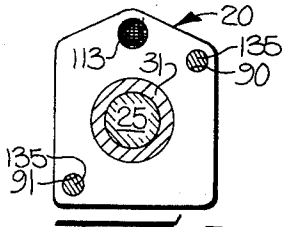

Fig-7

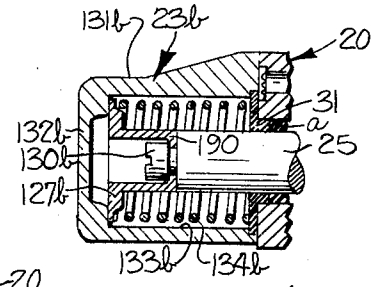

Fig-11A

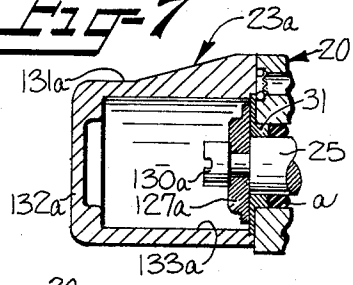

Fig-11

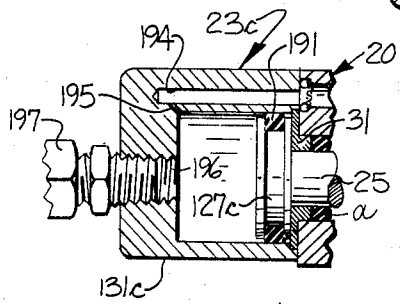

Fig-11B

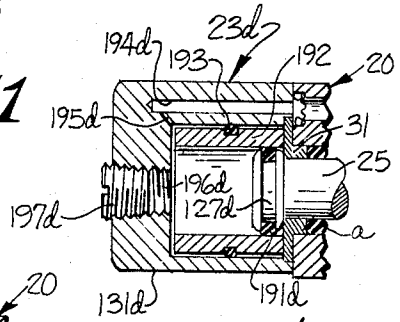

Fig-11C

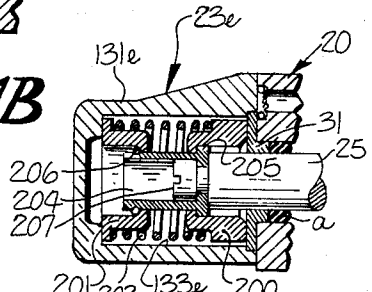

Fig-11D

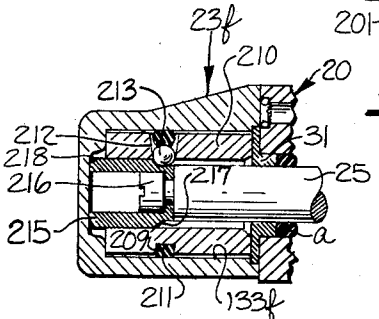

Fig-11E

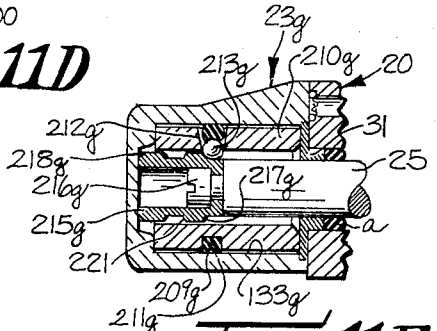

Fig-11F

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Nov. 2, 1965 J. E. BASS, JR., ETAL 3,215,158

STACK VALVE ASSEMBLIES WITH INTERCHANGEABLE COMPONENTS

Filed Oct. 9, 1963

5 Sheets-Sheet 5

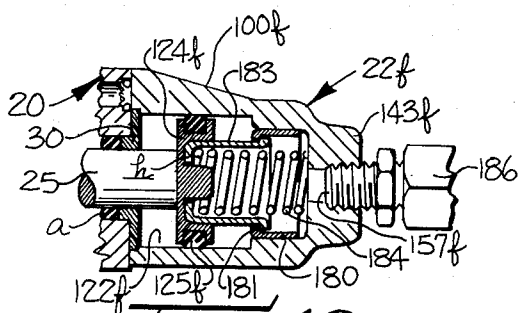

Fig-12E

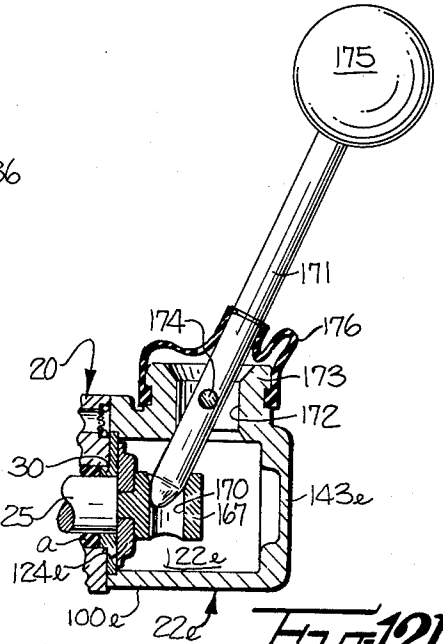

Fig-12D

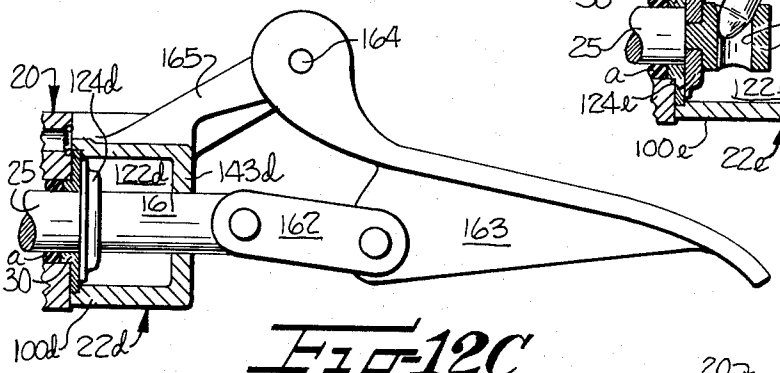

Fig-12C

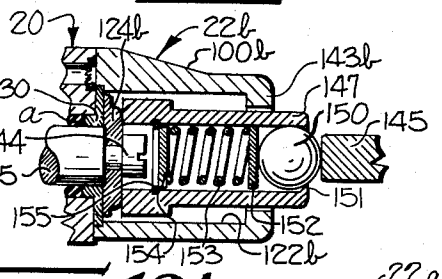

Fig-12A

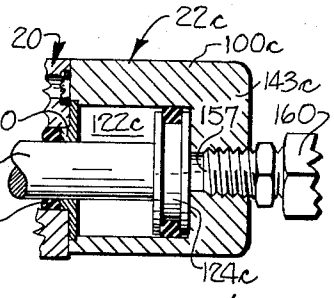

Fig-12B

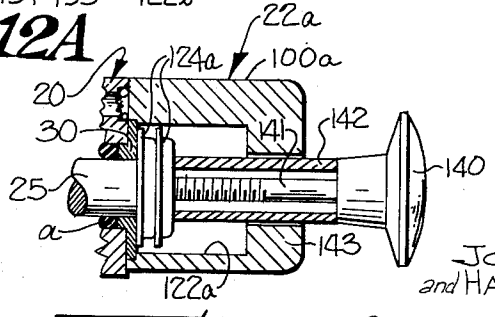

Fig-12

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United States Patent Office 3,215,158 Patented Nov. 2, 1965

3,215,158

STACK VALVE ASSEMBLIES WITH INTERCHANGEABLE COMPONENTS

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Filed Oct. 9, 1963, Ser. No. 315,017
3 Claims. (Cl. 137—269)

This invention relates to slide valves of the type characterized by axially movable pistons or valve cores, the axial shifting of which effects a change in the direction of flow of a fluid medium therethrough.

Many different types of slide valves have been devised heretofore which have included many parts which had to be assembled at the site of use thereof. During such assembling, care had to be taken to ascertain the intended relative positions of the parts so they could be secured together and would function properly. Also, the prior types of slide valves have been devised for specific purposes and for operation by individual specific means.

It is an object of this invention to provide an improved universal interchangeable slide valve assembly which has greater flexibility of use and is more readily commercially produced and assembled at its site of use than known prior art types of slide valve assemblies and which may be used individually or may be readily stacked in juxtaposed relation with like assemblies.

It is a more specific object of this invention to provide a slide valve assembly of the type described comprising an elongate base adapted to have any fluid-conveying conduits of a fluid system attached thereto and wherein a valve body is secured to the base and is arranged to control the flow of fluid through the base, there being various intercommunicating passageways in the body and the base which are symmetrically arranged in such a manner that the body may extend in either longitudinal direction relative to and parallel to the base and cooperating passageways will still be communicatively alined. Symmetrically located fastener-receiving holes are also provided in the base and the valve body, for the reception of screws therein, for securing the base and body together and facilitating interchangeability of the valve body with other like valve bodies.

It is still another object of this invention to provide a universal interchangeable valve assembly of the type described with a plurality of different types of valve-operating units adapted to be interchangeably secured to each end of the elongate valve body and wherein the different valve-operating units include means for shifting the valve core longitudinally within the elongate valve body.

Another object of the invention is to provide a valve assembly of the character described in which the width of the base is at least equal to or greater than the width of the valve body and in which ports extend transversely through the base to permit stacking the valve assembly in juxtaposed parallel relation with like valve assemblies.

The valve assembly of this invention is particularly devised for ease of maintenance, and quick and convenient modular replacement. The quick replacement of any malfunctioning subassemblies with like, properly functioning, subassemblies in accordance with this invention is a very important factor in automation. Heretofore, there have been instances in which an entire assembly line used in producing a given product had to be shut down for a considerable period of time during the replacement of malfunctioning parts of a valve assembly or during replacement of a complete valve assembly. On the other hand, the various subassemblies of the valve assembly of this invention may be replaced easily and quickly; with very nearly the facility of plugging an electrical plug into the socket of an electrical receptacle, and within a fraction of the time which would be required to replace an entire valve assembly of conventional construction or to replace individual worn or damaged parts thereof, thus greatly contributing to economy of production in an assembly line.

Some of the objects of the invention having been stated, other objects will appear as the description proceeds, when taken in connection with the accompanying drawings, in which—

FIGURE 1 is a perspective view of a bank or stack of valve assemblies embodying a first form of the invention;

FIGURE 1A is a top plan view of one of the symmetrical valve bodies showing the fastener-receiving holes therein for the reception of screws to secure the same to a corresponding base;

FIGURE 2 is an enlarged transverse vertical sectional view taken substantially along line **2—2** in FIGURE 1;

FIGURE 3 is a longitudinal vertical sectional view through one of the valve assemblies taken substantially along line **3—3** in FIGURE 2 and showing details of two types of valve-operating units connected to opposite ends of the valve body;

FIGURE 4 is a fragmentary transverse vertical sectional view taken substantially along line **4—4** in FIGURE 3;

FIGURE 5 is a perspective view of one of the spacer elements or cages positioned in the longitudinal bore of the valve body of FIGURE 3;

FIGURE 6 is a top plan view of the valve base upon which the valve body is mounted in FIGURE 3;

FIGURES 7 and 8 (Sheet 4) are views of one end of one of the valve-operating units and the corresponding end of the valve body taken substantially along the respective lines **7—7** and **8—8** in FIGURE 3 and showing the arrangement of the fastener-receiving or screw holes therein;

FIGURE 9 (Sheet 3) is a partially exploded perspective view of a second form of valve assembly according to the present invention having a different type of base from that of the first form of the invention shown in FIGURES 1–6, and showing two other types of valve-operating units in association therewith;

FIGURE 10 is a top plan view of the valve base shown in FIGURE 9;

FIGURES 11 through 11F (Sheet 4) and 12 through 12E (Sheet 5) are longitudinal vertical sectional views of other types of valve-operating units which may be interchangeably connected to either end of the valve body in place of the valve-operating units shown in FIGURE 3.

Referring more specifically to the drawings, the first embodiment of the invention shown in FIGURES 1–8 includes a stack or bank of slide valve assemblies, each of which is shown as being of the same construction, although they may differ from each other in some respects as will be later explained. In this instance, there are four valve assemblies shown in FIGURES 1 and 2, indicated at A, A^1, A^2, A^3, and only one of which will be described in detail, with like parts of each assembly being provided with the same reference characters, where applicable, to avoid repetitive description.

Essentially, each valve assembly A–A^3 comprises an elongate valve body or housing **20**, an elongate complementary base or block **21**, a primary valve-operating control unit **22**, and an auxiliary valve-operating unit **23**. The valve body **20** is of elongate symmetrical construction and has a longitudinally extending bore **24** therein within which a spool valve core or piston **25** is mounted for longitudinal or axial sliding movement by means of a plurality of resilient O-rings *a* (FIGURE 3) which are held in spaced relationship by a plurality of spacing ele-

ments or cages *b* arranged in axial alinement. As shown in FIGURE 5, each cage is of open construction; i.e., each spacing element *b* includes a pair of end flanges or rings **26** which are interconnected by ribs or bars **27** of relatively small cross-sectional area. The spacer elements *b* may be cast or molded from a suitable plastic material, if desired.

Opposed ends of valve bore **24** are partially closed by plates **30, 31** which bear against the corresponding endmost O-rings *a* and which are slidably penetrated by valve core **25**. Plates **30, 31** are held against opposed ends of valve body **20** by the corresponding operating units **22, 23**.

The O-rings *a* and the flanges **26** of the spacer elements *b* divide the longitudinal valve bore **24** into five chambers *c–g*. The valve core **25** is provided with a pair of spaced reduced neck portions **32, 33** which are so spaced and which are of such length relative to the axial length of chambers *c–g* that each of them establishes communication between an adjacent pair of said chambers when valve core occupies one extreme position or another extreme position in the opposite direction. When the valve core **25** occupies an intermediate or neutral position, it prevents communication between any two of the adjacent chambers *c–g*.

From the standpoint of economy of production of the valve assembly as well as from a standpoint of assembly both at the time of manufacture of the valve assemblies and at the time of partial assembly or installation thereof at the site at which the valve assembly or assemblies are to be used, it is an important feature of the present invention to provide the valve body **20** and the valve base **21** with passageways which are arranged symmetrically with respect to a first line extending transversely of and located halfway between longitudinally opposed ends of the valve body as well as with respect to a second line extending longitudinally of the valve body. This not only insures that valve bodies and bases, such as **20** and **21**, may be manufactured identically as is desirable in the manufacture of any production item, but it facilitates the interchangeability of different valve bodies with different bases and permits the assembly of the valve body **20** with the valve base **21** regardless of which direction the valve body **20** may extend longitudinally with respect to the base **21**. Also, in order to further facilitate the attachment of the valve body **20** to the base **21** and to facilitate stacking any desired number of the valve assemblies in juxtaposed side-by-side relationship, the elongate valve body **20** has a transverse width no greater than the width of the base.

The symmetrically arranged radial passageways in the valve body **20** of FIGURE 3 are indicated at *c'–g'* and their upper ends communicate with the respective chambers *c–g* formed in the longitudinally extending bore **24**. The passageways *c'–g'* extend downwardly to the flat bottom surface of the valve body **20** and are suitably enlarged for receiving therein corresponding resilient O-ring portions **35** of a cast or molded resilient gasket **36** of the present invention and upon which the valve body **20** is positioned. Each O-ring portion defines a hole **37** through gasket **36**, as shown in FIGURE 9. It is to be understood that conventional types of resilient O-rings may be substituted for the gasket, if desired.

In this instance, the centermost radial passageway *e* is located halfway between longitudinally opposed ends of valve body **20**. The passageways *d'*, *f'*, and passageways *c'*, *g'*, are located equidistantly, respectively, from opposed sides of the passageway *e'* so that the passageways *c'–g'* are longitudinally spaced symmetrically with respect to a line halfway between longitudinally opposed ends of the valve body **20**.

The base **21** of FIGURE 3 also has a plurality of vertically extending passageways *c''–g''* extending downwardly from the flat upper surface thereof and which register with the respective passageways *c'–g'* in the bottom of valve body **20**.

Each valve body **20** is constructed so as to be used interchangeably with each base **21**, and the valve bodies **20** are also constructed so each of them may be used interchangeably with a base of the type indicated at **21***a* in association with the valve assembly B shown in FIGURE 9. Since the valve body and the valve core associated with the second form of the invention in FIGURE 9 are substantially the same as the valve bodies **20** and valve cores **25** in FIGURES 1–5 and 7, the valve body and core in FIGURE 9 shall bear the same reference characters, where applicable, as are applied to the valve bodies and valve cores in FIGURES 1–5 and 7.

The base **21***a* shown in FIGURES 9 and 10 is interchangeable with any one of the bases **21**. Therefore, base **21** may be termed as a primary base and base **21***a* may be termed as an auxiliary base. The primary bases **21** (FIGURES 1, 2, 3, 4 and 6 are particularly devised to accommodate the stacking of two or more of the valve assemblies, such as A through A^3, in side-by-side juxtaposed relation, so as to control the flow of fluid from a common source to two or more independent fluid-operated devices. On the other hand, the auxiliary base **21***a* (FIGURES 9 and 10) is particularly devised for use in instances in which only a single valve assembly is required. Thus, as much of the description as has already been given for the primary base **21** also applies to the auxiliary base **21***a* and those elements of the base **21***a* which are identical to elements of the base **21** shall bear the same reference characters with the prefix "2" added, for purposes of comparison and to avoid repetitive description.

As best shown in FIGURES 3 and 6, the primary base **21** also is provided with three laterally extending fluid conducting or conveying ports **41, 42** and **43** which extend all the way through the base **21** and whose medial portions communicate with the respective passageways *c''*, *e''*, *g''*. For purposes of description only, the transverse ports **41, 43** may be termed as exhaust ports and port **42** may be termed as a supply port. It should be noted that the axes of passageways *e''* and port **42** intersect each other and the axes of the ports **41, 42** are spaced equidistantly from opposed sides of the axis of the centrally located port **42**. Corresponding ends of all the ports **41–43** are internally threaded or tapped, as at **44, 45, 46**, so that corresponding ends of pipes or conduits may be threadedly connected thereto. All the ports **41–43** are spaced the same distance below the flat upper surface of base **21**.

In this instance, a fluid inlet conduit or pipe **50** has its coupling **51** threaded into the threaded portion **45** of the port **42** of that base **21** associated with the valve assembly A in FIGURE 1. The ports **41, 43** simply serve as exhaust ports, in alternation, when the apparatus is used for controlling the flow of air. Of course, if the apparatus is to be used for controlling the flow of liquid, the threaded ends **44, 46** of the base **21** associated with valve assembly A may have suitable fluid return conduits, not shown, threadedly connected thereto.

Although the lower ends of passageways *c''*, *e''*, *g''* terminate at their juncture with the transverse ports **41, 42, 43**, it will be observed in FIGURE 3 that the passageways *d''*, *f''* extend all the way through the block or base **21** and have their lower portions threaded or tapped, as at **52, 53**, for the reception of the threaded upper ends or fittings of a corresponding pair of service conduits **54, 55**. The threaded lower portions **52, 53** of the vertical passageways *d''*, *f''* may be termed as service ports. Two of the service conduits **54, 55** are connected to and extend downwardly from each of the bases **21** of assemblies A–A^3 in the same manner as that shown in FIGURE 3, and each pair of conduits **54, 55** may be connected to a separate fluid-operated device, such as a double-acting or single-acting cylinder, a hydraulic motor, an air motor, or

the like. One of the service conduits **54**, **55** may be omitted if the fluid-operated device is in the form of a single-acting cylinder.

Opposed end portions of each base **21** are provided with transverse connector holes **56**, **57** therethrough (FIGURES 3 and 6) which are also spaced equidistantly from the transverse center line of the fluid conveying port **42** to facilitate interconnecting a plurality of the bases **21** in side-by-side juxtaposed relation as shown in FIGURE 2. It will be observed in FIGURE 2 that, when a plurality of the bases **21** are disposed in side-by-side juxtaposed relation, the corresponding connector holes **56**, **57** have a series of connector shafts therein, each of which is indicated at **58** and each of which is of a length no greater than, and preferably less than, the width of each base **21**. It is apparent that all the connector holes **56**, **57** are spaced the same distance below the flat upper surface of base **21**. Since all the bases **21** have their fluid conveying ports **41–43** threaded at one end only thereof, the bases **21** associated with the assemblies A, A^1, A^2 have the threaded ends of all the fluid conveying ports **41**, **42**, **43** thereof facing in the same direction. However, the endmost base **21** opposite from the inlet conduit **50** is turned end-for-end with respect to the remaining bases **21** so that both ends of the stack or bank of valve assemblies A–A^3 will have threaded portions **44–46** of the transverse fluid conveying ports **41–43** exposed for reception of the threaded ends of corresponding conduits or for the reception of suitable threaded plugs, such as the plug **59** shown in FIGURE 4, as desired. It should be noted that the plug **59** of FIGURE 4 closes that end of the port **42** of the base **21** associated with valve assembly A^3 opposite from that end of the port **42** of the base **21** of valve assembly A to which the conduit **50** is connected. Thus, conduit **50** then communicates with all the centrally located passageways *e''* in all the bases **21** (FIGURE 3).

Now, since the base **21** of assembly A^3 is turned end-for-end with respect to the bases **21** of the assemblies A, A^1, A^2, it will be observed in FIGURE 2 that the connecting hole **56** of the base **21** of valve assembly A^3 is alined with the connector holes **57** in the remaining bases **21**. This is one reason why it is important that each base **21** is formed symmetrically or that at least the passageways, holes and/or ports therein are formed symmetrically with respect to a given transverse line about midway of the length of each base **21** and with respect to a longitudinal line corresponding substantially to, and extending parallel with, the axis of the valve core **25** thereabove.

All of the connector holes **56**, **57** in the bases **21** should be of substantially the same diameter so that all the connector shafts **58** may also be of substantially the same diameter so as to be slidably received in the corresponding holes **56**, **57**. Each of the connector shafts has an internally threaded bore **58***a* in one end thereof (FIGURE 2) and a reduced externally threaded portion **58***b* on the other end thereof so that adjacent ends of adjacent shafts **58** are interconnected by threading the externally threaded portion of each shaft **58** into the internally threaded bore **58***a* of any adjacent shaft **58** immediately adjacent the same. Of course, one of the endmost shafts **58** then has its externally threaded portion **58***b* extending outwardly beyond the outer surface of the corresponding base **21** while the shaft **58** at the other end of the corresponding series has its internally threaded bore **58***a* exposed adjacent the outer surface of the opposite base **21**.

Accordingly, one of the two endmost shafts **58** (FIGURE 2) has a nut N threaded thereon and engaging the outer surface of the corresponding adjacent outermost base **21** and being threaded onto the corresponding reduced threaded portion **58***b*. The other endmost shaft **58** has a screw S threaded thereinto and engaging the outer surface of that base **21** which is most remote from the outer surface of the base **21** engaged by the nut N, thus securely fastening all of the bases and the remaining portions of the corresponding assemblies A, A^3 together.

From the foregoing description, it is apparent that, when several of the bases **21** are secured together in the aforesaid manner, all the transverse ports **41** are in alinement with each other, all of the transverse ports **42** are in alinement with each other, and all of the transverse ports **43** are in alinement with each other so that, in effect, three composite ports or channels are formed throughout the group of valve assemblies. If the fluid medium to be controlled by the valve assemblies A–A^3 is air, both ends of the passageways formed by the respective series of ports **41**, **43** may remain open. However, if the fluid medium is liquid or may not be exhausted into the atmosphere, either end of each of the composite passageways formed by the alined transverse ports **41**, **43** may be closed by a plug similar to the plug **59** and the other end thereof may have a return line connected thereto in the manner heretofore described. In the latter instance, base **21** of assembly A^3 may be turned end-for-end relative to the other bases **21**.

In either event, in order to prevent the leakage of fluid between the adjacent bases **21** at the junctures of adjacent transverse ports **41**, **42**, **43**, a resilient O-ring **70** is provided between each adjacent pair of bases **21** at the juncture of each adjacent pair of transverse ports **41–43**. It will be observed in FIGURES 4 and 6 that a shallow circular recess **70***a* is formed in the side of each base **21** opposite from that side which has the threaded portions **44–46** therein and which is substantially concentric with each of the transverse ports **41–43**. The depth of each recess **70***a* should be less than half the thickness of the corresponding O-ring **70** so as to provide an effective seal between adjacent bases **21** at the adjacent transverse ports **41–43**. When base **21** of assembly A^3 is turned end-for-end relative to the other bases (FIGURE 4), it is apparent that two O-rings **70**, or a double-thickness O-ring, may be provided in the recesses **70***a* then facing each other.

As heretofore stated, when only a single valve assembly is required, the auxiliary base **21***a* (FIGURES 9 and 10) is substituted for a corresponding base **21**. The auxiliary base **21***a* differs from the first form **21** in that the various ports which are adapted to have fluid conveying conduits connected thereto do not extend all the way through the base **21***a* as is the case with respect to the ports **41–43** of each base **21** (FIGURES 1, 2, 3, 4 and 6).

As best shown in FIGURE 10, one side of auxiliary base **21***a* is provided with three internally threaded transverse ports **44***a*, **45***a*, **46***a* which are of sufficient depth only to insure that they properly communicate with the respective passageways *2c''*, *2e''*, *2g''*. The other side of auxiliary base **21***a* is provided with two internally threaded transverse ports **52***a*, **53***a* which are also of sufficient depth only to insure that they properly communicate with the respective passageways *2d''*, *2f''*. It should be noted that none of the ports **44***a*–**46***a*, **52***a*, **53***a* extend entirely through the auxiliary base **21***a* and none of them communicate with others of the transverse ports in base **21***a*.

When the auxiliary base **21***a* is used in place of any one of the bases **21**, the two service conduits **54**, **55** may be connected to the ports **52***a*, **53***a* and the fluid inlet conduit **50** may be connected to the centrally located port **45***a* so that either of the bases **21**, **21***a* may be used interchangeably with any one of the valve bodies **20**.

It is important to note that the ports **44***a*, **45***a*, **46***a*, **52***a*, **53***a* are arranged in symmetrical relationship with respect to a transverse line approximately halfway between opposite ends of base **21***a*; i.e., the port **45***a* is located at a point substantially halfway between opposed ends of auxiliary base **21***a*, the ports **52***a*, **53***a* are located equidistantly either side of the axis of the port **45***a* and the ports **44***a*, **46***a* are also located equidistantly from opposed sides of the port **45***a*, but are spaced further apart than the ports **52***a*, **53***a*.

In order to facilitate securing each valve body **20** to either base **21** or **21***a*, opposed side portions of each valve body **20** are provided with a plurality of equally spaced symmetrically arranged fastener-receiving holes (FIGURE 1A), the fastener-receiving holes being arranged in rows which straddle the longitudinal bore **24** (FIGURE 3) through each valve body **20**. In this instance, three fastener-receiving holes are provided in each row adjacent each side of the valve body **20**, the holes in one such row being indicated at **61**, **62**, **63** and the holes in the other row being indicated at **64**, **65**, **66**. The centermost holes **62**, **65** in each valve body **20** are located at a point halfway between longitudinally opposed ends of body **20**.

The holes **61**, **63** are transversely alined with respect to the holes **64**, **66**, but the distance between the holes **61**, **63** and **64**, **66** is greater than the maximum diameter of the central ports **45**, **45***a* in the respective bases **21**, **21***a* and the distal edges thereof are spaced closer together than the distance between the proximal surfaces of the ports **44**, **46** and **44***a*, **46***a* of the bases **21**, **21***a*. The fastener-receiving holes **61–66** are also spaced equidistantly from a line extending longitudinally of the body **20** (FIGURES 1A and 9).

The fastener-receiving holes **61–66** in each body **20** are arranged in the aforesaid manner so as to insure that each valve body may be fastened to either base **21** or **21***a* at a plurality of points so as to insure a tight seal between each valve body and the corresponding base. In this connection, it will be noted that the gasket **36** is also provided with two rows of fastener-receiving holes, each row of which includes three holes which are spaced so as to register with the holes **61–66** in each valve body **20**. The holes in the gasket **36** corresponding to the holes **61–66** in valve body **20** are indicated at **71–76**, respectively, in FIGURE 9.

It is apparent that the gasket **36** may be positioned in either longitudinal direction with respect to the corresponding valve body **20**, since the holes **71–76** therein are symmetrically arranged. In other words, the holes **74–76** may be alined with the respective holes **63**, **62**, **61** and the holes **71–73** may be alined with the respective holes **66**, **65**, **64** with equal facility. Referring to FIGURE 6, it will be observed that the primary base **21** has four internally threaded fastener-receiving holes **81**, **83**, **84**, **86** therein symmetrically arranged so they may register with the respective holes **61**, **63**, **64**, **66** in the corresponding valve body **20** or they may register with the respective holes **66**, **64**, **63**, **61** with equal facility so that fasteners in the form of screws **87** (FIGURE 1) may be inserted through the holes **61**, **63**, **64**, **66** in body **20** and holes **71**, **73**, **74**, **76** in gasket **36** and threaded into the corresponding holes **81**, **83**, **84**, **86** in a corresponding primary base **21** for securing each valve body **20** to the first form of valve base **21**.

Referring to FIGURE 10, it will be observed that the second form of valve base **21***a* also has internally threaded fastener-receiving holes **81***a*, **83***a*, **85***a* therein symmetrically arranged with respect to the row of passages $2c''$–$2g''$ and spaced so as to register with either the three holes **61**, **63**, **65** or the three holes **64**, **66**, **62** in the corresponding valve body **20**, depending upon which longitudinal direction the valve body **20** may be positioned on the base **21***a*. Of course, once a valve body is positioned upon auxiliary valve base **21***a*, suitable screws, identical to the screws **87** in FIGURE 1, for example, may be positioned in the corresponding holes **61**, **63**, **65**, or **64**, **66**, **62**, as the case may be, and in corresponding holes in gasket **36**, and their ends may be threaded into the corresponding holes **81***a*, **83***a*, **85***a* in base **21***a*.

It is thus seen that all the valve bodies **20**, the gaskets **36**, and the bases **21**, **21***a* may be used interchangeably in forming multiple or single valve assemblies. Opposed ends of both bases **21**, **21***a* are each provided with a pair of vertically spaced internally threaded holes **88** (FIGURES 3, 6, 9 and 10) to accommodate securing to either end of either base **21** or **21***a* a form of primary valve-operating control unit to be later described. Each end of each valve body **20** is provided with a pair of diagonally opposed internally threaded holes **90**, **91** therein which are spaced equidistantly from the axis of the corresponding valve core **25**.

Holes **90**, **91** are provided to facilitate interchangeably securing various types of valve-operating units, including a portion of the aforementioned primary valve-operating unit mentioned heretofore, to either or both ends of each valve body **20**. There are many different types of valve-operating units to be later described which may be connected to opposed ends of the valve bodies **20**, depending upon the purpose for which the resultant valve assemblies are to be used.

The primary and auxiliary valve-operating units shown connected to opposed ends of the valve body **20** in FIGURES 1, 2 and 3 will now be described.

Each primary valve-operating control unit **22** comprises two casings **99**, **100** of built-up construction. The lower casing **99** serves an an electrical wire terminal box and is secured to one end of the corresponding base **21** by means of a pair of screws **101** threaded into the corresponding pair of holes **88**. Casing **100** is a composite control casing secured to one end of the corresponding valve body **20** as by screws **102**, only one of which is shown in FIGURE 1 (see FIGURE 2), and which are, of course, threaded into the corresponding holes **90**, **91** (FIGURE 7) in one end of the body of assembly A.

The upper outer portion of each casing **100** (FIGURE 3) has a solenoid coil **103** therein to opposed ends of which electrical conductors **104** are connected through the medium of an electrical connector **105** fixed in the upper wall of casing **99**. The conductors **104** associated with the coil **103** of each primary valve-operating unit **22** may be connected to a source of electrical energy through a separate switch means, not shown, as desired.

The coil **103** surrounds a tubular exhaust valve **106** and a portion of a solenoid plunger **107** normally biased away from valve **106** and toward an inlet valve or orifice **110** by a compression spring **111**. Each valve body **20** has a longitudinally extending channel **112** in its upper portion whose opposed ends are preferably provided with small screens or filters **113** therein and whose central portion communicates with the chamber *e* through the medium of a radial passage **114**. In FIGURE 3, channel **112** is shown alined with a passage **116** in the control casing **100** of valve-operating unit **22**. Passage **116** communicates with an annular chamber **117** formed in each casing **100** (FIGURE 2). Annular passage **117** also communicates with a port **118** which opens at valve **110**.

Valve **110** opens into a chamber **121** within which one end of solenoid plunger **107** and its spring **111** are positioned. Chamber **121** communicates with a cylindrical chamber or cylinder **122** by means of a passage **123**. Cylindrical chamber **122** has a piston **124** therein which carries an annular seal or O-ring **125** for engaging the inner surface of cylindrical chamber **122**. Piston **124** bears against and need not be secured to or formed integral with the corresponding end of valve core **25**.

The other end of valve core **25** in FIGURE 3 has a disk **127** suitably secured thereto, as by a screw **130**. Disk **127** is a part of the auxiliary valve-operating unit **23**, the housing of which is indicated at **131** and is of cup-shaped form. Housing **131** (FIGURES 1, 3 and 8) includes an end wall **132** and is secured to the corresponding end of the corresponding valve body **20** by a pair of screws **135** which extend through holes **90'**, **91'** alined with the respective threaded holes **90**, **91** (FIGURE 7) in the end of valve body **20**. The housing **131** of each auxiliary valve-operating unit **23** (FIGURES 1 and 3) has a cavity **133** therein within which a compression spring **134** is positioned. One end of compression spring **134** bears against disk **127** and the other end of compression spring **134** bears against the outer end wall **132** of the housing **131**.

The method of operation of the assembly A of FIGURE 3 will now be given assuming that the supply conduit **50** is connected to a source of compressed air, not shown, and the service conduits are connected to opposed ends of a double-acting cylinder, for example. When the parts occupy the position shown in FIGURE 3, compressed air flows into the lateral port **42** of base **21** in FIGURE 3 from conduit **50** and then flows upwardly through passageways *e''*, *e'* and into chamber *e*. Compressed air then flows past the neck portion **32** of valve core **25**, into chamber *d*, and through the vertical passageways *d'*, *d''* into service conduit **54**. At the same time, compressed air is returned from the double-acting cylinder, not shown, through conduit **55**, passageways *f''*, *f'*, chambers *f*, *g*, through passageways *g'*, *g''* and is thus exhausted through lateral port **43**.

Upon energization of the coil **103** of primary valve-operating unit **22**, plunger **107** moves out of engagement with valve **110** and into engagement with valve **106** (FIGURE 3) to prevent air from being exhausted through valve **106** as it opens valve **110**. In so doing, this permits compressed air to flow from lateral port **42**, through the alined passageways *e''*, *e'*, through chamber *e*, through radial passageway **114**, through channel **112**, through passages **116**, **117**, **118** and through valve **110** into the chamber **121**. Compressed air then flows from the chamber **121** through passage **123** and into cylindrical chamber **122** adjacent the outer surface of piston **124**.

This causes piston **124** and valve core **25** to move from right to left in FIGURE 3 in opposition to compression spring **134** so that the neck portions **32**, **33** then communicate with the respective chambers *c*, *d* and *e*, *f*, respectively. It is apparent that this reverses the direction of flow of the compressed air through the service conduits **54**, **55** since compressed air enters the chamber *e* of the valve assembly A in FIGURE 3 in the manner heretofore described, then flows from chamber *e* into chamber *f* and through passageways *f'*, *f''* to the service conduit **55** as compressed air is exhausted from service conduit **54** through passageways *d''*, *d'*, chamber *d*, *c*, passageways *c'*, *c''* and the lateral port **41**.

When coil **103** is subsequently deenergized, spring **111** moves solenoid plunger **107** against valve **110** and opens valve **106** so that compressed air may be exhausted through valve **106** and is prevented from entering chamber **121** through valve **110**. Thus, compression spring **134** then moves the valve core **25** from left to right to the position in which it is shown in FIGURE 3 as air to the right of piston **124** is exhausted through passage **123**, chamber **121**, through the central portion of coil **103** and through valve **106** to the atmosphere. It is apparent that each of the valve assemblies A^1, A^2, A^3 may be operated in the same manner as that just described for the valve assembly A.

In the event that it is desired to manually operate any one or more of the primary valve-operating units **22**, the composite casing **100** is provided with a manually operable plunger **136** (FIGURES 2 and 3), one end of which projects outwardly from casing **100** and the other end of which is enlarged and is normally spaced from the corresponding end of solenoid plunger **107**. Thus, in order to manually operate the primary valve-operating control unit **22** shown in FIGURE 3, an operator merely depresses plunger **136** and moves the same against solenoid plunger **107**, thus moving plunger **107** out of engagement with the open end of valve **110** and into engagement with the corresponding open end of valve **106**.

The valve core **25** will then be operated in the same manner as was the case when the solenoid coil **103** was energized. Of course, chamber **121** is so formed that plunger **136** will not close the upper end of passage **123** when it is moved inwardly against solenoid plunger **107**. As soon as the operator releases plunger **136**, spring **111** will again return solenoid plunger **107** to the position shown in FIGURE 3 and the pressure then existent in chamber **121** will return manually operable plunger **136** to the position shown in FIGURE 3.

In FIGURES 11 through 11F and 12 through 12E, there are shown various types of valve-operating units **23***a*–**23***g* and **22***a*–**22***f* which may be used interchangeably and in various combinations in place of the valve-operating units **22**, **23** shown in FIGURES 1, 2 and 3. The valve-operating units shown in FIGURES 12 through 12E may each be used as a control unit in place of the primary valve-operating unit **22** of FIGURE 3. The valve-operating units shown in FIGURES 11 through 11F may serve as auxiliary valve-operating units in place of the valve-operating unit **23** of FIGURE 3. Although all of the primary valve-operating units shown in FIGURES 3 and 12 through 12E cannot be used in combination with some of the auxiliary valve-operating units **23** through **23***g* shown in FIGURES 3 and 11 through 11F, the primary valve-operating control units **22** through **22***f* of FIGURES 3 and 12 through 12E may be used in combination with certain of the auxiliary valve-operating units **23** through **23***g* shown in FIGURES 3 and 11 through 11F, as will be later explained. The primary valve-operating unit **22** of FIGURE 3 may be used with the auxiliary valve-operating units **23***c*, **23***d*, **23***e* of FIGURES 11B, 11C and 11D, as desired. It is important to note that all of the valve-operating units shown in FIGURES 11 through 11E and 12 through 12F have housings which are of generally similar configuration to that of the housing **131** of auxiliary valve-operating unit **23** (FIGURE 3) and all of them have holes arranged therein in the manner of the holes **90'**, **91'** of the auxiliary valve-operating unit **23** (FIGURE 8) so that all the valve-operating units may be used interchangeably with each of the valve bodies **20**.

The primary and auxiliary valve-operating units **23***a*, **22***a* shown in respective FIGURES 11 and 12 are the same valve-operating units which are shown in association with the valve body **20** in the illustration of the second form of valve assembly shown in FIGURE 9 and will now be described in detail.

The valve-operating units **22***a*, **23***a* of FIGURES 9, 11 and 12 are provided for use in instances in which movement of valve core **25** in both directions longitudinally thereof is to be effected manually. Accordingly, the primary valve-operating unit **22***a* includes a cup-shaped housing **100***a* of substantially the same form as the housing **131** of valve operating unit **23** (FIGURE 3). Housing **100***a* is secured to one end of one of the valve bodies **20** by the screws **102** (FIGURE 9) and has a cavity **122***a* therein within which a pair of washers **124***a* are positioned, the innermost of which bears against valve core **25** and which may bear against the corresponding washer **30** held against the corresponding end of body **20** by the corresponding housing **100***a*.

A control knob **140** has a threaded stem **141** integral therewith or suitably connected thereto and which is threaded into the corresponding end of valve core **25**. In order to maintain the knob **140** in spaced relation from the washers **124***a*, a spacing sleeve **142** is provided therebetween which surrounds the stem **141** and loosely extends through the wall **143** of housing **100***a* opposite from the valve core **25**. The washers **124***a* may serve to limit the extent of longitudinal movement of valve core **25** and control knob **140**, since one of the washers **124***a* engages the fixed washer **30** upon movement of the valve core **25** in one direction and the other washer **124***a* engages the end wall **143** of housing **100***a* when valve core **25** and knob **140** are moved in the opposite direction. Valve-operating unit **22***a* may also be used when any one of the valve-operating units **23**, **23***b*, **23***e*, **23***f* or **23***g* is mounted on the other end of the corresponding body **20**.

The valve-operating unit **23***a* (FIGURES 3 and 11) is identical to the valve-operating unit **23** of FIGURE 3 with the exception that the compression spring therein

is omitted, since valve-operating unit 23*a* simply serves as a shield to prevent foreign matter from accumulating on the elements 127*a*, 130*a* and between the washers 127*a*, 31. Accordingly, those parts of operating unit 23*a* which are the same or similar to parts of the valve-operating unit 23 shall bear the same reference characters with the letter "*a*" added, to avoid repetitive description.

The valve-operating unit 22*b* of FIGURE 12A, when mounted on one end of a valve body 20, may be used when either of the valve-operating units 23 or 23*e* is mounted on the other end of a valve body 20. Unit 22*b* includes a housing 100*b* having a cavity 122*b* and a washer 124*b* therein, which are similar to the elements 100*a*, 122*a*, 124*a* of valve-operating unit 22*a*. Washer 124*b* is secured to the corresponding end of valve core 25 by a screw 144. The valve-operating unit 22*b* is particularly adapted to be operated by a cam 145 and should be used with an auxiliary valve-operating unit capable of yieldably urging the valve core 25 from left to right in FIGURE 12A, such as the valve-operating unit 23 (FIGURE 3) or 23*e* (FIGURE 11D).

The valve-operating unit 22*b* also includes a hollow or tubular plunger 147 whose reduced outer portion is mounted for longitudinal sliding movement in the end wall 143*b* of housing 100*b* and which has a ball 150 loosely mounted therein. The outer end of plunger 147 is restricted at 151 to limit outward movement of ball 150. The inner surface of ball 150 engages a disk 152 which bears against one end of a compression spring 153 within tubular plunger 147. The other end of spring 153 bears against a disk 154, which, in turn, bears against a snap ring 155 fixed in the plunger 147. The inner end of plunger 147 simply bears against washer 124*b*.

It is apparent that the plunger 147 reciprocates in accordance with the configuration of the cam 145 and, in the event of a high surface on cam 145 tending to move the plunger 147 inwardly beyond the extent to which it may move when the washer 124*b* is positioned against washer 30, the ball 150 may then recede relative to the tubular plunger 147. When unit 22*b* is used with unit 23*e*, it would only move valve core 25 between neutral position and the position establishing communication between chambers *c*, *d* in valve body 20 in FIGURE 3, as will become apparent in the description of unit 23*e*. Unit 22*b* may be used also with another unit identical to unit 22*b* mounted on the opposite end of a valve body 20.

The primary valve-operating unit 22*c* of FIGURE 12B is provided for fluid-pressure operation of the valve core 25 in one direction and may be used in combination with the auxiliary valve-operating unit 23 of FIGURE 3 for returning the valve core 25 to its normal quiescent position. The valve-operating unit 22*c* includes a housing 100*c* having a cavity 122*c* therein (FIGURE 12B) within which a piston 124*c* and an encircling O-ring *c* are positioned. The piston 124*c* bears against and need not be fixed to or formed integral with valve core 25. Piston 124*c* may be identical to the piston 124 of FIGURE 3.

The outer wall 143*c* of housing 100*c* has an internally threaded passageway 157 therein for receiving the threaded end of a conduit 160 leading from a suitably controlled source of compressed air or other fluid under pressure. It is apparent that, when pressure is introduced into chamber or cavity 122*c* through conduit 160, piston 124*c* and valve core 25 are moved from right to left in FIGURE 12B and, when fluid pressure is released from the chamber 122*c* through conduit 160, the spring 134 (FIGURE 3), for example, may return valve core 25 to its original position shown in FIGURE 12B. It is apparent that two of the valve-operating units 22*c* may be used on opposite ends of a valve body 20, or unit 23*e* may be used with unit 22*c*.

The primary valve-operating unit 22*d* of FIGURE 12C also includes a housing 100*d* having a cavity or chamber 122*d* therein through which an extension 161 of valve core 25 loosely extends. The extension 161 also loosely extends through the outer wall 143*d* of housing 122*d*. The valve-operating unit 22*d* is particularly adapted to be foot-operated and may be used in combination with an auxiliary valve-operating unit of the type indicated at 23 (FIGURE 3), 23*c* (FIGURE 11B), 23*d* (FIGURE 11C), or 23*e* (FIGURE 11D).

The extension 161 may be suitably secured to or formed integral with valve core 25 and has a limiting washer 124*d* fixed thereon which may serve to limit movement of valve core 25 in the same manner as that described for the washers 124*a* of FIGURE 12. The outer end of extension 161 has a link 162 pivotally connected thereto, the other end of which is pivotally connected to a foot pedal 163 pivotally mounted, as at 164, on an arm 165 formed integral with and projecting upwardly and outwardly at an angle from the housing 100*d*.

FIGURE 12D shows another form of primary valve-operating unit 22*e* devised for manual operation of the valve core 25 and which may be used with any one of the units 23, 23*a*, 23*b*, 23*e*, 23*f* or 23*g* (FIGURES 3, 11, 11A, 11D, 11E and 11F). Valve-operating unit 22*e* of FIGURE 12D comprises a housing 100*e* having an outer wall 143*e* defining a cavity or chamber 122*e* therein within which a washer 124*e* is positioned. In this instance, washer 124*e* is held against the corresponding end of valve core 25 by a shifting block 167 whose reduced portion extends through washer 124*e* and is threaded or otherwise suitably secured to the corresponding end of valve core 25.

Shifting block 167 has a vertically extending hole 170 therethrough in which the rounded lower end of a manually operable shifting rod or lever 171 is positioned. A medial portion of shifting rod 171 extends through a hole 172 formed in a projection 173 on the upper portion of housing 100*e*. Shifting rod 171 is pivotally mounted, as at 174, within the hole 172 and has a suitable knob 175 on its upper end adapted to be grasped by an operator for manipulating the shifting rod 171. A suitable resilient boot 176 encircles projection 173 of housing 100*e* and the shifting rod 171 to prevent dust or other foreign matter from entering chamber 122*e*, through hole 172.

The primary valve-operating unit 22*f* of FIGURE 12E is particularly devised so the valve core 25 normally will be maintained in neutral or closed position and may be moved from right to left by positive fluid pressure or from left to right by suction. The elements 100*f*, 122*f*, 124*f*, 125*f*, 143*f*, 157*f* of unit 22*f* are substantially the same as the respective elements 100*c*, 122*c*, 124*c*, 125*c*, 143*c* and 157 of the valve-operating unit 22*c* in FIGURE 12B.

The outer end portion of chamber 122*f* of housing 100*f* is reduced and has a sleeve 180 fixed therein which is restricted, as at 181, and within which the flanged outer portion 182 of a cup member 183 has longitudinal sliding movement. Flange 182 normally bears against the restriction 181 of sleeve 180 under the influence of a compression spring 184, one end of which bears against the outer wall 143*f* of housing 100*f* and the other end of which bears against the bottom *h* of the cup member 183. The annular bottom *h* of cup member 183 fits in an annular recess 185 formed in the outer portion of piston 124*f*. One end of a fluid-conveying conduit 186 is threadedly secured in the threaded passageway 157*f* and the other end of suction tube or conduit 186 may be connected to a suitably controlled source of fluid pressure or suction, not shown.

In its intended use, one of the valve-operating units 22*f* would be mounted on each end of a valve body 20 and each conduit 186 would be connected to a means, not shown, for alternatively introducing fluid pressure into and exhausting pressure from each housing 100*f*. Thus, in the absence of fluid pressure in either conduit 186, valve core 25 would occupy neutral or closed position. Upon fluid pressure then being introduced into one of the housings 100*f* through its conduit 186, the piston 124*f* therein would be forced away from the adjacent

cup member **183** and against washer **30** (or **31**). Upon the fluid pressure subsequently being exhausted from the latter housing **100***f*, the spring **184** in the other of the housings **100***f* would return valve core **25** to neutral position.

Valve-operating unit **22***f* also may be used with any one of the valve-operating units **22**, **23***c*, **23***d*, or **23***e* (FIGURES 3, 11B, 11C and 11D). The threaded passageway **157***f* may remain open, without pipe **186** connected thereto, when units **22** and **22***f* are combined on opposite ends of a common valve body **20**. The manner of operation of valve-operating unit **22***f* when used with any of the units **22**, **23***c*, **23***d* or **23***e* is apparent from the foregoing description and will not be repeated here.

It is apparent that, upon the application of suction within the sleeve **180** and cup member **183** and if unit **22***f* is used with a unit **23***a* or **23***e* (FIGURES 11 and 11D), the valve core **25** may move from left to right in FIGURE 12E. Such movement of the valve core **25** may be assisted by using an auxiliary valve-operating unit of the type indicated at **23** in FIGURE 3 in combination with the valve-operating unit **22***f* of FIGURE 12E, if desired. Upon releasing negative pressure or suction from conduit **186** and chamber **122***f*, it is apparent that spring **184** will then return valve core **25** to the position shown in FIGURE 12E.

The auxiliary valve-operating unit **23***b* in FIGURE 11A is quite similar to the valve-operating unit **23** of FIGURE 3 with the exception that it is so arranged as to normally urge the valve core **25** outwardly, rather than inwardly, with respect to the corresponding end of a valve body **20**. Accordingly, the elements of valve-operating unit **23***b* corresponding to like elements of valve-operating unit **23** will bear the same reference characters with the letter "*b*" added, to avoid repetitive description. However, instead of the washer **127***b* being positioned in engagement with the washer **31**, it will be observed in FIGURE 11A that the washer **127***b* has a tubular extension **190** which is preferably of substantially the same diameter as the valve core **25** and which is secured to the valve core **25** by the screw **130***b*. Thus, the compression spring **134***b* is positioned between and in engagement with the proximal surfaces of the washers **31** and **127***b* so that compression spring **134***b* urges the valve core **25** from right to left in FIGURE 11A while, conversely, the spring **134** urges valve core **25** from left to right in FIGURE 3. Unit **23***b* may be used with unit **22***e* (FIGURE 12D).

The auxiliary valve-operating units **23***c*, **23***d* of respective FIGURES 11B and 11C are quite similar to each other with the exception that the piston of valve-operating unit **23***d* has a smaller effective surface area than the piston of valve-operating unit **23***c*, although both of the housings thereof may be identical. The housings **131***c*, **131***d* and the chambers **133***c*, **133***d* of the respective auxiliary valve-operating units **23***c*, **23***d* may be identical to the housing **131** and the chamber **133** of the auxiliary valve-operating unit **23** shown in FIGURE 3. However, instead of the corresponding end of the valve core **25** being provided with a washer, such as is indicated at **127** shown in FIGURE 3, a relatively large piston **127***c* is positioned against, but need not be, the corresponding end of valve core **25** in the valve-operating unit **23***c* in FIGURE 11B and a relatively small piston **127***d* is positioned against, but need not be secured to or formed integral with, the valve core **25** in the valve-operating unit **23***d* in FIGURE 11C.

The pistons **127***c*, **127***d* are encircled by respective resilient sealing rings or O-rings **191**, **191***d*. The O-ring **191** engages the inner surface of the chamber or cavity **133***c* in FIGURE 11B. However, the O-ring **191***d* (FIGURE 11C) engages the inner surface of a reducing sleeve **192** of lesser length than the depth of cavity **133***d* and which is positioned in sealing engagement with the inner peripheral surface of cavity **133***d* by means of a resilient ring **193**.

The upper portions of the housings **131***c*, **131***d* are provided with respective longitudinally extending passages **194**, **194***d* which are so positioned that they are in alinement with the passage **112** in the valve body **20** when they are alternatively connected to the corresponding end of a body **20**. The outer ends of passages **194**, **194***d* are closed and respective relatively small passages **195**, **195***d* establish communication between the outer portions of the passages **194**, **194***d* and the outer ends of the respective cavities **133***c*, **133***d* of the housings **131***c*, **131***d*.

The outer end walls **132***c*, **132***d* of housings **131***c*, **131***d* (FIGURES 11B and 11C) have respective internally threaded holes **196**, **196***d* therein. The threaded hole **196** is shown with one end of a conduit **197** threaded therein which is adapted to be connected to or is a part of a suitable valve mechanism, not shown, for selectively exhausting pressure from the chamber **133***c*. The threaded hole **196***d* (FIGURE 11C) has a threaded plug **197***d* positioned therein.

In instances in which the valve-operating unit **23***c* (FIGURE 11B) is to be used, two of them are used, one of them being secured to each end of a valve body **20**. Thus, assuming that one of the valve-operating units **23***c* is connected to each end of the valve body **20** in FIGURE 3 in place of the valve-operating units **22**, **23**, as long as pressure is prevented from escaping from the two chambers **133***c*, equal pressure is maintained in each chamber **133***c* between the pistons **127***c* and the outer walls **132***c* of the housings **131***c*, since pressure is conveyed from chamber *e* of the valve body **20** through passageway **114** and channel **112** (FIGURE 3) through the passages **194**, **195** into the respective chambers **133***c* in the two units **23***c*.

It follows that, upon pressure being released from either of the chambers **133***c*, through its conduit **197**, and not being released from the other of the chambers **133***c*, the pressure in said other chamber **133***c* will move the corresponding piston **127***c* and the valve core **25** toward that chamber **133***c* from which pressure is being released. Thus, it is apparent that the valve core **25** may be moved in either direction, depending upon which of the two chambers **133***c* has pressure released therefrom.

The valve-operating unit **23***d* is particularly adapted to be used in combination with the primary valve-operating unit **22** of FIGURE 3. In this instance, since the surface area of piston **191***d* (FIGURE 11C) is substantially less than that of piston **124** (FIGURE 3), it follows that the introduction of pressure into the chamber **122**, in the manner heretofore described, causes the valve core **25** to move from right to left in FIGURE 3. However, upon deenergization of coil **103**, and the return movement of solenoid plunger **107** to where it closes valve **110**, fluid pressure from chamber *e* of valve body **20** will be transmitted through passages **114**, **112**, **194***d*, **195***d* into chamber **133***d* of valve-operating unit **23***d* and will thus return valve core **25** to the position of FIGURE 3. When valve **110** is opened and valve **106** is closed (FIGURE 3), by energization of the coil **103**, even though the same amount of pressure will be present in both of the chambers **133***d* and **122** (FIGURES 11C and FIGURE 3, respectively), the larger surface area of piston **124** as compared to that of piston **127***d* will cause the valve core **25** to move from right to left in FIGURE 3.

The valve-operating unit **23***e* of FIGURE 11D is provided for normally yieldably maintaining the valve core **25** in a neutral position in which the larger portions of valve core **25** prevent communiction between any of the chambers *c–g* of valve body **20**. However, the valve core **25** can then be moved in one or both directions from the neutral position either mechanically or manually, such as by means of any one of the valve-operating units **22** through **22***f* shown in FIGURES 3 and 12 through 12E, for example.

To this end, it will be observed in FIGURE 11D that the cavity or chamber **133***e* of housing **131***e* of auxiliary valve-operating unit **23***e* has a pair of flanged cup-like

spring seats **200**, **201** therein whose flanges are engaged by opposed ends of a compression spring **203**. The proximal end portions or bottoms of the spring seats **200**, **201** are slidably penetrated by a plunger **204** having suitable abutments **205**, **206** thereon which engage the distal surfaces of the bottoms of the cup-like spring seats **200**, **201**. The inner end of plunger **204** is secured to the corresponding outer end of valve core **25** by means of a screw **207**.

It is apparent that, when force is applied to the valve core **25** tending to move the same from right to left in FIGURE 11D, spring **203** is compressed as spring seat **200** moves from right to left therewith so that, upon such force being removed from valve core **25**, valve core **25** will return to the position in which it is shown in FIGURE 11D. Conversely, when force is applied to valve core **25** from left to right in FIGURE 11D, spring seat **201** will move from left to right with valve core **25** and will thus return the valve core **25** to its neutral position shown in FIGURE 11D when the latter force is removed from valve core **25**.

The valve-operating units **23***f*, **23***g* shown in FIGURES 11E and 11F are provided for yieldably locking a valve core **25** in different positions to which it may be moved by the knob **140** or control lever **171** of the respective valve-operating units **22***a*, **22***e* of FIGURES 12 and 12D, for example. Valve-operating units **23***f*, **23***g* include respective housings **131***f*, **131***g* which are substantially the same as or identical to housing **131** of valve-operating unit **23** (FIGURE 3), and which have respective chambers or cavities **133***f*, **133***g* therein within which respective peripherally grooved sleeves **210**, **210***g* are positioned.

Sleeves **210**, **210***g* are of substantially the same length as the depth of the corresponding cavities **133***f*, **133***g* so the sleeves **210**, **210***g* are locked against axial movement in the cavities **133***f*, **133***g*. Medial portions of the sleeves **210**, **210***g* have respective annular grooves **209**, **209***g* therein within which respective resilient O-rings **211**, **211***g* are positioned. The sleeves **210**, **210***g* also have respective radially extending chambers or holes **212**, **212***g* therein within which respective detents or balls **213**, **213***g* are loosely positioned. The holes **212**, **212***g* are preferably tapered inwardly so that they are of smaller diameter at the inner walls of the sleeves **210**, **210***g* than they are at the outer surfaces of the sleeves, and the balls **213**, **213***g* are of slightly larger diameter than the smallest diameter of the holes **212**, **212***g* so that they cannot pass entirely through the holes **212**, **212***g*. The O-rings **211**, **211***g* bear against the outer surface of and normally yieldably urge the respective balls **213**, **213***g* inwardly.

In FIGURE 11E, the valve core **25** has a plunger **215** fixed thereon, as by a screw **216**. The plunger **215** is of slightly greater diameter than the valve core **25** and is slidably movable within the corersponding sleeve **210**. Opposed ends of plunger **215** are beveled at **217**, **218** and the beveled surfaces **217**, **218** are so spaced that, when valve core **25** occupies its extreme left-hand position as shown in FIGURE 11E, the outer end of plunger **215** bears against the outer wall **132***f* of housing **131***f* and is retained in this position by the detent or ball **213**.

On the other hand, upon sufficient pressure being applied to the valve core **25** from left to right to FIGURE 11E, ball **213** is forced into the hole **212** and subsequently drops against the beveled surface **218** to maintain the valve core **25** in the other of its two positions. It is apparent that, upon the application of sufficient force to valve core **25** from right to left in FIGURE 11E, ball **213** will again recede into the hole **212** until the beveled surface **217** again moves into engagement therewith.

The left-hand end of the valve core **25** in FIGURE 11F also has a plunger **215***g* fixed thereto by a screw **216***g* and which is also provided with beveled surfaces **217***g*, **218***g* on opposite ends thereof. The plunger **215***g* may be identical to plunger **215** with the exception that it is provided with an annular groove **221** in the periphery thereof which is preferably substantially centrally located between the two beleved surfaces **217***g*, **218***g*.

The valve-operating unit **23***g* is operated in exactly the same manner as that described for the valve-operating unit **23***f* with the exception that the annular groove **221** in plunger **215***g* serves to yieldably lock the valve core **25** in an intermediate position. By referring to FIGURE 3, it is apparent that when the valve core **25** occupies intermediate position, this blocks communication between any of the adjacent chambers *c*–*g*.

It is thus seen that we have provided an improved valve construction which is adapted to interchangeably accommodate many different types of valve-operating mechanisms and wherein the valve bodies **20**, bases **21**, **21***a* and gaskets **36** may be assembled interchangeably without regard for which direction either end of the valve body **20** may be facing with respect to the ends of the valve bases **21**, **21***a* due to the symmetrical arrangement of the various ports, passages and passageways, through or in the valve bodies **20**, the gaskets **36** and the bases **21**, **21***a* and also due to the symmetrical arrangement of the fastener-receiving holes in the valve bodies **20**, the gaskets **36**, the bases **21**, **21***a* and in the various housings of the valve-operating units, thus greatly facilitating the commercial production and use of valve assemblies according to this invention.

In the drawings and specification there have been set forth preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only, and not for purposes of limitation, the scope of the invention being defined in the claims.

We claim:

1. In a slide type valve assembly, an elongate base having a flat upper surface, said base having a transverse supply port and a pair of transverse exhaust ports straddling and being equally spaced from said supply port, said supply port being located halfway between opposed ends of said base, all of said ports being spaced the same distance below said upper surface, said base also having a pair of substantially vertically extending service passageways therethrough straddling and equally spaced from said supply port, said base also having a separate base passageway extending downwardly from said flat upper surface to each exhaust port and said supply port, the upper ends of said passageways being located symmetrically with respect to a longitudinal line halfway between laterally opposed sides of said base and with respect to a transverse line halfway between opposed ends of said base, an elongate valve body having a longitudinal bore therethrough, an axially movable spool valve core in said bore, means dividing said bore into five chambers, said body having a flat lower surface and a separate second passageway extending downwardly from each chamber and opening at the lower surface of said body, said second passageways being spaced the same distance from each other as said base passgeways and said service passageways so as to register with corresponding base passageways and service passageways, means removably securing said body to said base with the flat surface of said body facing the flat surface of and extending parallel with said base, the centermost of said second passageways being located halfway between longitudinally opposed ends of said body, and all of said second passageways being located symmetrically with respect to a longitudinal line halfway between laterally opposed sides of said body.

2. In a slide type valve assembly, an elongate base having a flat upper surface, said base having a transverse supply port in one side thereof and a pair of transverse exhaust ports in said one side straddling and being equally spaced from said supply port, said supply port being located halfway between opposed ends of said base, said base also having a pair of transverse service ports in the other side thereof straddling and being equally spaced from said supply port, said base also having a separate

base passageway extending downwardly from said flat upper surface to and communicating with each port, the upper ends of said base passageways being located symmetrically with respect to a longitudinal line halfway between laterally opposed sides of said base, an elongate valve body having a longitudinal bore therethrough, an axially movable spool valve core in said bore, means dividing bore into five chambers, said body having a flat lower surface and a separate second passageway extending downwardly from each chamber and opening at the lower surface of said body, said second passageways being spaced the same distance from each other as said base passageways so as to register with said base passageways, means removably securing said body to said base with the flat surface of said body facing the flat surface of and extending parallel with said base, the centermost of said second passageways being located halfway between longitudinally opposed ends of said body, and all of said second passageways being symmetrically arranged with respect to a longitudinal line halfway between laterally opposed sides of said body.

3. In a slide type valve assembly, a plurality of similar elongate bases each having a flat upper surface, each base having a transverse supply port and a pair of transverse exhaust ports straddling and being equally spaced from said supply port, each supply port being located halfway between opposed ends of each base, all of said ports being located the same distance below said flat upper surface, each base also having a pair of substantially vertically extending service passageways therethrough straddling and equally spaced from the respective supply port, each base also having a separate base passageway extending downwardly from its flat upper surface to each respective exhaust port and the supply port, the upper ends of said passageways in each base being located symmetrically with respect to a longitudinal line halfway between laterally opposed sides of the respective base and with respect to a transverse line halfway between longitudinally opposed ends of said base, an elongate valve body for each base having a longitudinal bore therethrough, an axially movable spool valve core in each bore, means dividing each bore into five chambers, each body having a flat lower surface and a separate second passageway extending downwardly from each chamber and opening at the lower surface of the respective body, said second passageways of each body being spaced the same distance from each other as the upper ends of said passageways in each base so as to register with corresponding base passageways and service passageways of any one of said bases, means removably securing each body to a corresponding base with the flat surface of each body facing the flat surface of and extending parallel with the corresponding base, the centermost of said second passageways being located halfway between longitudinally opposed ends of each body, all of said second passageways of each body being located symmetrically with respect to a longitudinal line halfway between laterally opposed sides of the respective body, said bodies each being of no greater transverse width than the respective bases, and means securing said bases together in juxtaposed side-by-side relation with the transverse ports of each base alined with respective transverse ports of the adjacent base or bases.

References Cited by the Examiner

UNITED STATES PATENTS

2,295,111	9/42	Hemmings	251—367 X
2,486,087	10/49	Wright	137—596.13
2,586,906	2/52	Beckett et al.	137—625.65
2,651,324	9/53	Hodgson et al.	137—596.12
2,679,241	5/54	Dickson.	
2,834,368	5/58	Gray	137—271
2,869,567	1/59	Carlson	137—596.13 X
2,955,617	10/60	Collins	137—625.64
3,000,397	9/61	Schmiel	137—596.13
3,060,970	10/62	Aslan	137—625.69
3,076,477	2/63	Brandenberg	137—625.6
3,111,139	11/63	Beckett et al.	251—367 X
3,152,614	10/64	Carls	137—625.69

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