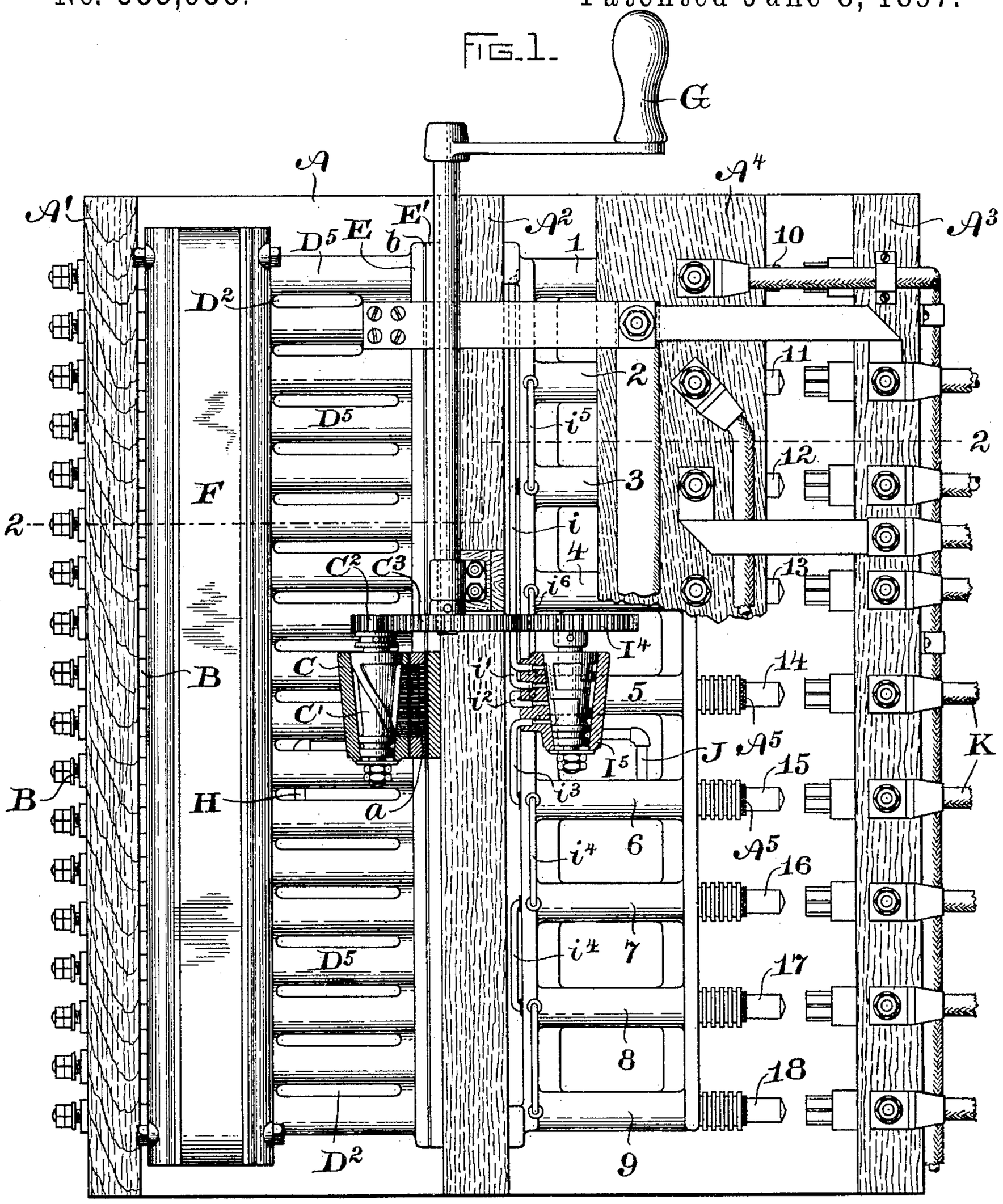
(No Model.) 3 Sheets—Sheet 1.

E. D. PRIEST.

PNEUMATIC CONTROLLER.

No. 583,938. Patented June 8, 1897.

FIG. 1.



WITNESSES.

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(No Model.) 3 Sheets—Sheet 2.

E. D. PRIEST.

PNEUMATIC CONTROLLER.

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FIG. 2.

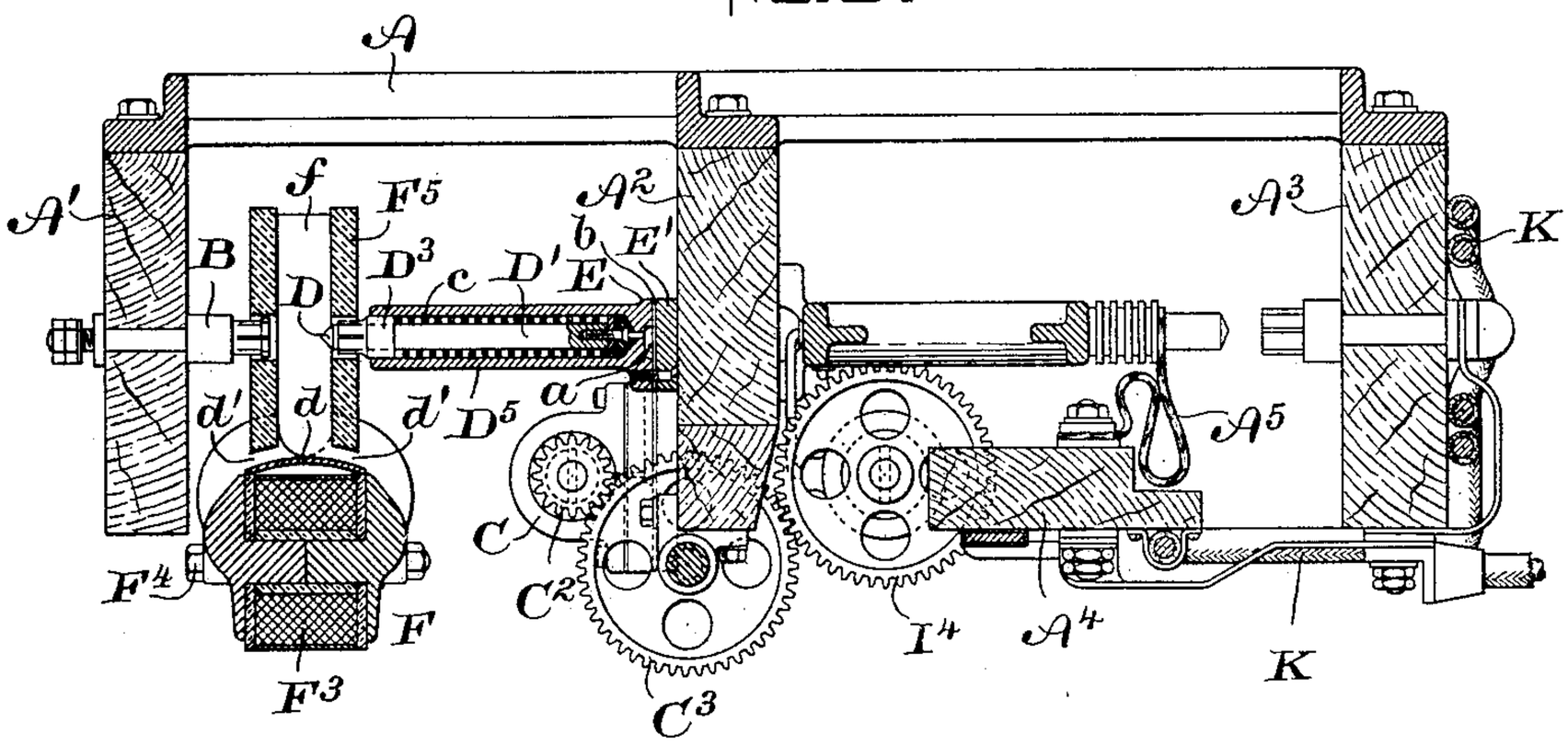


FIG. 3.

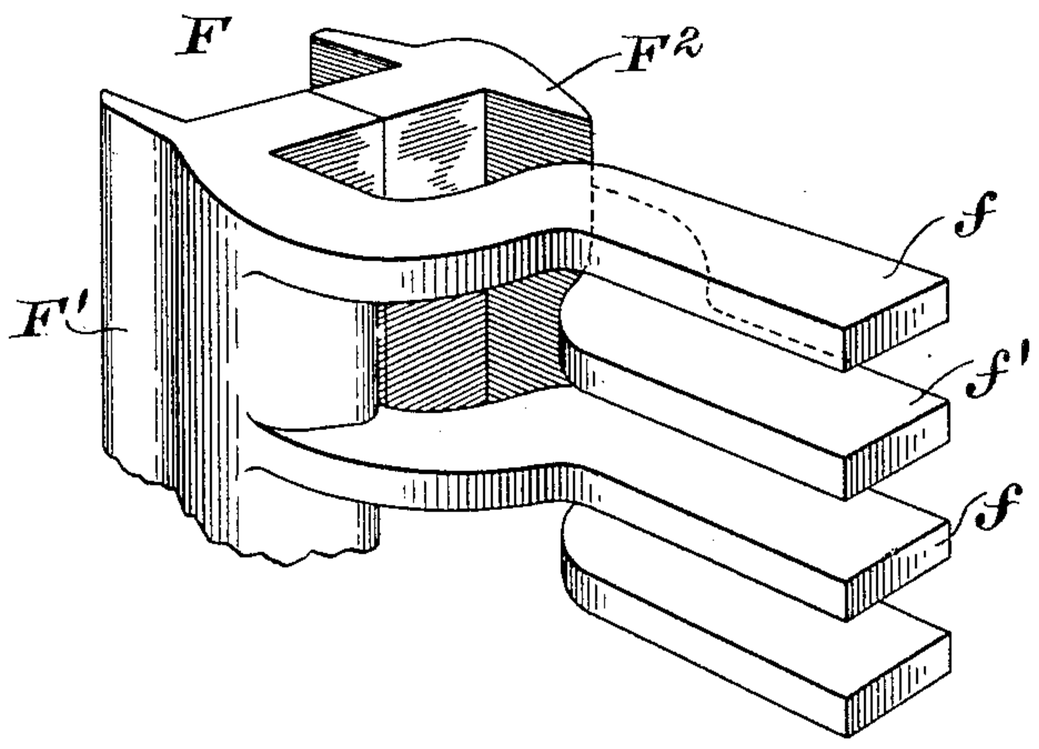


FIG. 4.

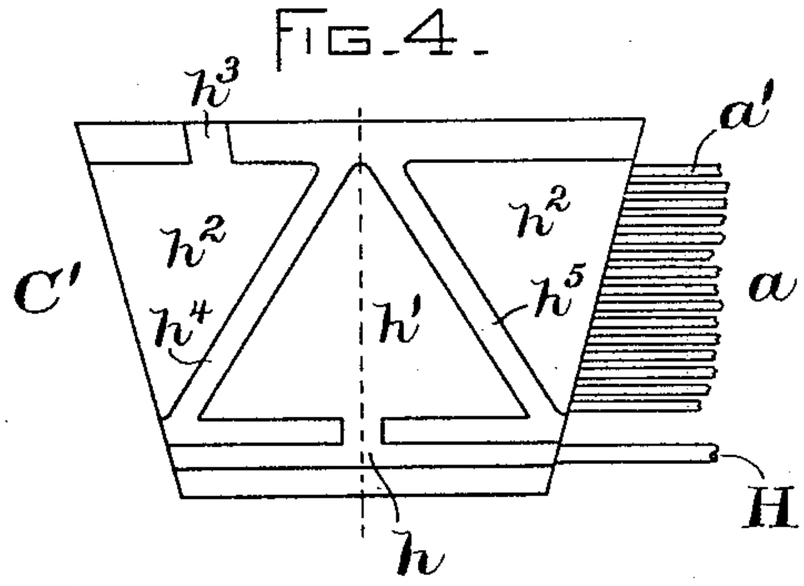
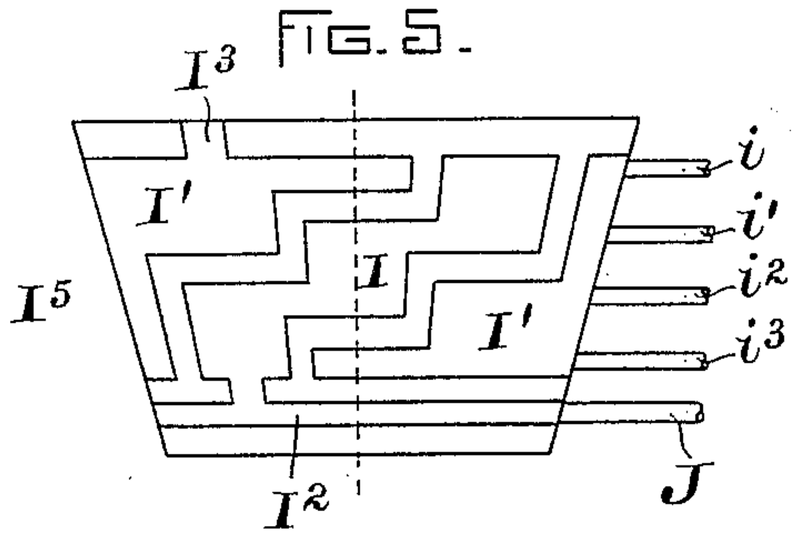


FIG. 5.



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(No Model.) 3 Sheets—Sheet 3.

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PNEUMATIC CONTROLLER.

No. 583,938. Patented June 8, 1897.

FIG. 7.

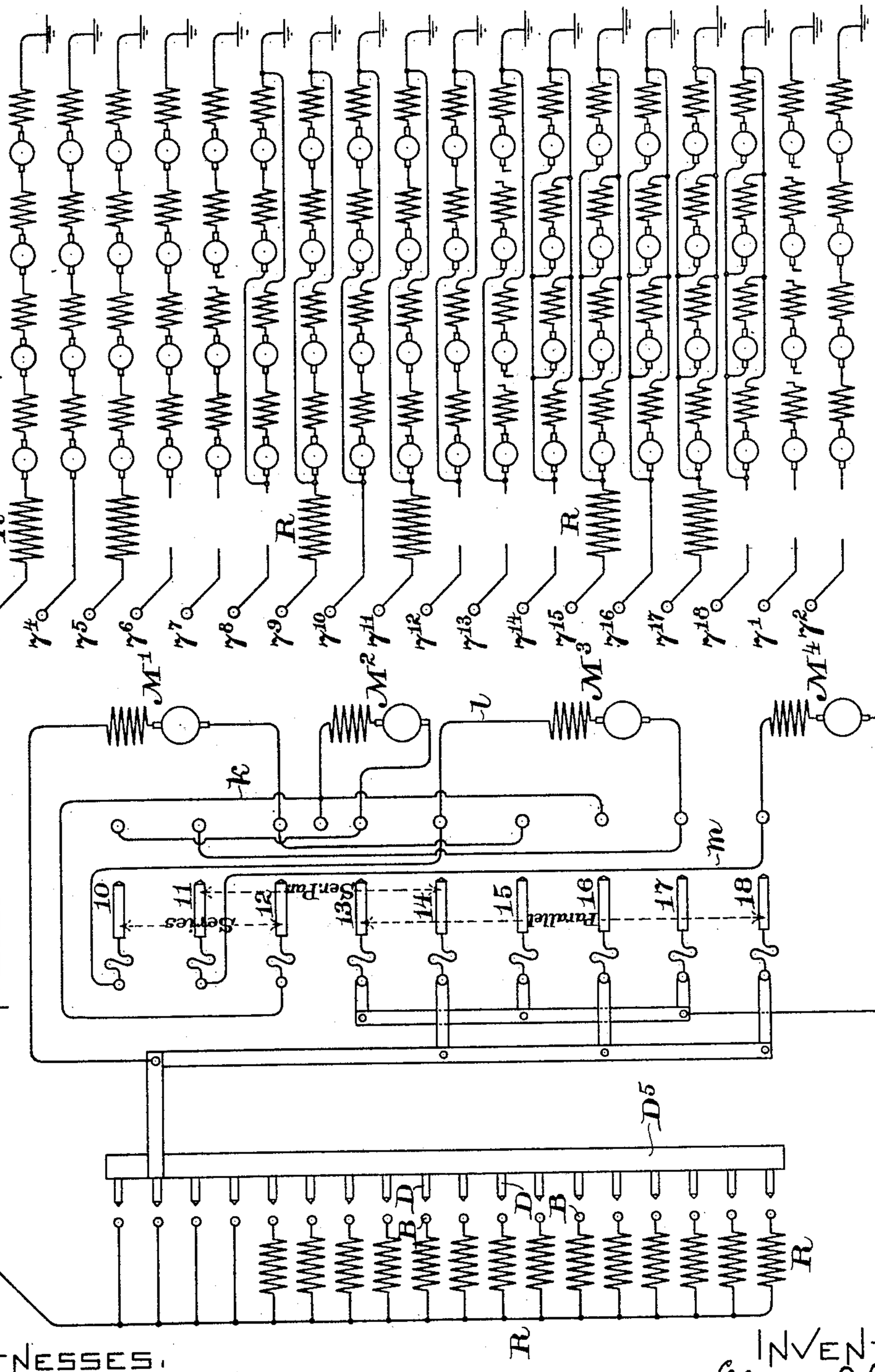

FIG. 6.

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UNITED STATES PATENT OFFICE.

EDWARD D. PRIEST, OF SCHENECTADY, NEW YORK, ASSIGNOR TO THE GENERAL ELECTRIC COMPANY, OF NEW YORK.

PNEUMATIC CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 583,938, dated June 8, 1897.

Application filed September 18, 1896. Serial No. 606,244. (No model.)

To all whom it may concern:

Be it known that I, EDWARD D. PRIEST, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Pneumatic Controllers, (No. 423,) of which the following is a specification.

Pneumatic controllers as heretofore constructed have been provided with commutating and resistance cylinders. These are actuated by means of pistons or other suitable mechanism when it is desired to vary the resistance of the circuit by cutting out resistance or change the motor connections from series to parallel, or vice versa. In controllers of this kind the inertia of the heavy moving parts is objectionable. The present invention has for one of its objects to overcome this feature and at the same time arrange the operating parts in such a relation that they are easy to operate and respond quickly to the actuating force. This I accomplish by substituting a plurality of separately-actuated contact devices for the commutating and resistance cylinders.

A further object of the invention is to provide for the positive operation of the contacts in breaking and making the circuit, reducing to a minimum the liability of injury caused by arcing between contacts in intermediate positions.

A further object of the invention is to arrange the operating-handle and controlling-valves in a manner that the handle can be continuously operated in one direction, if desired, or it may be operated in the usual manner by moving it around to the highest-speed position and then returning to the "off" position by a backward movement.

A further object of the invention is to provide a single operating-handle for actuating the valves regulating the admission of air to the contact-actuating cylinders.

A further object of the invention is to provide means for automatically returning the contacts to the off position if for any reason the air-supply fails.

A further object of the invention is to divide the valve mechanism into two parts for the purpose of simplifying the construction, to provide for the necessary adjustment of parts, and to facilitate the making of repairs.

The invention also relates to the construction of the blow-out magnet.

Certain other details of construction are designed to be covered by the claims.

In carrying out the invention separately-actuated pistons are employed, each piston operating a contact, either for the purpose of cutting resistance out of or into circuit or for changing the motor connections. Two valves are provided, one for the resistance-contacts and the other for commutating. These are connected together by gearing so that the resistance-valve makes three revolutions to one of the commutating-valves. The resistance-valve is so arranged that a complete revolution will cause the circuit to close with full resistance, cut out the resistance, and finally interrupt the circuit after the resistance has been reinserted. At the interval between the opening and closing of the circuit the commutating-valve operates to change the circuit of the motors from series to series parallel and then to parallel. A further rotation of the valves causes the resistance to be reinserted and the circuit to be interrupted at a number of points.

The resistance of the circuit is decreased by including sections of resistance in multiple with those already in circuit in a well-known manner. Each contact is mounted on the end of a piston and is adapted to engage with a stationary contact when air is admitted to its operating-cylinder. These pistons operate against a spring, so that they are returned without the use of air-pressure. This simplifies their construction, and at the same time insures the return of the pistons to the "off" position in case the supply of air fails.

In the accompanying drawings, attached to and made part of this specification, Figure 1 is a front elevation. Fig. 2 is a section on the line 2 2 of Fig. 1. Fig. 3 is a perspective detail view of the core of the blow-out magnet. Fig. 4 is a development of the resistance-valve. Fig. 5 is a development of the commutating-valve. Fig. 6 is a diagram of the motor-circuits, and Fig. 7 shows the motor combinations.

In Figs. 1 and 2, A is the metal frame, forming a support for the insulating-pieces A′ A^2 A^3. Mounted on the insulating-piece A′ are the contact-studs B. These are provided at their outer ends with nuts and a screw-thread-

ed portion for securing the resistance-leads. On the opposite ends they are provided with split contacts, which are engaged by the contacts D, carried by the pistons D′. The cylinders D^5 are cast in one piece, with spaces D^2 between them for reducing the weight. The right-hand side of the casting is formed with a flange E, provided with a flat surface, in which are grooves or passages *a*, leading from the cylinders to the resistance-valve C. Between the flange E and the plate E′ is a piece of fiber or other packing *b*, which separates the grooves one from another. The plate E′ is secured to the insulating-support A^2 by any suitable means.

The pistons D′ are provided with a packing of leather or similar material, and when air is admitted to the cylinders D^5 are forced outward against the action of the spring *c* until the end of the contact D engages with the split end of the stationary contact B. The cylinders are in electrical connection with the circuit, and to insure good contact between the cylinders and the contacts D split rings D^3 are employed, through which the contacts slide in moving forward and back.

A blow-out magnet F is employed to extinguish the arc formed when the circuit between the contacts B and D is broken. It is composed of two T-shaped pieces F′ and F^2, (see Fig. 3,) provided with poles *f f′*. The vertical portions of the T-shaped piece form the core for the energizing-coil F^3, which is separately wound and insulated and held in place by means of bolts F^4, securing the parts F′ F^2. The construction of the core is such that the alternate poles *f f′* are connected to opposite ends of the core. This makes them alternate in polarity, so that while an arc between *f* and *f′* is blown outward the arc between the next pair of poles *f′ f* is blown inward toward the energizing-coil F^3. To protect the coil against injury, a piece of refractory material *d*, Fig. 2, is placed between the arcing electrodes and the coil. Similar protection is afforded for the pole-pieces *f* and *f′*, and extending along their sides are pieces of insulating material F^5, which, with the pole-pieces, make separate chutes for each pair of arcing electrodes. To provide for the escape of gas, passages *d′* are made near the coil.

By the construction above pointed out I am enabled to dispense with a number of the energizing-coils usually employed and to provide a cheap blow-out magnet having a pair of poles for each arcing contact with a common energizing-coil. By alternately blowing the arcs outwardly and inwardly those between adjacent contacts are less liable to cause short-circuiting, the interval of time between the arcs which are blown in the same direction being twice as great as though they were all blown in the same manner.

The resistance-valve C, Fig. 1, is mounted on a projection of the plate E′. It is provided with a tapered plug C′, which regulates the admission of air to the cylinders D^5. At the top of the plug C′ is a pinion C^2, meshing with the gear C^3, the latter being operated by the handle G.

In Fig. 4 is shown a development of the taper valve-plug C′. *a* represents the passages or grooves leading to the cylinders D^5, and H is the inlet-pipe, entering the outer casing of the valve at a point opposite the groove *h*. Extending from the top to the bottom are two diagonal projections or ribs h^4 h^5. These are so arranged that two chambers *h′* h^2 are formed. *h′* is connected to the groove *h* and source of supply, and h^2 is open to the outer air through the opening h^3. When the plug C′ is rotated from left to right, air is admitted to the passages *a*. As soon as it reaches a point where the chamber *h′* is opposite them the rib h^5 being inclined the air is admitted to the passages *a* in succession. When the plug C′ has moved so that the dotted line is opposite the passages *a*, all of the resistance-cylinders receive air under pressure and the resistance is short-circuited. The upper passage *a′* regulates the operation of the upper four pistons. These are made of very low resistance and are designed to short-circuit the controlling-resistance R. A continued rotation of the valve cuts in resistance, first, however, interrupting the short-circuit.

The commutating-valve I^5, Fig. 1, is mounted on the insulating-support A^2, and extending therefrom are pipes *i*, *i′*, i^2, and i^3. The pipe *i* leads to the cylinder 1, *i′* to cylinder 3 and by pipe i^5 to cylinder 2, i^2 to cylinder 5, thence through pipe i^6 to cylinder 4, and i^3 to cylinders 6, 7, 8, and 9 by means of the pipes i^1.

Fig. 5 shows a development of the commutating-valve i^5. The plug is divided by means of ribs into chambers I I′, the chamber I being supplied with air under pressure from the inlet-pipe J, while the chamber I′ is open to the external air through passage I^3. With the valve in the position shown no air is admitted to the pipes. Upon moving the plug so that the chamber I is opposite the pipes *i* and *i′* air will be admitted to cylinders 1 2 3. A continued movement of the plug to the dotted-line position will open the pipe *i* to the external air through chamber I′ and opening I^3, and pipes *i′* and i^2 will receive air under pressure and supply it to cylinders 2, 3, 4, and 5. A further movement of the plug opens the pipes *i* and *i′* to the atmosphere, and pipes i^2 and i^3 are receiving air under pressure and supplying it to cylinders 4, 5, 6, 7, 8, and 9. A further movement of the plug in the same direction will open the pipes *i* and i^3, inclusive, to the external air. The construction of the pistons and cylinders being the same as described in connection with the resistance the circuit will be interrupted at a number of points corresponding with the number of contacts.

The plug is provided with a gear I^4, which meshes with the gear C^3, operated by the handle G and makes one revolution to three of

the resistance-valve, the purpose of which will be more fully described hereinafter. The stationary commutating-contacts are mounted on the insulating-support A^3 and extending therefrom are cables K, connected to the different motors.

The cylinders 1 to 9, inclusive, are not connected in the electric circuit and connection is made from the stationary contacts on the insulating-support A^4 to the piston-contacts 10 to 18, inclusive, by means of the flexible leads A^5.

Figs. 6 and 7 illustrate diagrammatically the connection of the circuits. T is the source of current-supply and is permanently connected to all the sections of the resistance R. The cylinders D^5 and contacts D are electrically one unit, and as air is admitted to the different cylinders one by one the contacts D establish connection with the resistance R through the contacts B, reducing the total resistance of the circuit by establishing multiple resistance-circuits. The upper four contacts are operated simultaneously and have practically no resistance.

The geared relation of the valves C and I^5 is such that the contacts 10, 11, and 12 are closed before the circuit is completed through the resistance. 7′ shows the circuit relation of the motors with both valves in the off position and 7^2 after the commutating-valve has closed its portion of the circuit. 7^3 shows the relation of the motors after the circuit has been closed through the resistance R. This latter is gradually decreased by rotating the handle G until it is all cut out, as shown in 7^4. Further movement of the handle in the same direction reinserts the resistance preparatory to changing the circuit, as shown in 7^5. The next instant the circuit is broken and by means of the commutating-valve the air is admitted under pressure to the cylinders 2, 3, 4, and 5. This actuates contacts 11, 12, 13, and 14, establishing a series-parallel relation of the motors, as shown in 7^8. The next step closes the resistance-circuit by means of the valve C, and the circuit connections are as shown in 7^9. The resistance R is diminished, cut out, and then cut in again, as shown in 7^{10} and 7^{11}, preparatory to interrupting the circuit, as shown in 7^{12}. The plug of the valve I^5 is now rotated to a position where the circuit between the motors is interrupted, as shown in 7^{13}. A continued movement causes air to be admitted to cylinders 4 to 9, inclusive, establishing a parallel relation of the motors, as shown in 7^{14}. The circuit is then closed, as shown in 7^{15}, and the resistance gradually reduced, as shown in 7^{16}, this being the last running position. Further movement of the valves causes the resistance R to be reinserted, as at 7^{17}, and the circuit interrupted, as shown at 7^{18}, and finally to establish the connections shown in 7′, which is the first position.

By arranging the valve mechanism in the manner described and making all circuit changes by inserting resistance before interrupting the circuit I am enabled to change the motors from open-circuit to parallel relation through a resistance at the first closing of the circuit. A further advantage to be gained by this construction is that when running at full speed with the motors in parallel the circuit can be immediately interrupted by a forward movement of the handle covering only a very small portion of its angular movement instead of moving it backward through all the previous steps.

Diagrams 7^4, 7^{10}, and 7^{16} represent running positions of the motors, and it will be seen that the resistance has been in circuit and cut out three times while the commutating-valve has only made one revolution, establishing the series, series parallel, and parallel relation of the motors.

Assuming that the circuit is closed with the motors in series the connections are as follows: trolley T, resistance R, motor M′, contact 12, by wire *k* to motor M^2, to contact 10, by wire *l* to motor M^3, to contact 11, by wire *m* to motor M^4, to ground.

The remainder of the circuit connections can readily be traced by assuming that the contacts 11 to 14, inclusive, are closed for the series parallel relation and contacts 13 to 18 for the parallel.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In a controller, a plurality of separate pneumatically-operated contacts for varying the resistance of the motor-circuits.

2. In a controller, the combination of a plurality of separate pneumatically-operated contacts, with a valve for regulating their operation.

3. In a pneumatic controller, the combination of separately-actuated resistance-contacts, cylinders and pistons for actuating the contacts, and a valve controlled by the operating-handle for regulating the admission of air to the cylinders.

4. In a controller, the combination of a plurality of separately-actuated contact devices, a piston and cylinder for each contact device, and a valve common to the cylinders, for regulating the admission of air thereto.

5. In a controller, the combination of a plurality of separately-actuated contacts for regulating the controlling resistance, a plurality of separately-actuated contacts for establishing certain motor combinations, and valve mechanism actuated by an operating-handle.

6. In a controller, the combination of a set of separate pneumatically-actuated contact devices, a valve therefor, a second set of pneumatically-actuated contact devices for establishing new motor combinations, a valve therefor, and a handle for operating the valves.

7. In a controller, the combination of a plurality of separately-actuated contacts, a valve, a number of passages leading therefrom, an operating device for the valve provided with a chamber to which air is admitted under

pressure, means for supplying air to the passages, and means for cutting off the supply of air from the passages, and opening them to the external air.

8. In a controller, the combination of a valve, an operating device for the valve provided with a chamber to which air is supplied under pressure, and a number of passages therefrom arranged so that an increasing number receive air as the valve is actuated up to a given point, after which the number decreases.

9. In a controller the combination of a valve, a plurality of separately-actuated contacts for varying the resistance of the circuit, means, controlled by the valve, for actuating the contacts, and means for establishing a new relation of the motor-circuits, the motors when so connected being controlled by the valve and separately-actuated contacts.

10. In a controller, the combination of a valve, a handle, a plurality of separately-actuated contacts controlled by the valve for reducing the resistance of the motor-circuit as the handle is moved to a given point, means for increasing the resistance as the handle moves beyond this point, and separately-actuated contacts controlled by a valve for establishing a new relation of the motor-circuits, the motor when so connected being controlled by means of the first-named separately-actuated contacts as before.

11. In a controller, the combination of a plurality of separately-actuated contacts, an operating device for each contact, a valve common to the operating devices for regulating the admission of air thereto, and a separate chute for each contact.

12. In a pneumatic controller, the combination of a valve, contacts controlled by the valve for closing the circuit and regulating the resistance, contacts controlled by a second valve for establishing different motor combinations, and means for actuating the second valve at a time when the circuit is interrupted.

13. In a pneumatic controller, the combination of pistons and cylinders for the operating-contacts for changing the resistance of the motor-circuit, with valve mechanism for regulating the admission of air to the cylinders, the arrangement of the valve mechanism being such that the connections of the motor-circuit can be changed from highest to lowest speed relation by a continued movement thereof.

14. In a pneumatic controller, the combination of a valve, contacts for establishing and regulating the circuit controlled by the valve, a second valve-controlling mechanism for changing the motor connections, and means for preserving a definite relation between the movements of the valves.

15. In a pneumatic controller, the combination of a valve, contacts controlled thereby for cutting resistance out of and into circuit as the valve is operated, a second valve, contacts controlled thereby for changing the motor connections, gearing between the valves, and a common actuating-handle.

16. In a pneumatic controller, the combination of a valve, resistance-contacts controlled thereby, a second valve, controlling mechanism for changing the circuit combinations and means connecting the valves in such a manner that the resistance-contacts are always actuated before the circuit is interrupted.

17. In a pneumatic controller, the combination of a valve, contacts controlled thereby for regulating the resistance each time a change is made in the relation of the motor-circuits, a rotary valve so arranged that its first and last positions are adjacent, and contacts controlled thereby for establishing a series or parallel relation of the motor-circuit.

18. In a switch mechanism, the combination of a plurality of contacts, with an arc-extinguishing means adapted to blow certain of the arcs in one direction and the balance in another.

19. In a switch mechanism, the combination of a blow-out magnet, and a core therefor, provided with a plurality of projections or fingers extending from each end, and so arranged that they alternate in polarity.

20. In a switch mechanism, the combination of a blow-out magnet, a core therefor made in two parts adapted to be bolted together after the energizing-coil is in place, and fingers projecting from each part of the core toward one another adapted to blow the arcs formed between the electrodes alternately outward and inward.

21. In a controller, the combination of a plurality of separate pneumatically-actuated contacts, a valve controlling the operating mechanism, stationary contacts engaged by the moving contacts, and flexible connections between the moving contacts and the source of supply.

22. In a controller, the combination of a plurality of separately-actuated contacts, a blow-out magnet for each pair of contacts, and separate chutes for restraining the arcs formed at each contact.

23. In a pneumatic controller, the combination of a plurality of contacts, a source of air-supply, a valve for regulating the operation of the contacts, and means for returning the contacts to their off position in case the supply of air fails.

24. In a pneumatic controller, the combination of a plurality of separately-actuated contacts, a valve for regulating the operation of the contacts, pistons and cylinders therefor, a source of air-supply, and springs for returning the contacts to the off position as soon as the air-pressure is relieved.

25. In a pneumatic controller, the combination of a rotary valve with contacts controlled thereby, the relation between the contacts and valve being such that a continuous rotary movement of the valve will cause the circuit to be established and the resistance

decreased, then increased and the circuit interrupted.

26. In a pneumatic controller, the combination of a valve, a plurality of separately-actuated contacts controlled thereby, and means for causing the circuit to be simultaneously interrupted at a number of points.

27. In a pneumatic controller, the combination of a rotary valve, contacts for establishing different motor combinations controlled thereby, and means for actuating the contacts, the valve being so arranged with respect to the actuating means, that the highest and lowest speed combinations are adjacent.

28. In a pneumatic controller, the combination of a resistance, a plurality of separately-actuated resistance-contacts, pistons and cylinders for operating the contacts, a valve mechanism for regulating the operation of the contacts, and a plurality of separately-actuated contacts controlled by the valve, for short-circuiting the resistance at a predetermined point.

29. In a controller, the combination of a plurality of cylinders, each provided with a piston for actuating a contact, passages leading from the cylinders, a valve provided with a port for each passage, and a plug controlled by the actuating-handle for admitting air to the cylinders.

30. In a pneumatic controller, the combination of a plurality of cylinders and pistons for actuating the resistance-contacts, cylinders and pistons for operating the series-parallel contacts, and a single handle for regulating the admission of air to the cylinders.

31. In a controller for electric motors, the combination of a plurality of contacts separately operated by a fluid under pressure, and circuit connections controlled by said contacts for regulating the operation of the motor or motors.

In witness whereof I have hereunto set my hand this 15th day of September, 1896.

EDWARD D. PRIEST.

Witnesses:
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A. F. MACDONALD.