(No Model.) 11 Sheets—Sheet 1.

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No. 522,209. Patented July 3, 1894.

FIG. 5.

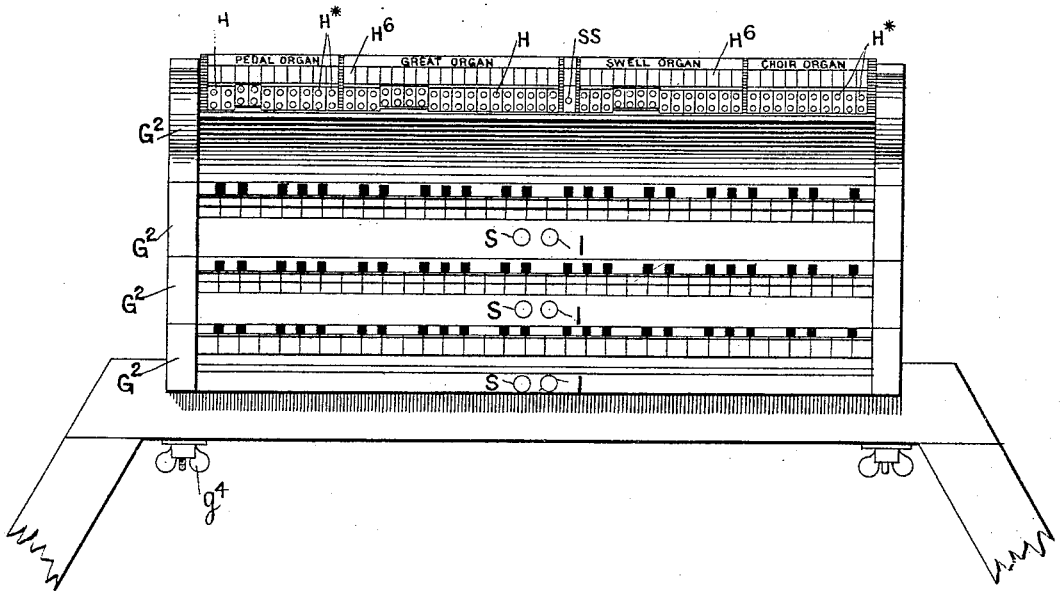
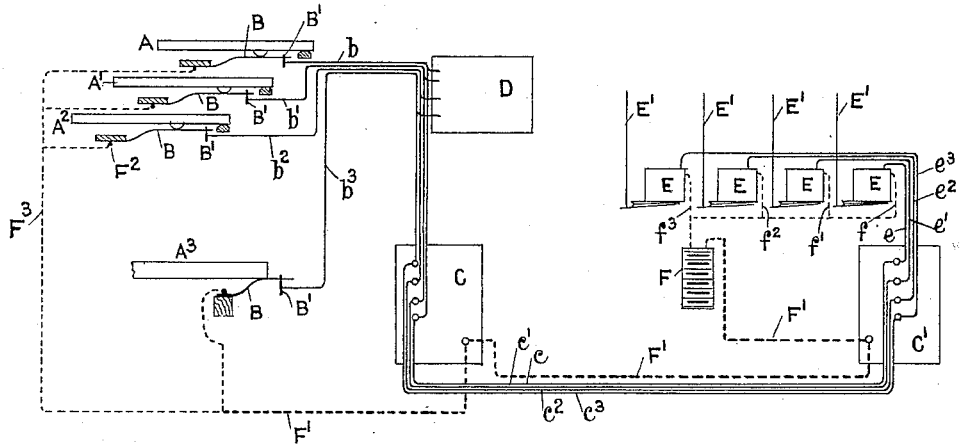


FIG. 1.



Witnesses
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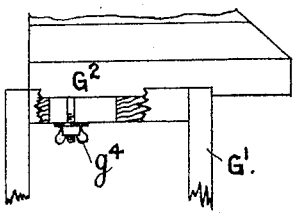
FIG. 4.



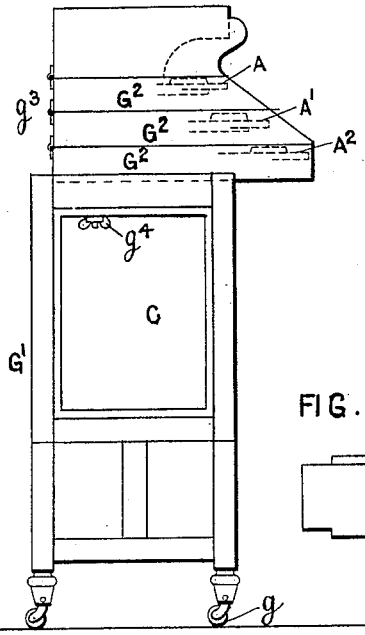
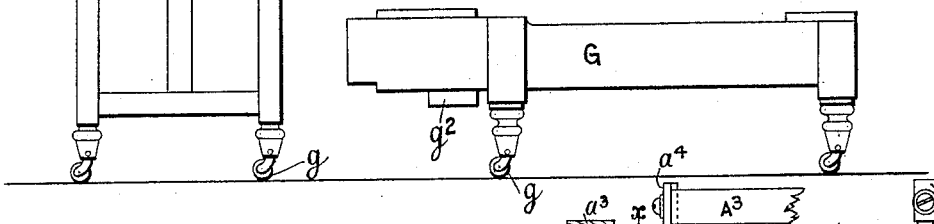


FIG. 2.



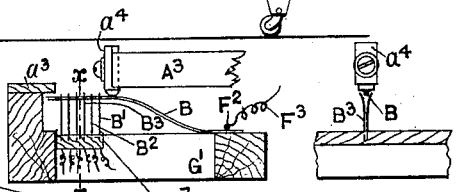
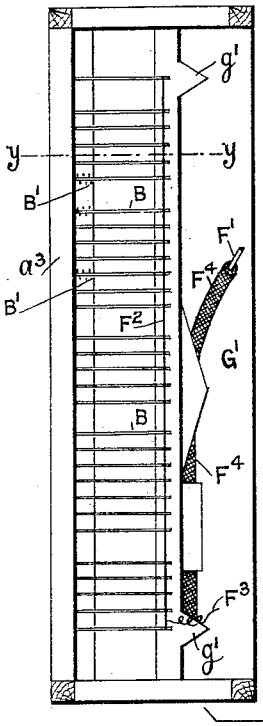


FIG. 11.

FIG. 12.



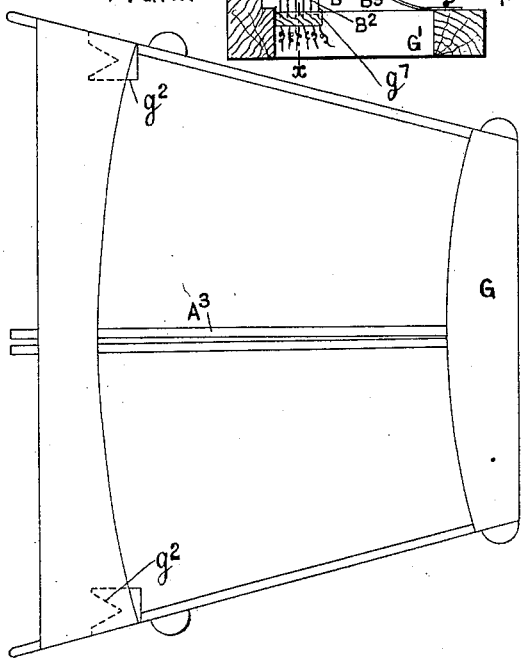


FIG. 3.

Witnesses
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FIG. 6.

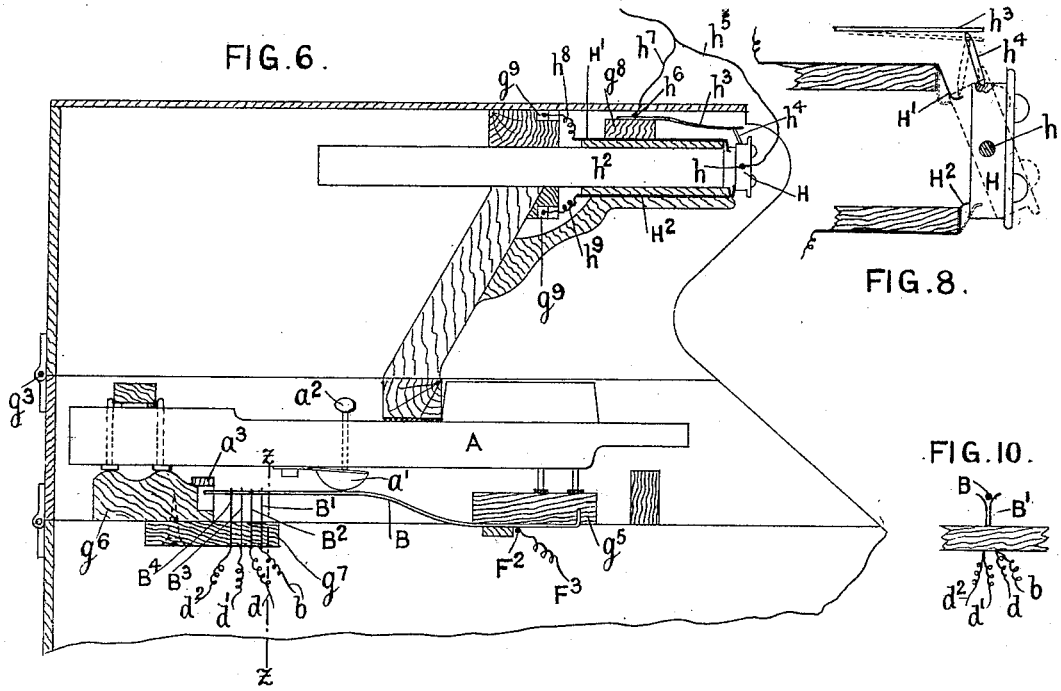


FIG. 8.

FIG. 10.

FIG. 7.

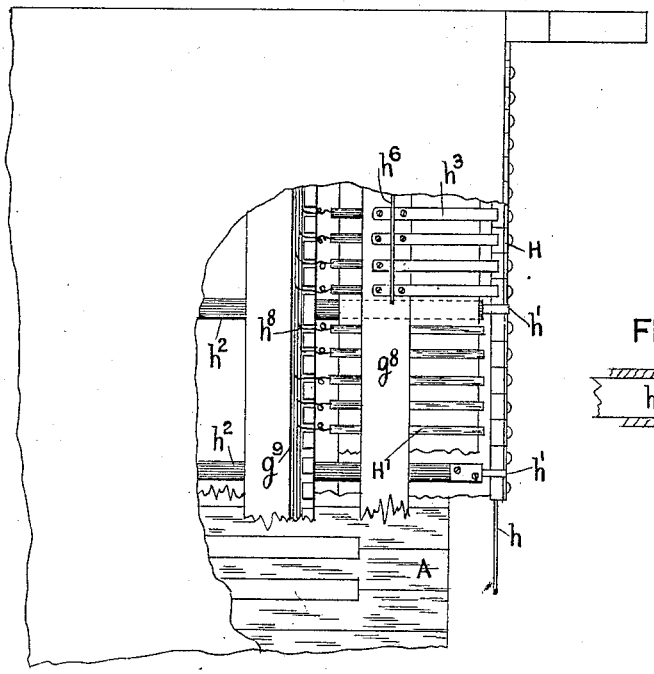
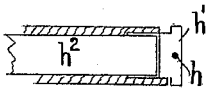


FIG. 9.



Witnesses
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FIG. 14.

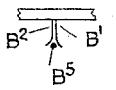


FIG. 13.

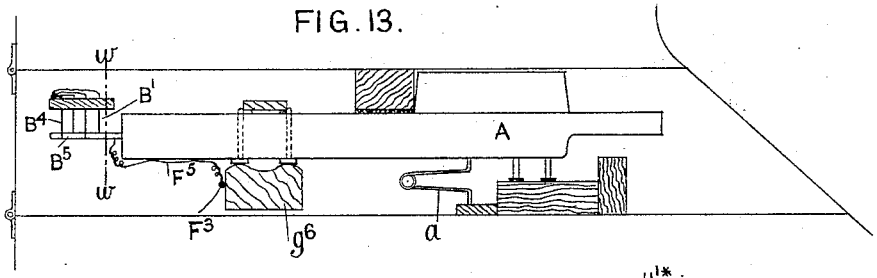


FIG. 15.

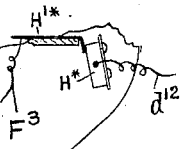


FIG. 16.

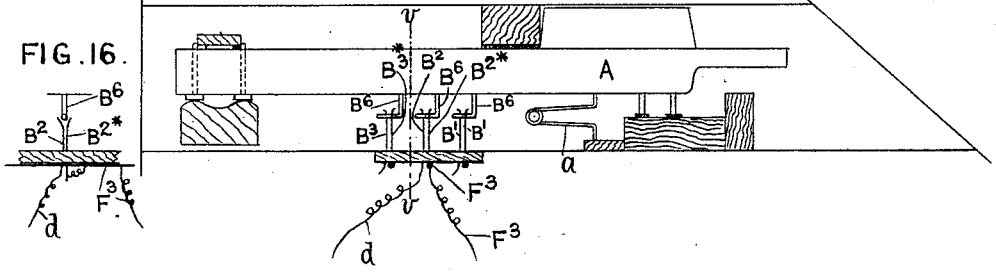


FIG. 27.

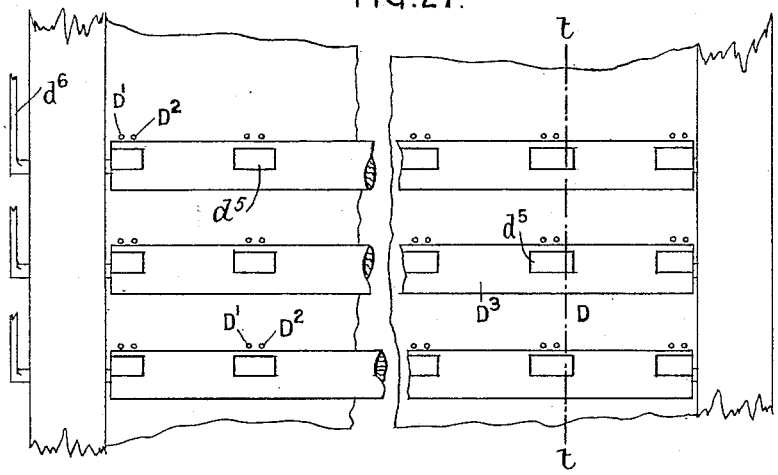
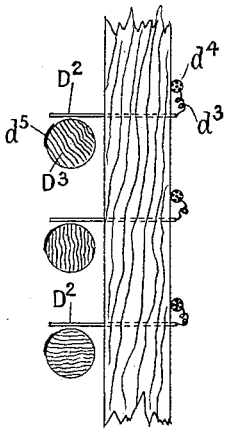


FIG. 28.



Witnesses
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by Dodger Sons, Atty.

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FIG. 18.

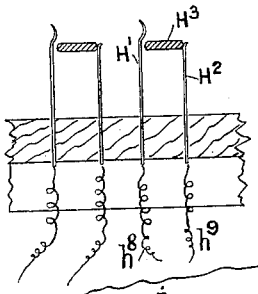


FIG. 17.

FIG. 25.

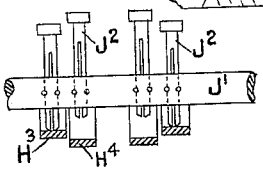
FIG. 24.

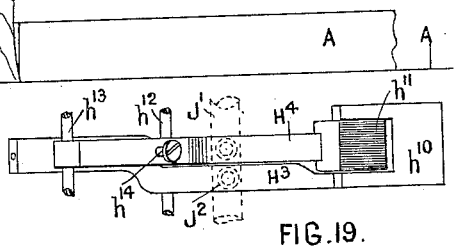
FIG. 23.

FIG. 25a.

FIG. 25b.

FIG. 22.





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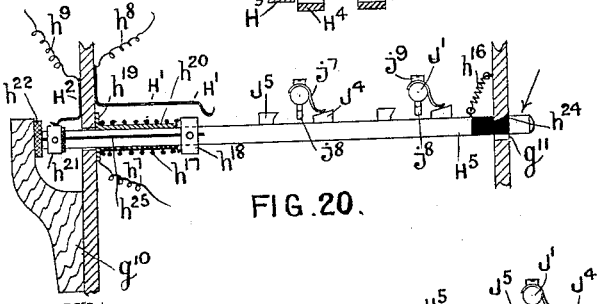

FIG. 20.

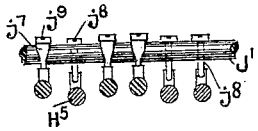

FIG. 26.

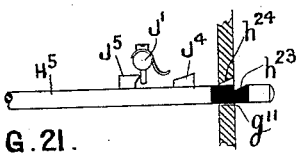

FIG. 21.

Witnesses
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FIG. 29.

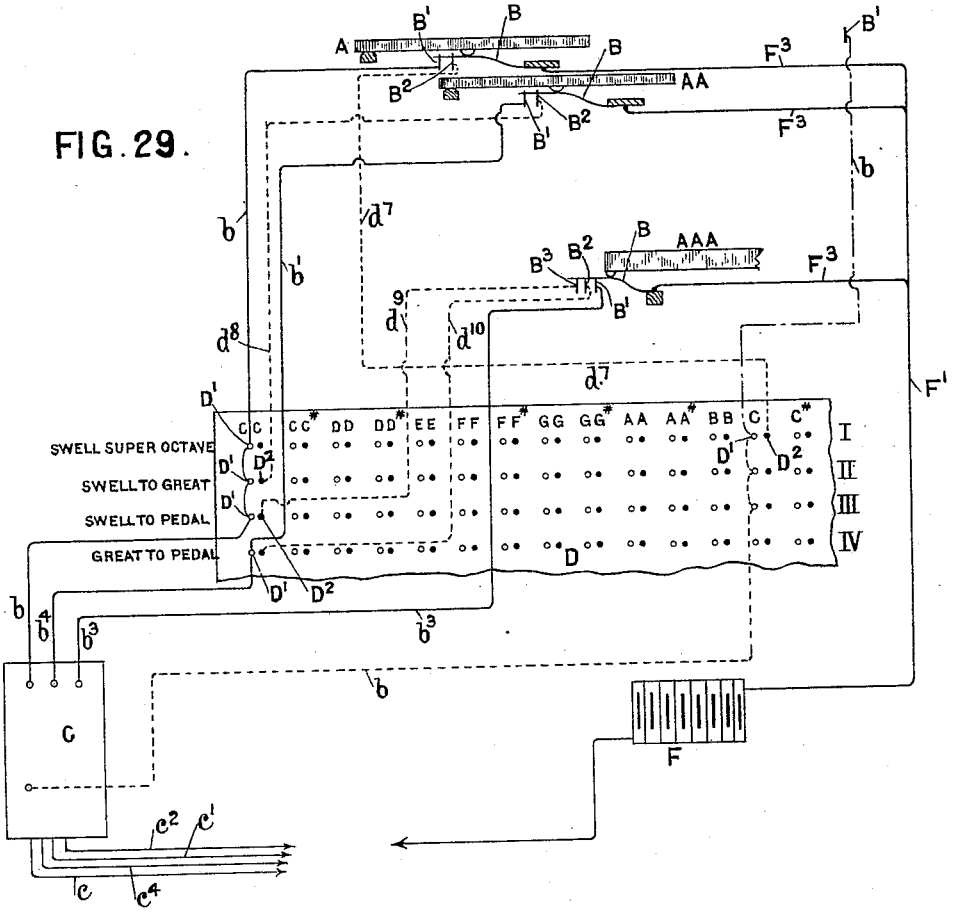
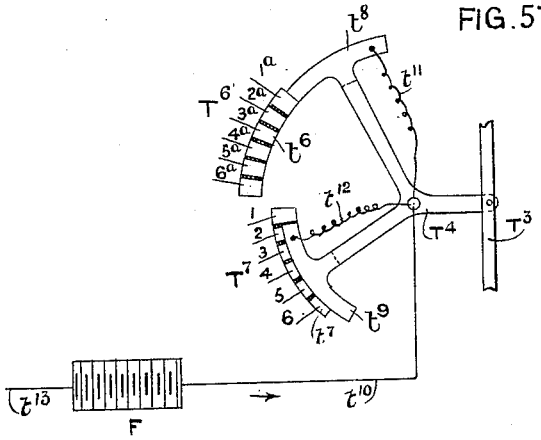


FIG. 57.a.



Witnesses
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by Dodger Sons, Attys.

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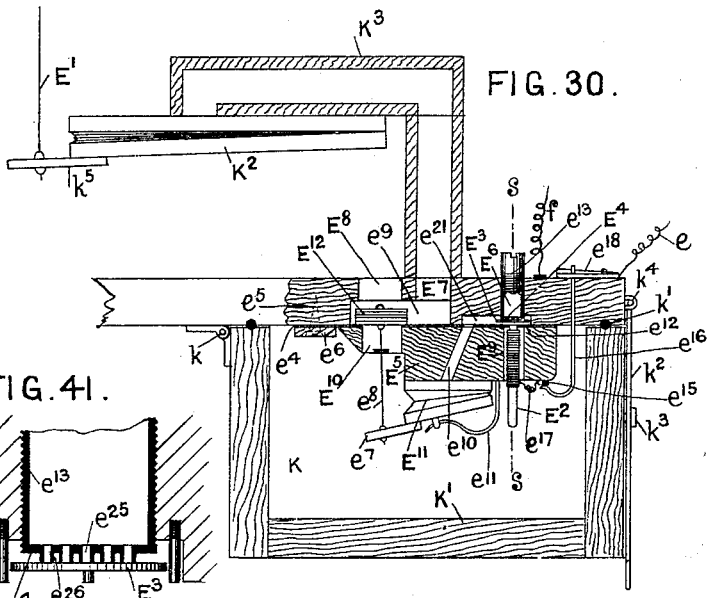

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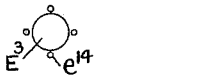

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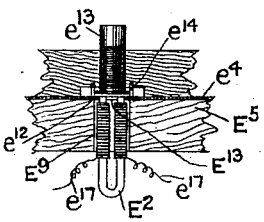

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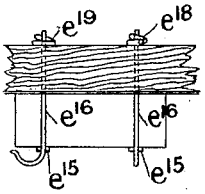


FIG. 32.

FIG. 41.

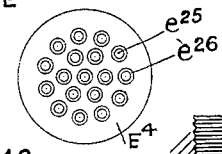
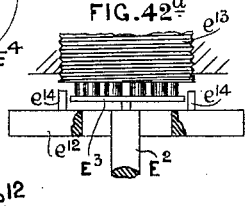


FIG. 42.



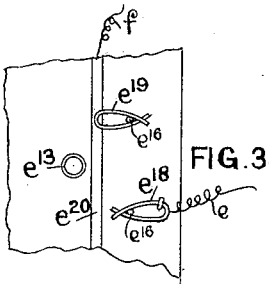


FIG. 33.

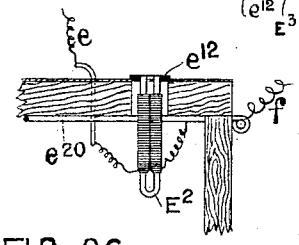


FIG. 36.

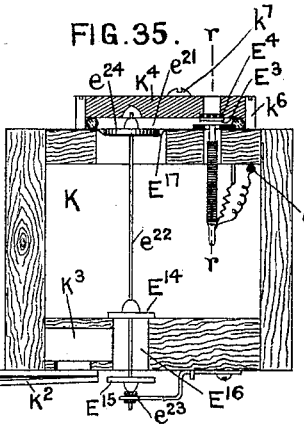


FIG. 35.

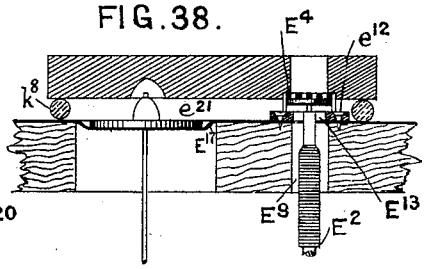


FIG. 38.

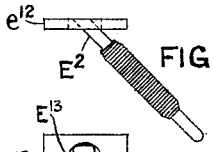


FIG. 39.

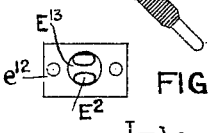


FIG. 40.

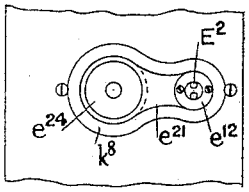


FIG. 37.

Witnesses
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ORGAN.

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FIG. 43.

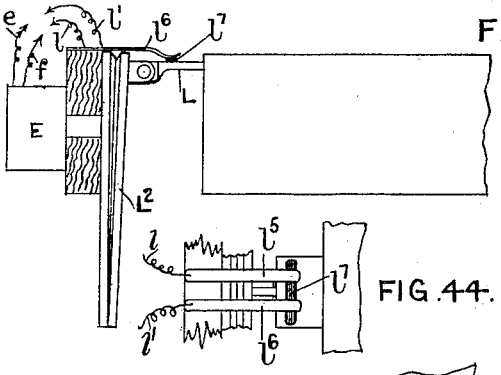


FIG. 44.

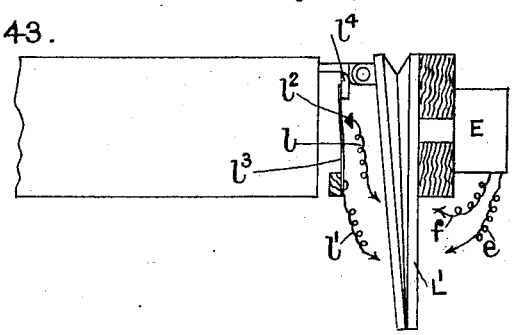


FIG. 45.

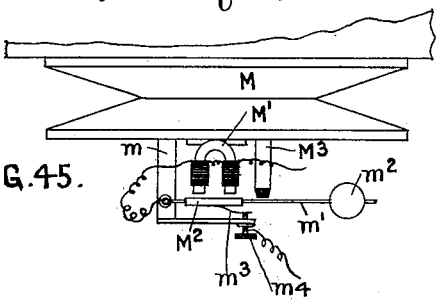


FIG. 46.

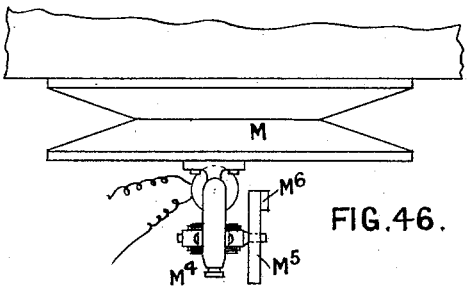


FIG. 47.

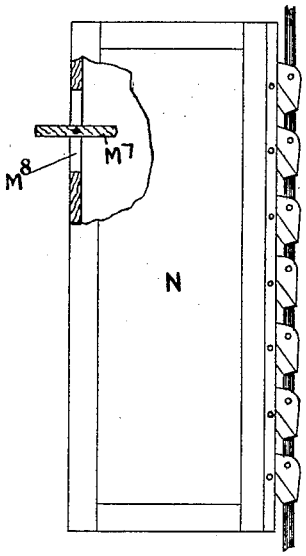
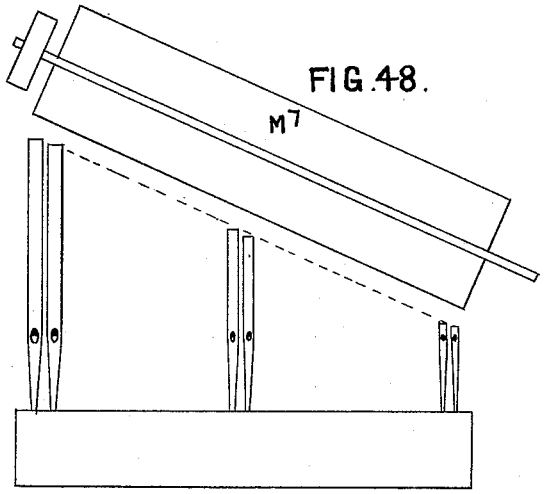


FIG. 48.



Witnesses

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Horace A. Dodge.

Inventor

Robert Hope-Jones,

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Attys.

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FIG. 49.

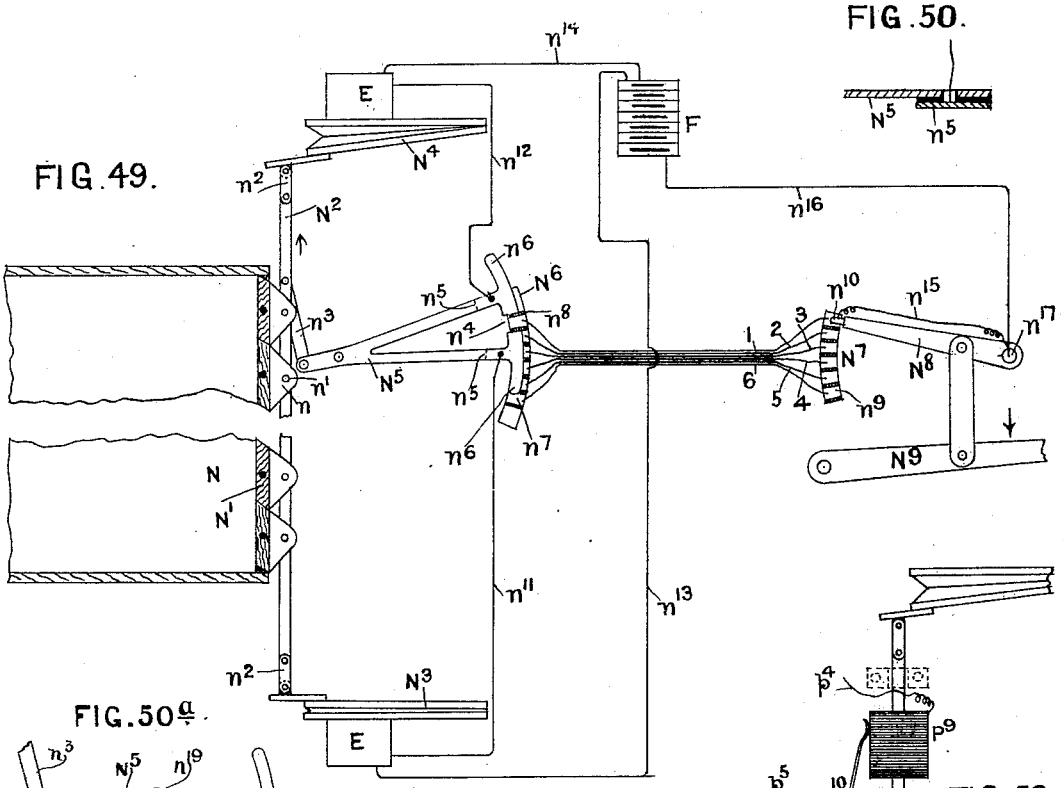


FIG. 50.

FIG. 50a.

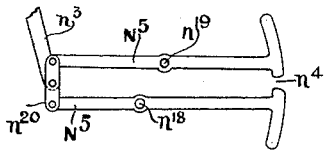
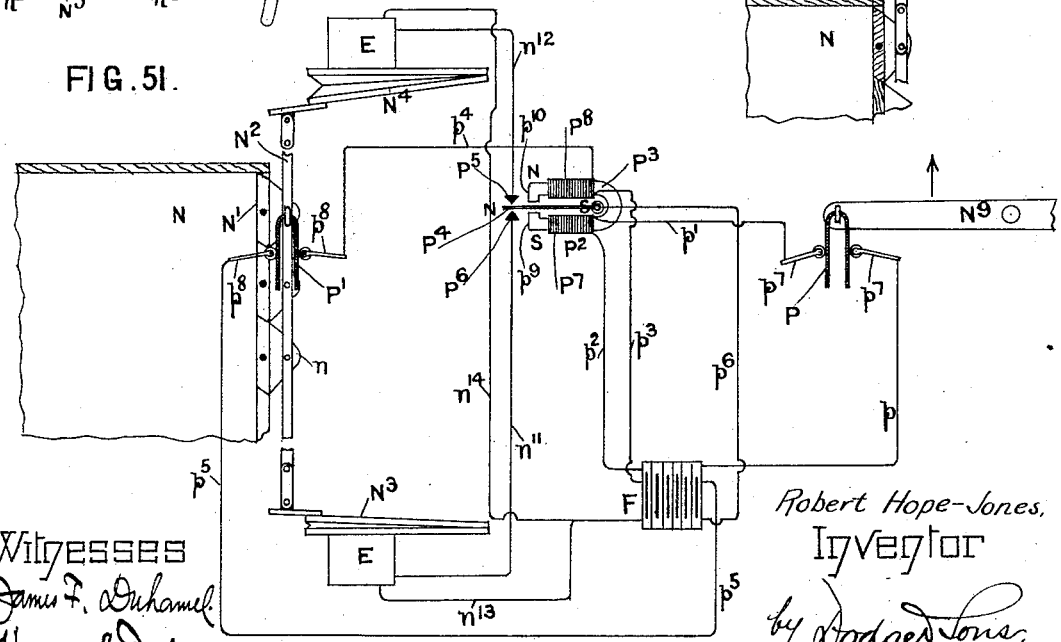


FIG. 52.

FIG. 51.



Witnesses
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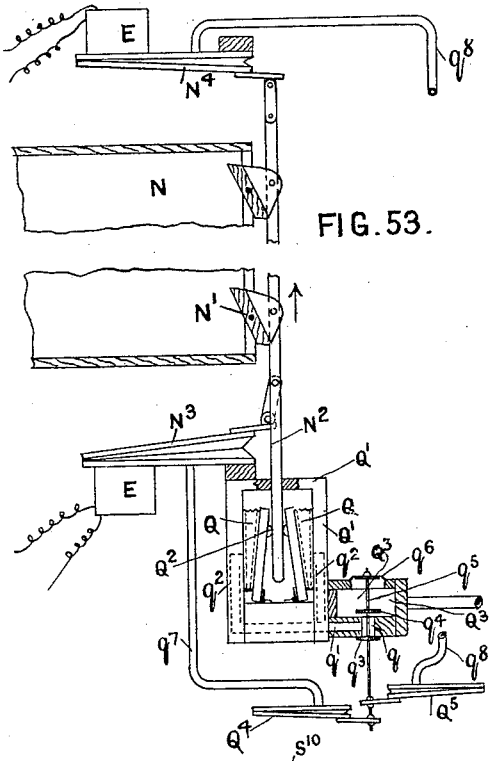
ORGAN.

No. 522,209. Patented July 3, 1894.



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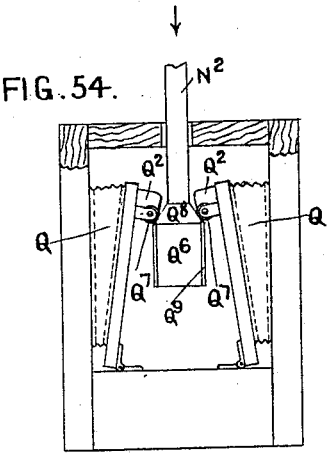

FIG. 54.

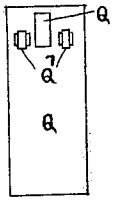

FIG. 55.

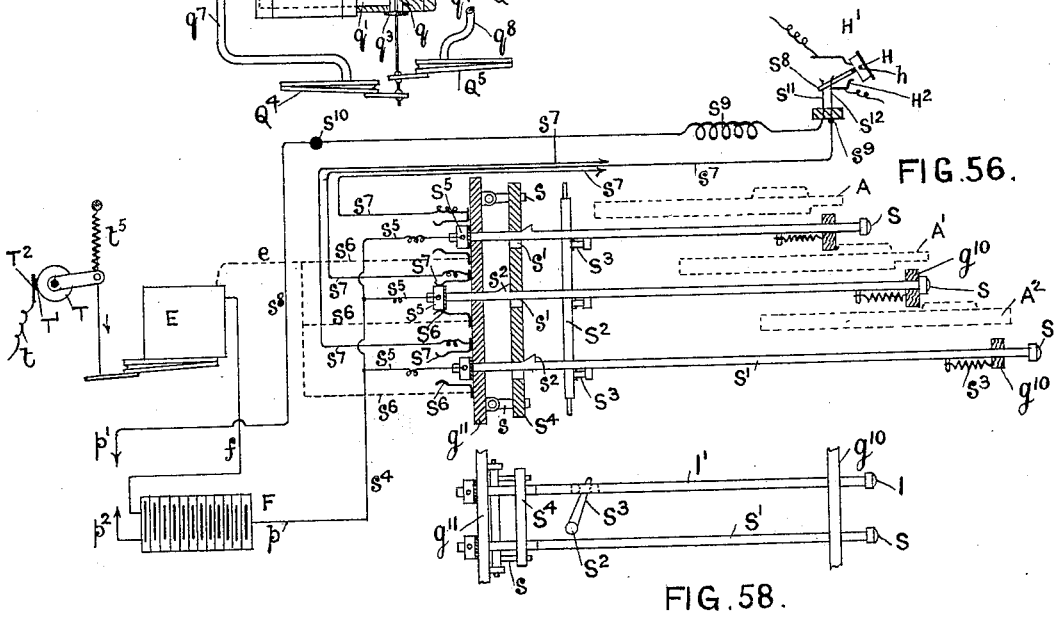

FIG. 56.

FIG. 58.

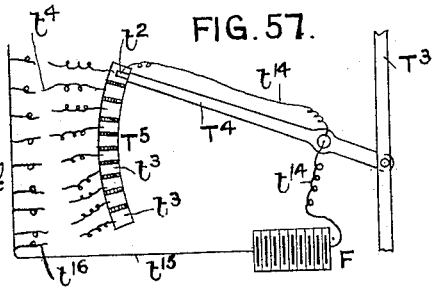

FIG. 57.

Witnesses
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FIG. 59.

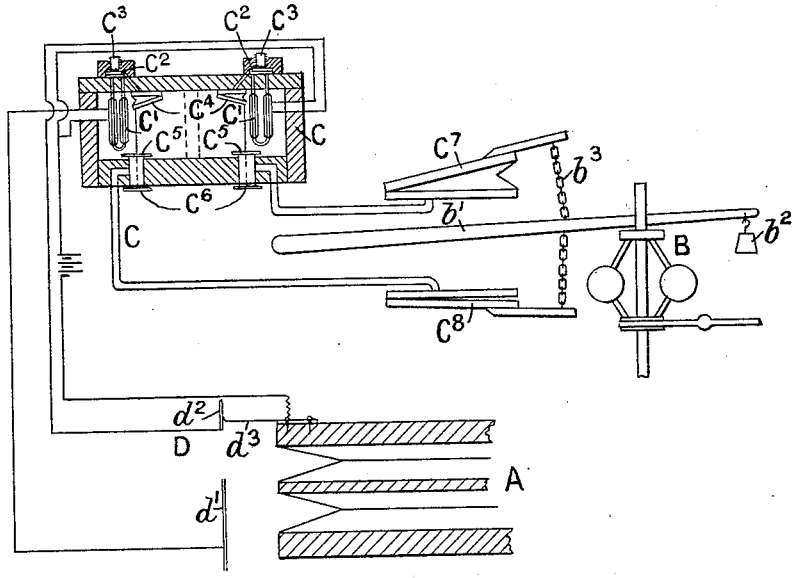
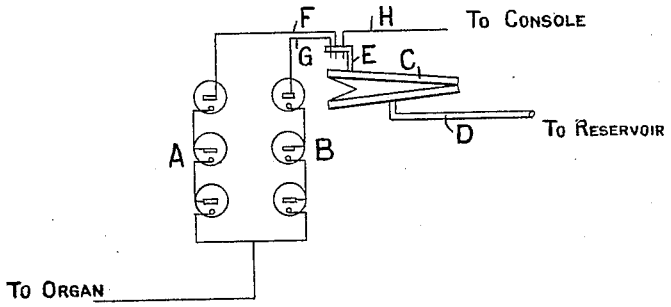


FIG. 60.



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ORGAN.

SPECIFICATION forming part of Letters Patent No. 522,209, dated July 3, 1894.

Application filed September 18, 1891. Serial No. 406,071. (No model.) Patented in England September 30, 1890, No. 15,461; in Germany August 22, 1891, No. 68,751; in France September 14, 1891, No. 216,104; in Belgium September 14, 1891, No. 96,380, and in Austria-Hungary September 1, 1892, No. 33,024 and No. 56,901.

To all whom it may concern:

Be it known that I, ROBERT HOPE-JONES, electrical engineer, a subject of the Queen of Great Britain, residing at Birkenhead, in the county of Chester, in the Kingdom of England, have invented certain new and useful Improvements in Organs, (for which I have received Letters Patent numbered and dated as follows: in Austria-Hungary, No. 33,024 and No. 56,901, dated September 1, 1892; in Belgium, No. 96,380, dated September 14, 1891; in England, No. 15,461, dated September 30, 1890; in France, No. 216,104, dated September 14, 1891, and in Germany, No. 68,751, dated August 22, 1891,) of which the following is a specification.

This invention relates to certain improvements in and appertaining to apparatus for combining, varying and controlling the speech of the various pipes, reeds, bells, &c., in organs or similar instruments, in a more effective, rapid and convenient manner than has hitherto been accomplished. Electricity and air pressure, or vacuum, are so employed as to enable a performer to admit or shut off the supply of wind to each pipe with unusual rapidity irrespective of his distance from the instrument; to couple the various departments, manuals, pedals or pipes and to operate and control the swell-shutters in a manner and with a readiness not before deemed possible; and to accomplish these ends without having to pull out or push in the more or less clumsy rods of wood furnished with knobs which have hitherto been employed, or to depress keys which offer unpleasant resistance to the touch of the finger. Novel arrangements of tremulants are also provided and are adapted to be operated by electricity or otherwise.

The invention may be understood from the following description, reference being had to the accompanying drawings, in which—

Figure 1 is a diagram illustrating in a general manner one method of arranging the electric connections between the console, organ and battery. Fig. 2 is a side elevation of the console with pedal board detached. Fig. 3 is a plan of same, the upper part of the console being cut away and pedal board detached. Fig. 4 is a detail view of an adjusting device for the key frames. Fig. 5 is a front view (on a larger scale) of the upper part of the console. Fig. 6 is a transverse section (on a still larger scale) through the upper manual and stop key frame. Fig. 7 is a sectional plan of Fig. 6. Fig. 8 is a full size view of a stop key and its connections. Fig. 9 is a detail view of one of the stop key supports, same scale as Figs. 6 and 7. Fig. 10 is a section on line z, z, Fig. 6. Fig. 11 is a section (on a larger scale) on line $y\ y$, Fig. 3. Fig. 12 is a section on line x, x Fig. 11. Fig. 13 is a transverse section showing a modified arrangement of the key contacts. Fig. 14 is a section on the line $w\ w$, Fig. 13. Fig. 15 is a similar view to Fig. 13, showing another modified arrangement of contacts, and also a portion of a coupler device. Fig. 16 is a section on line $v\ v$, Fig. 15. Fig. 17 is a section taken transversely to the manuals showing another arrangement of stop keys and also a composition apparatus. Fig. 18 is a section on the line $u\ u$, Fig. 17. Fig. 19 is a plan of the pair of stop keys shown in Fig. 17. Fig. 20 illustrates another arrangement of stop key. Fig. 21 shows the preceding stop key in its speaking position. Fig. 22 is a side elevation of a portion of the composition roller shown in Fig. 17 and the adjustable pins carried by said roller, the adjacent stop keys being shown in section. Figs. 23 and 24 show the aforesaid pins on an enlarged scale. Fig. 25 is a modified arrangement of the aforesaid adjustable composition pin. Figs. 25^a and 25^b are respectively front and side elevations (with parts in section) of modified arrangement for adjusting the said pins. Fig. 26 is a side view of the composition roller shown in Fig. 20, the adjacent stop keys being shown in section. Fig. 27 is a front view of a portion of the coupler board. Fig. 28 is a transverse section on line $t\ t$ of Fig. 27. Fig. 29 is a diagram showing the electrical connections between the keys, coupler board and organ. Figs. 30 to 34 illustrate the construction of one form of electro-pneumatic lever: Fig. 30 being a central section; Fig. 31, a section on line $s\ s$ of Fig. 30; Figs. 32 and 33, details of the electric connections; and Fig. 34, a plan of the primary valve and its guiding pins. Figs. 35 to 38 illustrate a modified form of the electro-pneumatic lever;

Fig. 35 being a central section; Fig. 36, a section on line *r r*, Fig. 35; Fig. 37, a plan of the primary valve chamber of the electro-pneumatic lever; Fig. 38, an enlarged view of the upper portion of the apparatus shown in Fig. 35. Figs. 39 and 40 are respectively side elevation and plan of a modified arrangement of the electro-magnet shown in the preceding figures. Figs. 41 and 42 are longitudinal section and plan of an improved form of valve-seat employed in the electro-pneumatic levers. Fig. 42^a is a slightly modified arrangement of the parts shown in Fig. 41. Fig. 43 is a sectional elevation showing the arrangement for cutting off the electric current at each operation of the stop sliders. Fig. 44 is a plan of the contact device shown at the left hand side of Fig. 43. Fig. 45 is a front elevation of an electrically operated tremulant. Fig. 46 is a modified form of electrically operated tremulant. Figs. 47 and 48 illustrate two different forms of mechanical tremulants. Fig. 49 illustrates, in a more or less diagrammatic manner, an electro-pneumatic arrangement for operating the swell shutters. Fig. 50 is a section on an enlarged scale through one end of the switch levers shown in Fig. 49. Fig. 50^a is a modified form of switch lever for the apparatus shown in Fig. 49. Fig. 51 shows, partly diagrammatically, another electro-pneumatic arrangement for operating the swell shutters. Fig. 52 shows a modified form of the variable resistance device employed in the arrangement illustrated in Fig. 51. Fig. 53 is a sectional elevation of an electro-pneumatic brake apparatus for the swell shutters. Fig. 54 shows, on an enlarged scale, an improved form of the preceding brake apparatus. Fig. 55 is a detail of the apparatus shown in Fig. 54. Fig. 56 shows, partly in diagram, part of an apparatus whereby a suitable bass on the pedal organ or a suitable accompaniment on one of the manual organs may be instantaneously brought into operation in connection with any manual upon which the operator may happen to be playing. Fig. 57 shows the remaining part of the preceding apparatus, the two parts being, however, operated as one apparatus. Fig. 57^a is a modification of the device shown in Fig. 57. Fig. 58 is a plan of part of the mechanism shown in Fig. 56; Figs. 59 and 60, views illustrating certain matters hereinafter set forth.

Fig. 1 gives a general idea of the electric arrangements for a three manual organ, and will serve to illustrate the invention, although it is to be understood that such arrangements are susceptible of considerable variation.

A, A′, A^2, are three finger keys, one for each manual, and A^3 is one of the pedal keys. Each key is provided with two or more electric contacts B, B′, which are closed each time the key is operated.

F is the battery or other source of electricity whence the current flows by a wire F′ to a test or terminal board C′ of ordinary construction placed within or near the organ. Thence the lead F′ is conducted to a second test or terminal board C placed on or near the console, and from said board the branch wires F^3 lead the current to the various contacts B, B′ aforesaid, and other devices within the console. These supply wires are shown in dotted lines. *b*, *b*′, b^2, b^3, are wires whence the current flows from the contacts B′ to the terminal board C. When a coupler board D, as hereinafter described, is employed, the said wires are brought past and connected to the same, as hereinafter shown and described in detail.

c, *c*′, c^2, c^3, are wires connecting the wires *b*, *b*′, b^2, b^3, on the terminal board C with the terminal board C′. From the terminal board C′, the various currents are led by wires *e*, *e*′, e^2, e^3, to their respective electro-pneumatic levers E constructed, by preference, in one of the ways hereinafter described. These electro-pneumatic levers operate, by means of pull-downs E′ or otherwise, the pallets or wind valves of their respective pipes, similar levers being also employed in connection with pedals, stop-keys, &c., for operating other parts of the organ, as hereinafter described, the connecting wires for these being led to the terminal boards, as in the case of the wires from the manuals and pedal clavier. From the electro-pneumatic levers, the return wires *f*, *f*′, f^2, f^3, are led to the battery F.

The key desk or console is preferably made portable, being conveniently mounted upon casters *g* as in Fig. 2, which figure (and also Figs. 3 to 6) shows the design of console that I employed in my original rough model. When organs are provided with movable consoles in this manner, it is sometimes advisable to mount the pedal-board G separately upon casters, as shown. The pedal-board is so arranged that, when rolled into position, the ends of the pedal keys A^3 come over or against their respective spring contacts B (as in Figs. 1 and 11) in such manner that the key contacts B, B′ are closed when the pedal keys are depressed. To guide the pedal-board into its exact position, V-shaped blocks *g*′ are provided on the console building frame G′ which engage corresponding recesses in blocks g^2 on the pedal-board when the latter is pressed home.

F^4, F′, Fig. 3, is the electric cable connecting the console with the organ, the connections between the cable and the various devices on the console not being shown. The cable is made flexible in order to permit of it being readily paid out or coiled up when the console is moved from place to place. If the circumstances require the cable to be of considerable length, it is provided with a stout, preferably stranded, insulated lead F′ acting as a supply to convey the current from the battery and organ to the console, or vice versa. The lead is preferably formed of a cable of bare wire insulated on the exterior, said lead being passed through the center of the connecting cable, the remainder F^4 of

which is formed of separate insulated wires, leading from the console to their respective devices in or near the organ, or vice versa.

A switch may be fitted upon the console for cutting off the electric current when the organ is not in use. This switch, when desired, may be furnished with a lock and key. Similar switches, placed where they may be readily actuated in either direction by the performer, are provided for instantaneously cutting off or joining up each department of the organ. It is generally advisable also to provide some form of switch, say, a "plug" switch, on to which all the main wires from the console, battery, &c., may be brought.

The console terminal board C may be conveniently placed at one side of the "building frame" G′, as shown in Fig. 2. This terminal board and the organ terminal board C′ will be found of great use if wishing to trace any particular wire. They may, however, be dispensed with, if desired.

By making the console portable, the performer is enabled to play the organ from any desired position, such as either from the choir or nave of a large cathedral. Should it be inconvenient to move the console from place to place, owing to structural hinderances, or the like, I provide a duplicate console in a second position, each of the two consoles being, in this case, furnished with a switch, to render it inoperative if occasion may require. It is advisable that the different key-frames G^2 and other parts of the console should be hinged together, say, in such a manner as that shown at g^3, Figs. 2 and 6, the joints between the frames being so arranged that each manual or other part can be turned back separately, so that access may readily be had to the upper or under side of the keys, contacts, &c., of each manual without disturbing the relative positions of the contacts and keys. The connecting wires in no way interfere with such movement and the various adjustments may be made to a nicety, it being possible to operate the keys and stop-keys and sound the corresponding notes and operate the stops, &c., while the various frames are turned back and the contacts, &c., fully exposed to view in their proper relative positions. The lowest key-frame may in a similar manner be hinged upon the console or organ building frame or upon a base piece sliding thereon. A more solid construction than this is unnecessary when electricity is made use of in the manner hereinafter described. The key-frames G^2 may be made to slide as a whole upon the building frame G′ of the console as seen in Fig. 4, and they may be adjusted horizontally in position by means of thumb-screws g^4, Figs. 2, 4 and 5. Arrangements may also be provided for adjusting the vertical height of the key-frames. These devices allow of the manuals being adjusted to suit different organists.

A, A, A, Figs. 6, 13 and 15, are the manual keys, which are usually short and may be centered in any convenient manner at the end remote from the performer, as in Figs. 6 and 15, or at some distance in advance of said end, as in Fig. 13, or at any other suitable point. The keys are kept in their normal position by springs of any suitable form or material, such as B, Fig. 6, or *a*, Figs. 13 and 15. In the arrangement shown in Fig. 6, the springs B are simply round metallic wires attached at their forward ends to the pin rail g^5 and projecting backward below their respective keys for some distance, say, almost to the balance rail g^6. A suitable regulating device is provided between each key and its respective spring, as, for instance, a felt covered button a' which is hinged to the lower side of the key, so as to press upon the spring and has its position adjusted by a screw a^2 passing through the key to its upper side where it is accessible without the necessity of moving the keys.

B′, B^2, B^3, B^4, are a series of key contacts of any required number, which are, in this case, formed of a series of metallic pins driven through or otherwise mounted upon a board g^7, cake of cement or other insulating support. They are so arranged that the free end of the spring B shall, upon the depression of its key, pass between and rub against the pins, as will be understood from Figs. 6 and 10, the pins being made sufficiently flexible and being placed at such a distance apart as to permit the spring to make a perfect rubbing contact between them, while offering a very slight resistance to the depression of the key.

a^3 is a rail placed above the ends of the springs B to prevent them springing out of place when the keys are removed. The pins B′, B^2, B^3, B^4, are connected respectively to wires *b*, *d*, *d′*, d^2. The wires *d*, *d′*, d^2, are connected to the coupler board D hereinafter described, while the wires *b* from all the keys in the manual are attached to the console terminal board C and are also led on to the coupling board (when employed) as hereinafter described. F^2 is a wire soldered to the row of springs B and in electric connection with a wire F^3 from the battery. The pins B′, B^2, &c., may be made of any metal or alloy preferably one that is not readily oxidized.

Instead of utilizing the key springs B as contacts, any other suitable form of contact device moving with the key may be employed, as, for instance, that shown in Figs. 13 and 14, which consists of a simple metallic stem B^5 projecting from the rear end of the key and adapted to be brought into contact with the pin contacts B′, B^2, B^3, B^4, aforesaid, which are mounted, in this case, above it. Each stem B^5 is connected by an electric conducting wire F^5, passing along the under side of the key, with the supply cable F^3, secured to the balance rail g^6.

In Figs. 15 and 16, the contact pins B′, B′, B^2, B^{2*}, B^3, B^{3*}, &c., are arranged in pairs, each pair being connected with its own circuit,

and the key carries on its under side a series of bent wires B^6—or other suitable separate insulated metallic projections (one for each pair of pins B′, B′, B^2, B^{2*}, B^3, B^{3*}) which are adapted to be thrust between and rub against their respective pins at each depression of the key, and thus complete the circuits, so far as concerns the key contacts.

The contacts for the pedal keys may be arranged in any of the ways above described. In Figs. 3, 11 and 12, the pedal keys are shown provided with the first named arrangement, namely, a series of contact pins B′, B^2, &c., engaged by the key springs B. The end of each pedal key is preferably provided with an adjustable regulating block a^4 (or an adjustable device similar to that shown for the manuals, Fig. 6) which presses upon the key spring B, as seen in Figs. 11 and 12.

In each of the above arrangements of key contacts, the actual contact occurs at one or more small points only, being made by the surfaces of two cylinders (or bodies with similarly curved surfaces) having their axes, more or less, at right angles to each other and rubbing one upon the other, a construction under which a clean contact surface is always insured with a minimum amount of friction. Or two or more pieces with very narrow edges may be employed in lieu of two or more cylinders. Or one or more of the pieces may be provided with a pointed projection or projections adapted to rub against the surface of the other piece or pieces, which latter in this case may be flat, or nearly so. The contacts may be made in duplicate or triplicate. To insure a more perfect insulation of the pins than is afforded by the wooden board g^7, the pins may be cast into a cake of insulating material, and the latter attached to said board, or the pins may be set in cloth or silk lined holes in a board, moisture being excluded by a covering of wax.

For controlling the speech of the various stops or ranks of pipes, I employ, if desirable, instead of the usual more or less clumsy stop handles or knobs (or in addition to these) a simple and convenient stop governing arrangement, by means of which the ranks of pipes individually or collectively, may be brought into, or put out of action by the slightest touch of the player's finger, and even it may be without his having to lift his hand from the keys. In carrying this into effect, I provide, in place of the above knobs or handles (or in addition to them) a series of small cams, buttons, levers, tablets or plates, called "stop keys" which are so mounted that they can be moved with a slight touch or push of the finger, instead of having to be grasped by the hand or pulled out like the old stop handles. These stop keys may be placed on, above, or otherwise near to, one or more of the manuals, or between any or each two of them, and preferably so that they may be accessible from one or more of the manuals without lifting the hands from the keys thereof.

The stop keys of the entire organ may, by means of a stop switch, hereinafter described, be connected to a battery or other source of electricity, and each such key is furnished with one, two or three contacts. These contacts are connected by a small cable of wires to the terminal board C.

The stop keys and their connections may be arranged and constructed in a great variety of ways, three of which may be described by way of illustration only.

In one arrangement, I arrange, in a convenient position on the edge of the music desk and overhanging the upper manual, a series of short vertical levers or tumblers H, which form the stop keys. They may be arranged in one or more rows, but, in the drawings, one row only is shown (see Fig. 5) the stop keys in which are divided into groups corresponding with the various departments of the organ, and some of them are shown tilted backward in their speaking position. The stop keys H are pivoted at or about their centers upon a horizontal axis or axes h, which, in my rough model, was, as shown, supported upon several small brackets attached to the ends of wooden bars h^2 suitably secured to the console. Each stop key is provided with a light spring device, which, in this instance, consists of a flat spring h^3, secured at its rear end upon a wooden strip g^8 and projecting forward above the end of the stop key, and of a short pointed pin h^4 inserted between the free end of the spring and the end of the stop key, the ends of the pin resting in small indentations in these two parts, as seen in Fig. 8. The parts are so arranged that, in the two extreme positions of the stop key, the pin h^4 lies on opposite sides of a line perpendicular to the spring h^3, so that the action of the latter is to thrust the upper end of the stop key forward or backward and hold the stop key securely in either of its two positions, thus rendering it impossible for it to stick at any intermediate point. This spring device has also a further advantage that it only offers a very slight resistance to the movement of the stop key so that a light touch upon either end of the key is sufficient to change its position. Behind the ends of each stop key there are arranged respectively two contacts H′, H^2, in such manner that, when one end of the key is depressed on to its contact H′, the other end is withdrawn from its contact H^2. The stop keys may be provided with more than two contacts when desired. The contacts consist of thin insulated strips of metal bent over at their forward ends and turned outward slightly, as shown in Fig. 8, so that the bent ends, which are flexible, effect a rubbing contact upon the rear surface of the stop key, the latter being metallic and in electrical connection with its axis h. The said axis is connected by a supply wire h^5 to the battery or

other source of electric energy. A safety supply connection is also provided through the wire h^7, a wire h^6 soldered to the springs h^3, and through the springs h^3 and pins h^4. The wires h^8, h^9, from the contacts H′, H², are carried along grooves g^9 in the woodwork of the console to the terminal board C. The contacts of one series, say, the upper one H′, are connected through the console terminal board with their respective electro-pneumatic levers (hereinafter described) in such manner that, on the depression of the upper end of any given stop key in the series, the corresponding electro-pneumatic lever is energized or operated, and, in turn, operates the corresponding stop slider or vent, so as to open the stop. Each of the lower series of contacts H² is similarly connected with an electro-pneumatic lever in such manner that, when the said lever is energized by the depression of the lower end of any of the stop keys in the series, its action is such as to cause the slider or vent to be operated or released in such manner as to close the corresponding stop.

Arrangements are provided, as hereinafter described, whereby the circuit is broken as soon as the slider or vent is fully operated in either direction.

In Figs. 17, 18 and 19, another form of stop key is shown. Each "stop" in the organ is represented at the console by a pair of small keys or levers H³, H⁴, which may be placed horizontally or at an inclination, as shown. They may be placed in a row just underneath one of the manuals—the keys of which would be made to overhang and the finger plates of the stop keys made small so as not to interfere with the ordinary use of the manual keys—or they may be placed as shown, just below the music desk G³ and above the upper manual. The finger plates h^{10}, h^{11} of the stop keys may be somewhat similar in appearance to those of the manual keys as usually made, the white key H³ being used for bringing its stop into action and the black key H⁴ for silencing the same, or vice versa. By preference, the black finger plate h^{11} is made smaller than the white one h^{10} and so arranged as to rise through the same at its rear end, as seen in Figs. 17 and 19, and may itself be covered on the upper surface by a thin plate of white ivory. Each pair of stop keys is so pivoted that, when the white key is depressed, the black key will be raised, and vice versa, the preferable arrangement being that, for the position of silence, the white key shall be raised and the black key depressed, so that the upper surfaces of the two come flush or almost flush, while, for the position of speech, the white key will be depressed and the black key raised. This simultaneous movement of the two stop keys may be obtained by pivoting the white key H³ at some distance from its rear end as at h^{12}, and the black one H⁴ at some point in the rear of the pivot h^{12}, as at h^{13}, and by connecting the two by an adjustable screw h^{14} passed through the rear end of the black key H⁴ and bearing upon the upper side of the key H³ in the rear of its pivot h^{12}. The keys are so formed or bent (as seen in Figs. 17 and 19) that the rear end of the black one lies above that of the white one, while the front ends of both lie side by side in approximately the same plane, the finger plates being, however, arranged as above described. The pivots or axes h^{12}, h^{13} may run part of or the whole length of the row of stop keys and be supported upon brackets h^{15} placed at suitable distances apart. Each pair of stop keys is provided with a spring device h^3, h^4, as hereinbefore described, which insures it remaining either in the "speaking" or "silent" position. The rear end of the key H³ works between two spring contacts H′, H², Figs. 17 and 18, the curved rubbing parts of which are so arranged that, when the key is in its silent position, as shown, its end bears against the contact H², while, in its speaking position, the said end is raised out of contact with the contact H² and into contact with the contact H′. h^8 and h^9 are the wires connecting the contacts H′ and H² with their respective circuits and electro-pneumatic levers. The current supply for both circuits is made through wires h^7, h^6, the key spring h^3, the pin h^4 and the ends of the key H³. This latter form of stop key may be, with ease, incorporated in the pin rail and frame which holds the manual keys.

Another arrangement of stop key is shown in Figs. 20 and 21. The keys consist of rods H⁵ having their forward ends projecting through a plate just below the music desk, or through the key slip, and their rear ends supported in a suitable bar or board g^{10}, the keys being arranged in one or more rows, as desired. Each key is capable of moving bodily in the direction of its length within certain limits, and its front end is also capable of a limited vertical movement, the holes g^{11} through which the key passes being elongated or slightly enlarged to permit of such movement. h^{16} is a spring tending always to elevate the forward end of the stop key, and h^{17} is a second spring acting to thrust the stop forward bodily, the latter spring being inserted between a metallic collar h^{18} on the stop key and a metallic washer h^{19} fixed on the support g^{10}. These springs may of course be arranged in a variety of ways, or one spring may be made to serve the two purposes. The rearward movement of the stop key is limited by a sleeve h^{20} inserted between the collar h^{18} and the washer h^{19}, the sleeve, in the present case, being formed in one with the washer. h^{21} is a metallic collar faced with felt and limiting the forward movement of the key. h^{22} is a felt buffer against which the rear end of the key may strike when the latter is pushed in. The key is shown in the position of silence, being retained therein by the engagement of a notch h^{23} (Fig. 21) in the key, with the beveled edge h^{24} on the upper part of the hole g^{11}. A light downward touch on the key in the direction

of the arrow in Fig. 20 is all that is needed to release it and cause it to spring forward under the action of the spring h^{17}. A backward touch in the direction of the key axis replaces the key in the position of silence, as the spring h^{16} raises the notch h^{23} on its forward end into engagement with the aforesaid beveled edge. The collars h^{18} and h^{21} are connected electrically by an insulated wire h^{25} let into the body of the stop key. In the silent position, the current passes through the supply wire h^{7}, washer h^{19}, spring h^{17}, collar h^{18} and wire h^{25}, to the collar h^{21} and thence by the contact H^{2} to the return wire h^{9}. In the position of speech, the current passes through the wire h^{7}, washer h^{19}, spring h^{17} and collar h^{18} to the contact H′ and thence to the battery by wire h^{8}.

It will be obvious that the preceding form of stop key could be so mounted and arranged as to be brought into the speaking position by an upward touch on its forward end. Also its spring device could be so arranged as to render the use of the notch or detent h^{23} unnecessary.

Where a dynamo is employed, or where, for any other reason, there is no great need to economize the electric current, one of the contacts (H′ or H^{2}) mentioned on each of the foregoing forms of stop keys may be omitted and the remaining contact utilized to energize a single electro-pneumatic lever, which may draw the stop slide or vent on or off as the case may be, the return movement being effected by a spring.

All patterns of the stop keys may be provided in duplicate or triplicate if desired (either connected together or independent of each other) so as to be more accessible from each of the manuals. A stop switch is also provided and placed in some convenient position, whereby, by the lightest touch, the electric power from all the stop and coupler keys of the entire organ is cut off or put on, so that the performer is enabled to prepare beforehand, or as he has opportunity during the performance, such combinations of stops and couplers for the entire organ as he will subsequently require. The stop switch may, if desired, be in the form of any of the stop keys hereinbefore described. In Fig. 5, one of the last named kind, marked S, S, is shown placed among the stop keys about the middle of the row.

H^{6}, Figs. 5 and 17, is a name plate placed above the stop keys and bearing the full names of the various stops, couplers, &c., actuated thereby. Abbreviated names are also sometimes placed upon the stop keys themselves. Some of the stop keys shown in Fig. 5, as, for instance, those marked H^{*}, are used to actuate the couplers as hereinafter described.

It is sometimes advisable to have the stop keys of different colors, say, for example, the flue stops white, the reeds red, and the couplers black.

Composition and combination pedals, pistons, keys or contacts may be arranged to actuate any desired number or combination of the stop keys, or the combination pedals or contacts may be arranged simply to move the sliders or stop-valves without affecting the stop keys. This latter plan, however, I do not recommend, as the performer has then only his memory to rely upon as to what stops are drawn.

In Fig. 17, J is a composition key, conveniently arranged below the stop keys and above the upper manual in such position as not to interfere with the performer's fingers. The key J is pivoted at its rear end, as at j, and is connected by a chain or cord j' and chain wheel j^{2} with a composition roller J′, Figs. 17, 19 and 22, in such a manner as to partially rotate the roller at each depression of the key, the roller being provided with a helical spring (not shown) by which it and the key are returned to their normal positions as soon as the latter has been released by the performer. The roller J′ lies transversely to the stop keys, running, if desired, across the entire row of them, and it is provided with a series of pins or projections J^{2}, Figs. 17 and 22, arranged one above each of the lever stop keys H^{3}, H^{4}. The pins J^{2} are made adjustable, so that the performer, by simply lifting off the music desk G^{3}, may arrange his composition as required. When a pin is thrust through the roller into its lower position, its end rests upon or in proximity to the adjacent stop key H^{3} or H^{4}, so that the latter, if it happen to be in its elevated position when the roller is actuated, is depressed, and the corresponding stop or coupler brought into or out of action according as the depressed key is a white one H^{3} or a black one H^{4}. If a pin J^{2} is drawn up to its higher position, the key below it is in no way affected by the movement of the roller. This will be clearly understood by reference to Fig. 22.

A convenient method of rendering the pins readily adjustable in their two positions is shown in Figs. 23 and 24. The pins are split from their lower ends upward, as at j^{3}, and are each provided on opposite sides (or on one side only) with transverse grooves j^{4} corresponding in their relative positions with the two positions of the pin. j^{5}, j^{5}, are two pins running transversely through the roller J′ on each side of the pin J^{2} and intersecting to about half their diameter the holes through which the pin passes. As the pin J^{2} is pulled up or pushed down with some force, its two limbs are pressed toward each other and ride over the pins j^{5} by which it was previously held, until, the next pair of grooves j^{4} being reached, the limbs spring apart and engage the pins j^{5} with sufficient force to hold the pin J^{2} in position during the operation of the roller.

The pin arrangement shown in Fig. 25 is rather better than the preceding, as, by it, it is impossible for the performer, when he is setting his composition roller, to inadvertently put both pins of a pair of stop keys H^{3}, H^{4} into the operating position, and thus ren-

der the roller unworkable. A single pin J^3 suffices for both keys of a pair, the said pin being pivoted somewhat stiffly, as at j^6, upon or in the roller J′ in such manner that it can readily be turned to either side to bring its lower end above either key of the pair.

In Figs. 25ª and 25ᵇ an arrangement is shown whereby the composition pins may be readily adjusted without the necessity of removing the music desk G^3. H^3, H^4 are the stop keys, the rear portions of which are, in this case, turned on edge. Each stop key is provided, below the roller J′, with a notch j^{10} of suitable depth. The end of the pin J^3 rests upon or in close proximity to the bottom of the notch when the adjacent key is in its elevated position. The remote ends of the notches j^{10} are provided with striking pieces j^{11}. The roller, in addition to its turning movement, is capable of a limited longitudinal movement in either direction, such movement being imparted to it by any suitable lever or operating device under the control of the performer. A spring or springs (not shown) keeps the roller normally in its central position, that is, with the pin axes j^6 midway between their respective keys. To arrange his composition, the performer first depresses all the keys H^3, the stops or coupling movements of which he desires to speak when the roller is operated, and elevates all the rest, the keys H^4 occupying respectively the reverse positions. He now reciprocates the roller J′ longitudinally, the spring aforesaid returning it to its normal position when released. This movement causes the pins J^3 to strike the striking pieces j^{11} of the elevated keys (H^3 or H^4) and be thrown over into position above the notch j^{10} in the corresponding depressed keys (H^4 or H^3), as will be readily understood from Fig. 25ª. However the position of the stop keys may be varied meanwhile, the rotating of the roller brings on the desired combination of stops and takes off the rest, as before described, the pins J^3, however, striking the bottom of the notches j^{10} instead of the upper edges of the keys. If desired, however, the striking pieces j^{11} could project above the upper edges of the levers, the notches j^{10} being dispensed with and the pins J^3 working upon the upper edges of the levers. Or the striking pieces may be fixtures, being to that end mounted on a rail in proximity to the levers.

Any number of composition rollers and keys may be provided, as, for instance, at J′*, J′**, and the internal portions of the keys H^3, H^4 may be made of any desired length to accommodate them. The rollers may be turned by any known method from the movement of keys, pushes, or pedals. The pins J^2 or J^3 may be left without the power of ready adjustment, if desired, or a plain or stepped rib might be substituted for them. The pins may be tipped with or formed of hard rubber to prevent noise in working.

In Figs. 20, 21 and 26, another composition arrangement is shown. J′, J′, are the composition rollers, lying transversely to the stop keys, as before, and operated by any suitable device, such as that already described herein. Each stop key is provided with an equivalent number of pairs of projections J^4, J^5, the members of each pair being arranged one on each side of its respective roller J′. j^7 are stiff spring pieces which are secured upon the rollers J′, and are adapted, when the rollers are turned, to come in contact with the upper ends of the adjacent projections J^4 and press their stop keys downward to a sufficient distance to permit them to spring into the speaking position, as hereinbefore described. j^8 are pins projecting through the rollers between their respective projections J^4, J^5, and adapted, when the rollers are turned, to catch upon the sides of the adjacent projections J^5, as seen in Fig. 21, and to press their stop keys backward into the silent position. The pins j^8 may be made adjustable as hereinbefore described with reference to Figs. 23 and 24. The spring pieces j^7 may also be attached to pins j^9, as seen in Figs. 20 and 26, and these may also be adjustable. The latter pins, however, do not project so far through the rollers as to come into contact with the projections J^5 when the roller is turned. It will be understood that the performer, in any given composition roller, places the spring pieces j^7 opposite those stop keys which are to be silenced and the pins j^8 opposite those which are to speak.

A roller J′ with pins J^2 or J^3 may also be applied to the type of stop key shown in Fig. 8, by permitting the pins to operate upon two stems, projections or other devices mounted upon the back of, or otherwise moving with, the stop key.

Figs. 27 and 28 show the construction of the coupling board D, and Fig. 29 illustrates, in a simple form, the system of electric connections suitable for a two-manual organ. The coupling board D has a number of slightly flexible metallic pins D′, D^2, passed through it, each of which is connected to a separate wire d^3, the wires being gathered into small cables d^4 at the back of the board and led off to the proper points on the console or organ. The pins are arranged in pairs, and the pairs formed into rows as shown. In close proximity to each row of pins there is a long roller switch, formed of a roller D^3 provided, on its periphery, with short insulated metallic strips d^5, so arranged that, on the roller being turned a short distance about its axis, the strips d^5 are brought into or put out of contact with their respective pairs of pins, the electric connection between each pair of pins being thus made or broken. Each roller is provided with a lever arm d^6 and its movement is effected by the organist, by mechanical, pneumatic, electric, electro-pneumatic, or electro-mechanical means.

Referring now to Fig. 29, the light pins D′ of each pair are connected to the contacts B′ B′ B′ of the notes to be struck by the per-

former. The adjacent dark pins D^2 are connected to the contacts B^2 B^3 aforesaid which are in circuit with the notes to which the first named notes are respectively to be coupled. To explain the diagram in detail, A, A A, A A A, are keys belonging respectively to the "swell," "great" and "pedal" claviers, B′ are the contacts in the circuits by which said keys play their own notes, B^2 B^3 are the contacts connected with the coupler circuits, and B the supply wire contacts common to all the contacts B^2 B^3 of their respective keys, as hereinbefore described with reference to Fig 6. The row I of pins (and its roller switch) is for coupling, to the keys of the "swell" organ, their super octaves on the same manual, the row II for coupling "swell" to "great," the row III for coupling "swell" to "pedal," and the row IV for coupling "great" to "pedal." There are as many light pins D′ in a row as there are keys in the corresponding clavier to which it is connected, and there are in most cases a corresponding number of dark pins D^2. When the key A is struck, the current is led from the battery F through the wires F′ F^3 through the key contacts B B′ along the wire *b* to the corresponding pins D′ D′ D′ on the rows I, II and III and thence to the console test board C, through wire *c* and the electro-pneumatic action in the organ back to the battery. Thus the note of the depressed key is sounded. If the super octave roller switch (row I) be in its operative position, the current passes from battery F and along wires F′ F^3 to the contacts B B^2 of the key A. Thence it passes from along wire d^7 to pin D^2; thence by the switch to the adjacent pin D′ connected to the wire *b* forming part of the circuit of the super octave of the depressed key; thence by the test board C, through wire c^4 and the electro-pneumatic action of the super octave pipe; and so on back to the battery, the super octave being thus sounded with its sub octave. In a similar manner, if a key (say C C) on the "great" manual be struck, the circuit is completed through wires F′ F^3, the contacts B B′ of key A A, wire *b*′, pin D′ on row IV (all the pins D′ of which are in circuit with the contacts B′ of the "great" manual for a purpose hereinafter seen), wire b^4, test-board C, wire *c*′, corresponding electro-pneumatic action and battery F, the key's own note being thus sounded. If the "swell" to "great" coupler switch (row II) be now brought into action, the circuit is completed through the wires F′ F^3, the contacts B B^2 of key A A, wire d^8, pins D′ D^2, swell key wire *b*, test-board C, &c., to the battery. The corresponding note C C on the "swell" organ being thus sounded. In a similar manner, when the key A A A (note C C) on the "pedal" clavier is struck, its circuit is completed through the wires F′ F^3, the contacts B B′ of key A A A, wire b^3, test-board C, &c., to battery F, and the "swell" note C C is coupled to the "pedal" note by the contact B^3, wire d^9, pin D^2 (row III), roller switch, adjacent pin D′, &c., as will be readily understood from Fig. 29. The "great" is coupled to "pedal" in a similar manner, the "pedal" contact B^2 being employed and connected with the "great" circuit wire b^4 by wire d^{10}, pin D^2 (row IV), roller switch and pin D′. It will be noticed that the first twelve pins D^2 in row I are not required when this row is employed for coupling to the super octaves.

The coupling board and roller switches may be placed in or near the console, as in Fig. 1, or it may be located in or near the organ, the rollers being operated from the console by any suitable means, preferably by a series of electro-pneumatic levers, connected by wires to the console, as hereinafter described. This plan would, however, render necessary a greatly increased number of wires in the main cable F′ F^4.

Instead of using a coupling board and roller switches as above described, I may connect one-half B^2 B^3 of the various contacts B^2 B^{2*} B^3 B^{3*}, Fig. 15, directly with their respective terminals on the terminal board C. For instance, the super octave contact B^2 of the key "C C" would be connected through the wire *d* to that pin on the terminal board which was in the circuit of the super octave key "C." The wire F^3 permanently connects together all the pins B^{2*}. The contacts B^6 B^2 B^{2*} of any given key on the manual would be closed at each operation of said key, but the closing of such contacts would not complete their particular circuit unless the wire F^3 was also connected to the battery by means of a small switch or key operated at will by the performer. Such an arrangement is shown in Fig. 15, the key H^* and its contact H'^* being in the form of and arranged in a similar manner to the stop keys already described herein. The coupler keys may also be conveniently grouped with the stop keys in front of the music desk, as seen in Fig. 15. The wire d^{12} forms part of the supply wire from the battery. The entire arrangement of the circuit will be understood by reference to Figs. 1, 15 and 16.

The great simplicity of the above described electrical coupling arrangements enables me to make use of couplers which, though very advantageous, have not hitherto been generally used in organs. In a large organ, every manual may couple on its own keys, or may couple every other manual on to its own keys in sub octave, quint, unison, super octave, &c., and every manual may be coupled on to the pedals in unison, quint and super octave, and this either independently or simultaneously.

I will now proceed to describe the electro-pneumatic levers, reference being had to Figs. 30 to 42ª:—In most of my arrangements, I employ very small electro-magnets E^2, preferably of a horse-shoe form, and generally wound with a quantity of fine insulated wire, so as to insure a high resistance. E^3 is a very light

piece or disk of soft iron (which may, if desired, be tinned or varnished and be coated with a thin soft material such as paper, kid, cloth, &c). This disk is so arranged that, in its normal position, it lies very close indeed to the poles of the magnet E^2, the disk forming, in fact, the armature of the magnet and the primary valve of the electro-pneumatic lever. E^4 is a perforated valve seat hereinafter more fully described, against which the disk bears in its normal position, as shown. Two different forms of the electro-pneumatic action are depicted in the drawings by way of illustration, that particular form shown in Figs. 30 to 33 being a reproduction of the experimental model designed originally to actuate the pallets of a sound board constructed for ordinary mechanical action. Describing these in detail:—One, two or more long wooden boxes K, which may be placed facing each other, are provided, to contain the electro-pneumatic pallets, and these boxes are supplied with wind from the organ bellows. The lower covers K′ of the boxes are hinged as at *k* and packed with rubber or other material as at *k′* in such a manner that, although perfectly air-tight when closed, they may be opened so as to readily give free access to the electro-pneumatic pallets. The covers are held closed by hooks k^2 pivoted at k^3 on the cover and engaging staples k^4 on the top of the box. Each box is furnished on the outside with a set of pneumatic bellows K^2, which form the last members of the electro-pneumatic train or lever and are so placed as to come immediately below the pull downs E′ of the sound board it is desired to play upon, the tails k^5 of the bellows being, in fact, connected with the pull downs or with a rod E′ connected thereto as shown. The entrance of the supply pipe K^3 to each of these pneumatic bellows is controlled by its electro-pneumatic pallet within the box K. The body E^5 of the electro-pneumatic pallet is made of wood, covered on its upper face with leather e^4 and hinged on to the upper board of the box by the end of the leather, secured by a screw e^5 and small strip of wood e^6. The body piece E^5 may be broader and not nearly so long as the pallets usually employed in ordinary mechanical action sound boards. The body piece E^5 covers three openings E^6 E^7 E^8 in the upper part of the box, two of which, E^6 and E^8, communicate with the atmosphere (the former through the valve seat E^4), and the third with the pipe K^3 leading to the pneumatic bellows K^2. The body E^5 is pierced by two openings E^9 and E^{10}, Figs. 30 and 31, which would allow the air from the box K to escape into the atmosphere if this were not prevented as hereinafter described. Upon the under side of the body E^5 and near to its center is mounted a small bellows E^{11}, which, by means of a tail-piece e^7 and light rod e^8, governs the position of the secondary pneumatic valve E^{12}, which normally closes the opening E^{10}. The top of the box is, on its under side, recessed or otherwise provided with a chamber or chambers as at e^9 e^{21}, so as to make room for the primary and secondary valves E^4 and E^{12} which are located respectively between the holes E^9 and E^{10} in the body piece E^5 and the aforesaid openings E^6 and E^8 leading to the atmosphere. The inside of the small bellows E^{11} communicates by means of a hole e^{10} with the recess e^{21} in which the primary valve E^4 is situated. A light spring e^{11} tends to keep the bellows E^{11} normally distended and the valve E^{12} closed.

The small horse-shoe electro-magnet E^2 is made of soft iron wire about one-eighth of an inch in diameter, and has its poles passing through and fixed into a small plate e^{12} of zinc, brass or other suitable metal, the poles being securely soldered to the plate which is let into or placed upon the leather e^4 and is fixed firmly to the body-piece E^5. The surface of the plate, together with the poles of the magnet, may have one or two coats of lacquer. The plate is pierced with a hole E^{13} placed over the hole E^9 aforesaid, the air passing between the poles. The magnet is fixed in the body E^5 with its poles uppermost, and in such a position that they come opposite to the hole E^6 in the wind box, which, as before described, opens to the atmosphere. This hole is, by preference, fitted with a piece of tube e^{13} of metal or other suitable material, bearing a thread on its outside. At its upper end, the tube e^{13} is prepared for the reception of a screw-driver for the purpose of adjustment and the lower end of the tube is closed by the armature valve-seat E^4 which may be of metal and is, by preference, pierced by a number of fine holes and embossed, if desired, as hereinafter described. The primary valve E^3 is placed upon the poles of the magnet E^2 and the tube E^{13} is screwed down so as to bring the valve seat E^4 within a very minute distance from the valve. Three or four guide-pins e^{14}, Figs. 31 and 34, may, with advantage, be fixed in the under side of the top of the box to prevent the disk valve moving from its proper position. Two metallic studs or contacts e^{15} are placed on the under side of the body and a couple of spring-hooks e^{16}, which pass through the top of the box, press upon the studs e^{15} and keep the piece E^5 in its position. The hooks are capable of being turned aside to permit of the body E^5 being thrown back about its hinge. The ends e^{17} of the wire which surrounds the magnet are soldered one on to each of the studs e^{15}. The shanks of the hooks e^{16} pass through the top of the box and bear respectively against spring contacts e^{18} e^{19} (see Fig. 33). The former is connected by wire *e* with the organ terminal board C′, and the latter is soldered to a conducting strip e^{20}, whence a return wire *f* leads to the battery. If now a current of electricity be made to pass from one hook e^{16} to the other through the coils of the magnet, the light iron disk E^3 forming the primary valve will be drawn on to the poles of the magnet and close

the opening E^{13} between the same, opening at the same time the small holes in the valve-seat E^4 and thus allowing the compressed air, which was inside the small bellows E^{11}, to escape into the atmosphere by way of the hole e^{10}. The bellows E^{11}, being unsupported by internal pressure, will now collapse under the pressure of air in the box K in spite of the spring e^{11} and will, through its tail-piece e^7, move the secondary valve E^{12} in such a manner as to close the opening E^8 to the atmosphere and allow a considerable flush of wind to pass through the openings E^{10} and E^7 and pipe K^3 into the pneumatic bellows K^2, and so actuate the pull-down E′ and open the pallet in the sound-board, or operate any other device to which it may be connected. Upon the cessation of the electric current, the primary valve E^3 will be blown against the valve-seat E^4, the bellows E^{11} will again be filled with wind through the holes E^9 and E^{13}, recess e^{21} and hole e^{10}, and the spring e^{11} will cause the secondary valve E^{12} to return to its former position and so shut off the supply of wind from the bellows K^2 and open the latter to the atmosphere through the hole E^8. The bellows K^2 now collapses and closes the sound-board pallet or other part operated by the bellows.

In the simplified form of electro-pneumatic lever which I prefer, and which is shown in Figs. 35 to 38, the bellows E^{11} is replaced by a flexible diaphragm E^{17} attached to the top of the wind-box and connected by a light rod (or rods) e^{22} with the secondary valve, which may be formed of two disks E^{14} and E^{15} or of two plates of suitable shape fixed to the rod at opposite ends of a hole E^{16} passing through the bottom of the box, said hole being the equivalent of the holes E^{10} and E^8 and recess e^9 in the apparatus shown in Fig. 30. The hole E^{16} communicates by a pipe or passage K^3 with the pneumatic bellows K^2 for actuating the pull-down E′. The disk valves E^{14} and E^{15} are fixed on the rod at such a distance apart that, when one end of the hole E^{16} is closed to the wind-box by the disk E^{14}, the other end is open to the atmosphere past the disk E^{15}, and vice versa.

e^{23} is a guide for one end of the rod e^{22}, and e^{24} a disk by which the opposite end of the rod is secured to the diaphragm E^{17}.

K^4 is a removable cover forming the top of the recess or chamber e^{21} containing the primary valve E^3 and diaphragm E^{17}. The cover is held in position by guide-pins k^6 and screws k^7. The side-walls k^8 of the recess e^{21} are formed of a rubber or other compressible ring, and, by adjusting the screws k^7, the position of the valve-seat E^4 (and, consequently, the valve E^3) may be adjusted with respect to the poles of the magnet E^2. Or the side walls k^8 may be rigid and the valve-seat may be carried and adjusted by a threaded tube, such as e^{13}, Fig. 30. The strip e^{20} aforesaid for the return circuit is placed inside the wind box, as shown.

e is the wire for the supply circuit of the magnet.

The action of the apparatus is very similar to that previously described. The attraction of the primary valve E^3 to the poles of the magnet closes the opening E^{13} E^9 and permits the compressed air in the chamber e^{21} to escape through the valve seat E^4. The pressure in the wind box now raises the diaphragm E^{17} (which is of greater area than the secondary disk valve E^{14}), thus opening the bellows supply passage K^3 to the wind box, and, at the same time, closing it to the atmosphere by the disk E^{15}. On the circuit being broken the chamber e^{21} is again filled with compressed air from the wind box, as hereinbefore described, and the double valve E^{14} E^{15} returned to its normal position.

It will be noted that, in the above arrangement of primary valve, both poles of the magnet act directly upon the disk E^3 to draw it bodily off the seat E^4 on to the opening E^{13}, also, that the magnetic field is fully concentrated upon the armature or disk valve and that the magnetic circuit is almost complete. I am thus enabled to bring the total power of the magnet to bear upon the valve in the most direct and efficient manner, and to thereby effect a great economy of electric energy, or a reduction in the size of the magnet or both. In order to secure a greater area of pole surface for the attraction of the primary valve, the magnet E^2 may be placed at an inclination to its supporting plate e^{12}, and, therefore, to the valve, as seen in Figs. 39 and 40. In order to prevent sparking at the contacts of the stop-keys or at other points at which the circuits of the electro-magnets require to be broken, I usually wind the magnet coils in two, three or more separate layers of different lengths or of wire of different gage, the adjacent ends of the wires being all connected together and to the circuit wire.

The valve seat E^4 is in most cases so constructed that the pressure of the air in the recess e^{21} shall not greatly oppose the movement of the valve E^3 toward the poles of the magnet, and that a very small movement of the said valve shall open a comparatively large area for the passage of the air. To this end, the valve seat is provided with a number of fine holes or one or more very narrow holes of considerable length which are each preferably surrounded by a narrow bearing strip embossed or otherwise formed upon the face of the valve seat. The holes are preferably so arranged as to present, within a limited area (and when taken in the aggregate) a greatly extended edge over or past which the air may escape.

One form of valve seat constructed on the above principle is shown in Figs. 41, 42 and 42^a, in which e^{25} is a series of small holes each surrounded by a narrow bearing strip e^{26} standing up for some distance beyond the body of the valve seat. It will be readily un-

derstood that the pressure of the air on the lower (magnet) face of the valve is to a large extent counterbalanced by the pressure on a large part of the opposite face of the valve, and that, to open all the holes e^{25} to their fullest extent, it is only necessary to impart to the valve a movement equal to one-fourth the diameter of one of such holes. It will be readily conceived that valve seats may be constructed upon the aforesaid principle having many various forms and arrangements of holes, or even with one narrow hole suitably disposed. It will also be obvious that the same principle may be applied to the construction of seats for the secondary valves E^{12} or E^{14}, or for any flat or disk valves employed within the organ, console or their adjuncts.

In the modified arrangement shown in Fig. 42ª, the guide-pins e^{11} are mounted in the magnet-plate e^{12}. I am thus enabled to reduce the diameter and therefore the weight of the valve E^3 to a minimum. It is preferable to construct the valve-seat E^4 of iron so that it exerts a more or less repellent force on the armature valve E^3.

It will be obvious that the above described forms of electro-pneumatic levers may be employed in organs worked by pressure, exhaust or vacuum or a combination of two or more of these, the arrangement of the valves being modified accordingly.

When one or more of the electro-pneumatic levers above described is or are applied, to actuate a vent or stop-slider L, Figs. 43 and 44, one or more pneumatic bellows L′ L^2 of larger dimensions than those shown in Fig. 30 or 35 is or are provided, the said bellows being connected to the slider and so arranged as to push or pull the same. In Fig. 43, a bellows is shown applied to each end of the slider, the bellows being adapted respectively to open and close the slider when their respective electro-pneumatic levers E E are operated by a stop-key, as before described.

Suitable switch or contact devices are arranged in connection with the slider in such manner that the electric circuit of the active electro-pneumatic lever shall be broken as soon as said lever has caused the slider to be fully opened or closed or almost so, and that, at the same time, the circuit of the inoperative lever shall (so far as concerns the movement of the slider) be closed and thus enable the latter lever to operate when the circuit is entirely closed by the action of a stop key. Any useless consumption of the electric current is thus prevented.

l l′ are wires forming parts of the circuit, which, by the operation of a stop key, and through the medium of its corresponding electro-pneumatic lever E, as hereinbefore described, operates to fill the bellows L′ and push open the slider. The wires *l l′* are connected respectively with a fixed contact l^2 and a spring contact l^3. When the slider is closed, the contact l^3 bears against the contact l^2, but, as the slider approaches its fully open position, an insulated abutment l^4, moving with the slider, strikes the contact l^3 and breaks the circuit. A similar arrangement may be provided at the opposite end of the slider to break the circuit when the slider is fully closed or almost so. By way of illustration, a different form of contact device is shown at the opposite end of the slider consisting of two fixed spring contacts l^5 l^6, Fig. 44, forming parts of the circuit *f l l′ e* of the electro-pneumatic lever E, and of an insulated metallic strip l^7 moving with the slider and adapted to connect the strips l^5 l^6 when the slider is open or almost open but to be put out of contact with them as soon as the slider has been fully or almost closed. This latter arrangement is to be preferred, as it is furnished with rubbing contact surfaces.

The foregoing description refers more especially to the application of my electro-pneumatic action to an organ sound board built upon the old plan, that is to say, having pallets and sliders. But my arrangements are more readily adapted to such organs as are furnished with a small pallet for each pipe and a system of vents for controlling the "stops."

Fig. 45 illustrates an arrangement whereby I am enabled to obtain the trembling effect usually secured in an organ by a vibrating pneumatic valve. M is a concussion bellows furnished with the usual springs, (not shown) attached to the under side of the sound board at or about its center and communicating therewith in the well known manner. M′ is an electro-magnet attached to the bottom of the concussion bellows. M^2 is a movable armature pivoted at one end to a support *m* on the bellows M and having an extension or arm *m′* at its opposite end provided with an adjustable weight m^2. m^3 is a spring attached to the armature and serving to support the latter upon an adjustable pin m^4 carried by the support *m*. M^3 is a post mounted upon the bellows and furnished with a rubber tip which lies normally in close proximity to the upper side of the arm *m′*. The action of the apparatus is the same as that of the ordinary contact breaking device. The vibration of the weighted armature M^2 *m′* m^3 and the reaction of the magnet on the armature, as well as the succession of blows delivered on the post M^3 throw the bellows into a state of vibration and produce the required vibratory or trembling effect in the air contained in or passing through the sound board and pipes open thereto. Or the same effect may be produced by a small electric motor M^4, Fig. 46, which is mounted on the bellows M and is provided with a wheel M^5 weighted on one side, as at M^6. The rapid rotation of the unbalanced wheel M^5 causes the bellows to be vibrated, as will be readily understood. Or an electric or other motor may be arranged to rotate or oscillate a fan or shutter M^7 placed in an opening M^8 in the side of the

swell-box N, as in Fig. 47. Or the fan M^7 may be placed near the pipes, preferably near their upper ends as in Fig. 48. In both these arrangements, the fan acts directly on the sound waves.

Where a swell-box with Venetian shutters is employed, I insure the moving of the latter in accord with the transmitting or swell pedal on the console in a variety of ways, two only of which may be described by way of illustration.

Referring to Figs. 49 and 50, N is the swell-box, N′ the swell shutters and N^2 the rod connecting the shutters together by means of lugs n and pins n' so as to move them all simultaneously. N^3 N^4 are a pair of pneumatic bellows, connected by links n^2 to the ends of the rod N^2 respectively, and adapted to be operated in opposite directions by means of their electro-pneumatic levers E as hereinbefore described with reference to Fig. 43. N^5 is a switch lever connected at one end by a link n^3 with the rod N^2 and having its opposite end adapted to move over a quadrant N^6. The quadrant end of the switch lever is provided with an insulating block or gap n^4 and its working face is furnished with insulated contact pieces n^5 (see Fig. 50) extending from the sides of the gap n^4 to the extremities of the horns n^6 of the lever. The working face of the quadrant N^6 is provided with a series of insulated contact pieces n^7 separated by narrow strips n^8 of insulating material. N^7 is a quadrant on the console having a series of insulated contact pieces n^9 arranged in a similar manner to the pieces n^7 aforesaid. n^{10} is an insulated contact piece mounted upon a pivoted arm N^8 movable with the pedal N^9 (or carried by the pedal itself) and adapted to move successively over the contact pieces n^9 on the quadrant N^7 with each depression of the pedal. The contact pieces are preferably spring mounted. The switch lever contacts n^5 are connected respectively by wires n^{11}, n^{12}, with their respective electro-pneumatic levers E, the return wires n^{13} n^{14} from the latter being led to the battery F. 1, 2, 3, 4, 5, 6, are a series of wires connecting the six contact pieces n^9 with the six pieces n^7 respectively. The pedal contact n^{10} is connected with the battery F by wires n^{15}, n^{16} and pivot n^{17}.

The operation of the apparatus is as follows:—The pedal being depressed from the position shown so as to bring the contact n^{10} on to (say) the second section n^9, an electric current passes from the battery F through the wire n^{16}, pin n^{17}, wire n^{15}, contacts n^{10} and n^9 and wire 2 to the second section n^7 of the organ switch quadrant, and thence through lever contact n^5, wire n^{11}, electro-pneumatic lever E and wire n^{13} to the battery again, thus operating the electro-pneumatic lever and partly opening the bellows N^3 and shutters N′. This movement of the shutters causes the quadrant end of the switch lever N^5 to move downward until the gap n^4 is brought exactly opposite to the second contact section n^7. The gap being a little wider than the section n^7, the circuit is now broken and the electro-pneumatic lever E and bellows N^3 cease to operate. The shutters, however, remain in their partly open position, being balanced by the weight of the lever N^5 or otherwise, or braked as hereinafter described. In a similar manner, the shutters are opened step by step as the pedal switch contact n^{10} moves successively over the sections n^9. When the contact n^{10} is moved over its quadrant in a reverse direction, the shutters are closed step by step by means of the electro-pneumatic lever E and bellows N^4 and its connections. In the position of rest, as shown in the drawings, both circuits are closed, the gap n^4 in the switch lever being opposite the first section n^7. In the arrangement shown, the shutters are opened in five distinct and approximately equal steps. It will be obvious, however, that the number of the steps may be considerably increased by increasing the number of sections n^7 and n^9 traversed by their respective contacts n^5 and n^{10} during the depression of the pedal. It will also be obvious that the length of the various steps may be varied as hereinafter described by varying the length or distance apart (or both) of the contacts n^7 of the organ switch as hereinafter described, and this may be accomplished either with or without varying the contacts n^9 on the console switch.

It will be obvious that the arrangements of contacts above described could be employed in a reverse manner, the contact n^{10} or n^6 (or both) being fixed and the quadrant N^7 or N^6 (or both) being movable with the pedal N^9 and shutters N′ respectively.

In Fig. 51, there is depicted another arrangment for operating the swell shutters. The shutters are opened and closed, as before, by the alternate action of electro-pneumatic levers E and bellows N^3 N^4. P is a variable resistance mounted upon or otherwise moving with the swell pedal N^9, and P′ is a similar resistance attached to or otherwise moving with the shutter connecting rod N^2 or with one or more of the shutters. P^2 is a polarized relay of any suitable form, consisting, in this case, of a horse-shoe shaped electro-magnet P^3, a polarized vibrating tongue P^4 and a pair of contacts P^5 P^6. The coil P^7 of the magnet is connected in a circuit p p' p^2 with the variable resistance P, and the coil P^8 with a circuit p^5 p^4 p^3, including the resistance P′, the two coils being so wound and their circuits so connected to the battery F, that, in the normal condition of the apparatus, the magnet poles are inert, and have no action upon the free end of the tongue P^4 which lies between them and is, as usual, held in its central position by a light spring device or controlling magnet (not shown). The stationary end of the tongue is connected by a wire p^6 with one pole of the battery, and the contacts P^5 P^6, arranged one on each side of

the free end of the tongue, are connected through the circuit wires n^{12} n^{14} and n^{11} n^{13} of their respective electro-pneumatic levers E E with the other pole of the battery, p^7 p^8 are spring or rolling contacts bearing upon the variable resistances P P′ respectively, and connected in the respective circuits of the latter.

In the normal position of the apparatus, the relative proportions and positions of the two resistances P P′ are such that the circuits p p' p^2 and p^5 p^4 p^3, are balanced and the magnet poles p^9 p^{10} allow the tongue to lie in equilibrium midway between the contacts p^5 p^6. On depressing the swell pedal and raising the resistance piece P, the resistance of the circuit p p' p^2 is increased, the poles p^{10} p^9 are respectively polarized (say) N and S and the tongue P^4 moved into contact with the contact P^6. This completes the circuit through the contact P^6, wires n^{11} n^{13} and electro-pneumatic lever E, battery F, wire p^6 and tongue P^4, and causes the bellows N^3 to move the rod N^2 upward and open the shutters more or less. The upward movement of the rod N^2 raises the resistance piece P′ and increases the resistance of the circuit p^5 p^4 p^3, until the balance between the two resistance circuits is restored and the tongue P^4 assumes its normal position and breaks the circuit of the lower electro-pneumatic lever E. In a similar manner, the depression of the resistance P operates the upper electro-pneumatic lever E and closes the shutters. It will thus be seen that each minute movement of the swell pedal in either direction opens or closes the shutters to a corresponding amount, the movement being free from all pauses or jerks, and in exact accord with the movement of the pedal.

Fig. 52 shows an improved form of variable resistance device for the apparatus just described. P^9 is a light cylinder, of wood or other suitable material, upon which there is wound a single bare coil of fine wire having sufficient electrical resistance. The various turns of the coil do not touch each other. The cylinder is mounted on the shutter operating rod N^2, and moves up and down with the same. P^{10} is a light insulated spring, mounted on the swell box and bearing against the surface of the coil. p^5 p^4 are the wires connecting the spring and the upper end of the coil respectively to the resistance circuit. It will be seen that, as the coil is raised or lowered, the number of turns of wire through which the current has to pass and consequently the resistance of the circuit is correspondingly increased or diminished. It will be understood that a similar resistance device is connected to and moves with the swell pedal.

It is well known to organists that the first small opening movement of the swell shutters permits the escape of a volume of sound which is much greater, in proportion to the movement of the shutters and swell pedal, than the increase of volume effected by any subsequent movement of a similar amount. In order, therefore, that the volume of sound emitted may vary as the movement of the pedal, it is necessary that equal increments of movements in the swell pedal, when operated to open the shutters, shall effect increments of movement in the swell shutters, of a continually increasing amount. This may be effected in the apparatus shown in Fig. 49 by so arranging the sections n^7 that their length or distance apart (or both) shall increase from the top to the bottom of the quadrant at such a rate as shall be found most suitable, the section or sections nearest the top of the quadrant being made very small or placed close together (or both). When the sections are equal in length and their distance apart varies, the gap n^4 has a fixed width slightly greater than that of a contact section. When the length of the sections varies as well as, or instead of, their distance apart, the width of the gap n^4 is varied automatically so that it is always wider than the particular section opposite to it. This may be effected by mounting the two arms of the switch lever N^5 upon separate pivots n^{18} n^{19} located at different but suitable points in their length, as seen in Fig. 50ª. The inner ends of the arms N^5 are connected to a cross link n^{20} which in turn is connected at its center to the end of the link n^3 aforesaid. It will be readily understood that, as the contact ends of the arms N^5 move down over the quadrant N^6, the gap n^4 increases in width, the rate of increase depending on the relative positions of the pivots n^{18} and n^{19}.

When the apparatus shown in Figs. 51 and 52 is employed, the foregoing effect is obtained by increasing the diameter of the swell shutter resistance cylinder P^9 from the bottom to the top at a constant or varying rate, so that equal increments of resistance introduced into the circuit p p' p^2 by the opening movement of the swell pedal shall, in order that the circuits may be balanced, require increments of movement in the swell shutter resistance P′. It is preferable to place the upper end of the tapered resistance cylinder eccentrically to the rod N^2 so that the side next the spring contact P^{10} shall lie approximately parallel to the axis of the rod. A tapering resistance device such as described may also be placed on, or move with, the swell pedal, or both pedal and shutters may be provided with such a device.

An automatic switch may be provided in connection with the swell pedal to break the connection of the circuits of the swell shutter apparatus with the battery when the pedal is stationary.

A pneumatic or electro-pneumatic brake is sometimes employed to check undue movement in the shutters and to hold the latter firmly in position after each movement thereof. An arrangement suitable for this purpose is depicted in Figs. 53, 54 and 55. Q Q are a

pair of bellows hinged at one end to a supporting frame Q′ and located one on each side of the shutter operating rod N^2 at its upper or lower end. The free ends of the bellows are provided with brake shoes Q^2, say of rubber, adapted to grip the rod between them when the bellows are operated, the adjacent part of the rod being also, by preference, covered with rubber. Q^3 is a wind-box communicating by a passage q with the atmosphere and q' q^2 are passages leading from the passage q to the bellows Q. q^3 q^4 are a pair of disk valves controlling opposite ends of the passage q and attached to a rod q^5 supported from a flexible diaphragm q^6, of larger area than the valve q^4, and mounted in the top of the wind-box. Q^4 Q^5 are a pair of small pneumatic bellows having their tail-piece connected with the rod q^5, in such manner that either bellows, when operated, acts to draw down the said rod. The bellows Q^4 Q^5 communicate respectively, by pipes q^7 q^8, with the swell shutter bellows N^3 N^4. In the normal position of the apparatus, the bellows Q^4 Q^5 are closed, the passages q' q^2 are open to the wind-box Q^3 and the bellows Q pressed firmly against the shutter-rod N^2. If, now, the electro-pneumatic lever E of the swell shutter bellows N^3 be operated, the said bellows is filled with compressed air and a small portion of such air passes by pipes q^7 into the bellows Q^4 and causes the valves q^3 q^4 to be drawn down, thus closing the passage q to the wind-box and opening it to the atmosphere. This releases the bellows Q and permits the rod N^2 to move freely under the action of its bellows N^3. As soon as the lower electro-pneumatic lever E is put out of action, the pressure of air in the bellows N^3 is relieved, as hereinbefore described, the pressure being also reduced in the bellows Q^4. The wind in box Q^3 raises the diaphragm q^6, closes the valve q^3 and bellows Q^4, and opens the valve q^4 again to the wind-box, whereby the bellows Q are filled and the brake-blocks Q^2 are instantly applied to the rod N^2. The action is precisely similar when the upper electro-pneumatic lever E and bellows N^4 are operated to close the shutters, the bellows Q^5, however, coming into operation in this case. If desirable, the pipes q^7 q^8 could each be supplied with an independent electro-pneumatic lever, arranged in circuit with its respective lever E.

Figs. 54 and 55 show a slightly modified arrangement of the preceding apparatus, whereby the shutters may be held firmly closed and undue movement, arising from a tendency of the shutters to rebound when closed, may be counteracted. Q are the bellows of the brake-apparatus and Q^2 are the brake-blocks, which, in this case, work against an enlarged part Q^6 of the shutter-rod N^2. Q^7 are one or a pair of rollers mounted upon each bellows below or on each side of the blocks Q^2. The rollers Q^7 are so situated that, when the shutters are closed, they bear upon the tapered part Q^8 of the rod just above the enlargement Q^6 so that the bellows Q, by pressing them against the said tapered part, exert a downward pressure on the rod to keep the shutters firmly closed. Should the shutters rebound when closed, the pressure of the rollers, acting as aforesaid, instantly counteracts such rebound and closes the shutters firmly. The rollers Q^7 and blocks Q^2 and their bearing surfaces are so placed that the blocks are out or almost out of contact with the enlargement Q^6 by the time the rollers begin to bear upon the tapered portion Q^8. This may always be insured by slightly grooving or cutting away the corners of the part Q^6 of the rod as at Q^9, the wheels Q^7 being thus quite clear of the rod as soon as they leave the tapered part Q^8, and the blocks Q^2 begin to bear upon the part Q^6. This modified arrangement may be applied to the opposite end of the rod N^2, the extreme end of the rod being tapered and the position of the bellows, rollers and blocks being modified accordingly.

The swell pedal may, by the simple attachment or removal of a spring by the performer, be made "balanced" or self-closing at pleasure. Or two pedals, one balanced and the other self-closing, may be provided and may be connected with a switch by which the performer may bring either pedal into the circuit as desired. Under certain circumstances, it is well to add a finger-key or touch (similar to one of the stop-keys aforesaid) for the better control of the swell-cutters, such key being thrown out of action by any suitable mechanical or other device as soon as the weight of the foot comes upon the pedal. On actuating this finger-key, the supply of electricity to the swell-pedal will be cut off and a current will be transmitted directly to the electro-pneumatic lever or levers provided to open the swell shutters.

An electrical switch, push or contact, may be conveniently placed on or below each one of the manuals, and so arranged that, by its means, a current may be sent through any of the stop-keys or couplers which may be open on its respective manual to a suitable stop or combination of stops (or of stops and couplers) in the pedal organ so as to cause these stops to speak and the remaining pedal stops to become silent.

Figs. 56, 57 and 58 show one form of apparatus and will serve to illustrate this part of the invention, although the principle underlying it is capable of being embodied in many different forms. S S S are three push buttons or studs, placed one below each of the manuals (see also Fig. 5) and hereinafter called "suitable bass" studs. I I I are a similar series of push studs arranged alongside the studs S S S and hereinafter called "independent pedal" studs, their object being partly to restore any of the depressed studs S to their normal position when required. Each of the studs I or S is carried by a rod I′ or S′, which is at its forward end supported by and works within

the key-slip g^{10}, and at its rear end it passes through and works within a board g^{11}. S^2 is a vertical shaft having three arms S^3 engaging respectively the three rods I′ so that the movement of any one of said rods effects the movement of the others. S^4 is a board supported in front of the board g^{11} upon pivoted arms s so that it can readily rise or fall for a short distance. Each rod I′ or S′ passes through a hole s' in the board, the said hole being large enough to permit also of the passage of a nose or detent s^2 on the upper side of each of the rods S′, and on one at least of the rods I′. s^3 are springs tending to thrust their respective rods S′ or I′ outward. In the normal position of the parts, the three studs I I I are pushed inward and retained in that position by the arrangement of their noses s^2 with the back of the board S^4, while the studs s are pushed outward and their noses are located in front of the board S^4 as is the case with the upper and lower studs shown in Fig. 56. If now one of the studs S (say the central one) be pushed in, as shown, its nose s^2 will raise the board S^4 and release the studs I I I which move forward under the influence of their respective springs. The pressing in of any one of the independent pedal studs I I I releases whichever of the studs S happens to be pushed in at the time. It will thus be seen that only one stud S or all the studs I can rest in their pushed-in position at the same moment. The studs I S and their connections may also be so arranged as to permit the manual key-frames to be hinged as hereinbefore described.

Each "suitable bass" stud S is provided with a suitable contact device, such as an insulated collar S^5—attached to the rear end of its rod S′ and connected to the battery by wires s^4 s^5—and two insulated spring contacts S^6 S^7 adapted to bear upon the collar in the pushed-in or operative position of the stud. The wires s^6 s^7 from the said contacts are connected to separate circuits for purposes hereinafter described.

Within the organ there is located a roller switch T, Fig. 56, similar to that shown in Figs. 27 and 28. T′ are the roller contact pieces, and T^2 is one of a series of pins adapted to be placed in or out of contact with the pieces T′ when the roller is turned. Each pair of pins T^2 and wires t form parts of the circuit of a pedal stop key or coupler, the whole of the "off" and "on" circuits of the pedal stop keys and couplers being led past the roller T. E is an electro-pneumatic lever adapted to operate the roller T in one direction, and t^5 is a spring to return the roller when the lever E is put out of action. The return wire f is connected to the battery, while the wire e is connected to the wires s^6 aforesaid. Or the roller T may be operated by two electro-pneumatic levers for each of the "suitable bass" studs as in the case of the slider shown in Fig. 43, a circuit being broken at each operation of one of said levers (as hereinbefore described) and the electro-pneumatic levers being suitably arranged to permit of each pair operating the roller independently of the others.

In the normal position of the apparatus the roller switch is closed and the "on" or "off" circuits of the pedal stop keys and couplers are complete at that point. As soon, however, as a "suitable bass" stud is pushed in, the contacts S^6 S^5 are closed, the circuit of the electro-pneumatic lever E closed, and the switch roller operated in such manner as to break both the "off" and "on" circuits of all the stop keys and couplers of the pedal organ.

Each stop and coupler key for the manual organs is furnished with a third independent contact device, which, when the "tumbler" type of key is employed, may consist of an insulated stem S^8 projecting from the back of the stop key and two flexible contacts S^{11} and S^{12} against which the stem bears when the stop key is tilted into its speaking position. The contact S^{11} is connected with a permanent resistance coil S^9, through which a small current may be sent, when the stop key is in its speaking position, if the circuit be otherwise closed. All the coils S^9 are connected to a "suitable bass" wire S^{10}, and the coils may be so arranged that the relative amounts of their resistances are in inverse proportion to the relative powers or volumes of their respective stops. Thus the very loud stops would have small resistance coils only (or even none at all). It will thus be seen that the amount of current sent through the wire S^{10} varies directly as the number and power of the stops in action. The wire S^{10} is connected by a wire s^8 to the wire p' of the relay circuit p p' p^2 of a variable resistance and electro-pneumatic controlling device such as shown in Fig. 51, and the return wire p^2 of said circuit is connected to the battery F, the wire p, that is, the wire s^4, being connected to the opposite pole of the battery. Each contact S^7 is connected by a wire s^7 with a separate wire s^9 connecting all the contacts S^{12} of its own particular manual. When the contacts S^8, S^{11}, S^{12} are closed, the variable current traversing the circuit p, s^4, s^5, S^5, S^7, s^7, s^9, S^{12}, S^8, S^{11}, S^9, S^{10}, s^8, p', P^7 (Fig. 51) p^2 and F, causes a rod T^3 (Fig. 57) moving with an adjustable resistance device P′ (Fig. 51) to be raised and lowered in exact accord with the variations of said current as hereinbefore described. T^4 is a lever connected to the rod and moved up and down thereby. One end of the lever has a contact t^3 which moves over the face of a switch quadrant T^5, provided with a number of separate insulated contact sections t^3. The circuits of certain set combinations of pedal stops or of pedal stops and couplers are connected, through suitable electro-pneumatically operated switch devices, by one or more wires t^4 with their respective sections t^3, and the lever contact t^2 is connected to the battery F by wires t^{14}. The

opposite pole of the battery is connected by wires t^{15} t^{16} with the opposite terminals of the electro-pneumatic levers for operating the said switch devices. The switch device T^4 T^5 is so arranged that different combinations of manual stops or stops and couplers bring into action suitable set combinations of pedal stops and couplers.

If desired, the wires s^9 may be duplicated for each manual, one wire being connected to the contacts S^{12} belonging to the stop keys of the stops of one particular class of tone, the other to the contacts S^{12} of the stop keys of another class of tone. Each of the divided wires s^9 is connected through distinct resistances S^9 and suitable bass wires S^{10} with a separate switch arrangement such as is shown in Fig. 57. Or the switch may be arranged and connected as shown in Fig. 57ª, so that the pedal stops and couplers are brought on one by one in order as the current in the "suitable bass" wire S^{10} is increased.

T^6 T^7 are two quadrants provided respectively with insulated contact pieces t^6 t^7 over which the contacts t^8 and t^9 of the lever T^4 work. The contacts t^8 and t^9 are connected by wires t^{10} t^{11} t^{12} to the battery F, the other pole of which is connected by a wire or wires t^{13} with return wires of all the "off" and "on" electro-pneumatic levers of all the pedal stops and couplers. The wires 1, 2, 3, 4—of the contact pieces t^7 are connected respectively to the wires of the "off" electro-pneumatic levers aforesaid, while the wires 1^a, 2^a, 3^a, 4^a,—of the contacts t^6 are connected to the wires of the "on" electro-pneumatic levers aforesaid. As the contacts t^8 t^9 are moved downward by the action of the rod T^3, they successively break the circuits 1, 2, 3—and close the circuits 1^a, 2^a, 3^a—, thus bringing the corresponding stops and couplers on one by one. The switch is preferably so arranged that the contact t^9 leaves the first contact piece t^7 and breaks the circuit of this "off" electro-pneumatic lever before the contact t^8 touches the first piece t^6 and completes the circuit of the "on" electro-pneumatic lever, In the reverse movement of the lever T^4, the various electro-pneumatic levers are successively operated to silence their respective stops.

Simultaneously with the operating of the "suitable bass" stud S to break the stop key circuits of the entire pedal organ, as before described, the collar S^5 of the bass stud comes into contact with its contact S^7 and completes the circuit of the "suitable bass" wire S^{10} as before described, thus instantly bringing into operation a suitable combination of pedal stops or of stops and couplers.

Each manual may, if desired, have a distinct "suitable bass" wire, but all may be connected to the same wire to work the roller switch T aforesaid. Also each manual may, if desired, work the same switch lever T^4 or different switch levers, each operating a different set of combinations. If desired, each "suitable bass" stud, when pushed in, may directly couple the manual concerned with the pedals.

It will be obvious that an arrangement such as that described above could be used in connection with the manuals for the purpose of instantly obtaining on any one of the manuals a suitable accompaniment to another manual upon which the performer may be playing. Also the swell pedal may be provided with one or more contacts made to act in a similar way to the stop keys aforesaid, so that an additional current may be transmitted to the "suitable bass" wire or wires and thus cause more pedal stops to speak when the swell-box is open.

It will be obvious that forms of switches other than those shown in Figs. 27, 28, 49, 50^a, 57, and 57^a may with advantage be employed.

It will be obvious that, in an organ arranged and constructed as hereinbefore described, the instrument may with facility be divided into any number of portions, and the pipes or even a single stop may be made to stand in any position that is desirable for ornamental purposes, without depriving the pipes of the advantage of standing exactly over their own wind.

When organs, arranged in the manner hereinbefore described, are blown by gas, water or other motive power, contacts may be made and broken by the rise and fall of the wind reservoirs, which will actuate electro-pneumatic levers and so regulate the speed and working of the engine or of the bellows or the air-compressors. If primary or secondary batteries in parallel be used to supply the electricity, it will be found advisable to arrange an automatic switch which shall disconnect each set of cells from the other sets and from the organ when the wind is out of the organ and shall re-establish the connection when blowing re-commences.

In Fig. 59, A is the collapsible reservoir supplying wind to the organ, and B is the governor or any other speed-controlling device for regulating the gas, steam, hot air, water or electric motor employed; C C are the electro-pneumatic levers, similar to that described in this specification or of any other known form adapted, by means of the magnets C′, the armature valves C^2, the valve seat C^3, the bellows C^4, the valves C^5, C^6, and the bellows C^7 C^8, to raise or lower the lever b' and the adjustable weight b^2. D is the contact device in which d' d^2 are metal plates connected respectively with the circuits adapted to operate the electro-pneumatic levers which will lower and raise the weight b^2. d^3 is a spring connected with the common return wire and fixed to moving part of the reservoir A. In the position in which the apparatus is drawn, the reservoir A being full, the spring d^3 is in contact with the plates d^2, and the electro-pneumatic lever which inflates the bellows C^7 is operated and the weight b^2 lifted by the chain b^3. When the reservoir sinks a little, the spring d^3 will leave

the plate d^2 and the bellows C^7 will no longer lift the weights b^2. Again, when the reservoir A sinks still lower, the spring d^3 will come in contact with the plate d', the bellows C^8 will be inflated, thus reinforcing the weight b^2 and increasing the speed of the motor considerably. In practice, it is often found convenient to give the organist control of a switch, which enables him to operate the mechanism above described independent of the reservoir A and the switch D.

In Fig. 60, A and B are two sets of primary or secondary batteries, being joined together in parallel. C is a bellows connected by the pipe D to the reservoir of the organ and carrying a metal contact piece E adapted to rub between or otherwise make a contact with the wires F G from each of the sets of batteries and to connect them with the wire H. Until the wind is in the reservoir, the bellows C is collapsed and each set of cells is disconnected from the other set and from the organ.

I declare that what I claim is—

1. In an organ, the combination with the console frame G′ having a series of electric contact devices for the pedal keys; of a separate portable pedal board G provided with the pedal keys, all substantially as shown and described.

2. In combination with the console building frame G′ having a series of electric contact devices for the pedal keys, a separate portable pedal-board G carrying said keys, and a guiding device adapted, when the pedal-board is moved up against the console building frame, to guide the keys into position above their respective contact devices, substantially as described.

3. The combination of the portable console frame G′, the key-frame G^2 adjustable as a whole thereon, and the separate portable pedal frame G, substantially as described.

4. In an electric organ, the combination, with a series of finger keys, and a series of contact devices adapted to be closed and opened thereby, of a hinged frame upon which said keys, contacts and their immediate connections are mounted whereby a ready access may be obtained to the keys, contacts and connections without altering the relative positions of the same, and the keys may be actuated and their notes sounded, or stops or couplers operated while the frame is thrown back and said contacts and connections are fully exposed to view, substantially as and for the purposes described.

5. In an electric organ, two or more superposed frames hinged one upon the other and carrying respectively the manuals and stop keys with their various contact devices and immediate connections, the lowermost frame being hinged upon a supporting bed, and each being capable of being thrown back separately, substantially as and for the purposes described.

6. In an electric organ, an oscillatory stop-key arranged conveniently to the performer, and furnished with one or more electric contacts for the purposes described, in combination with a light spring device adapted to hold the key in its extreme positions, and prevent it from resting in any intermediate position, substantially as and for the purpose described.

7. In an organ, a series of oscillatory stop-keys arranged side by side in one or more rows, in combination with a series of spring devices connected respectively with said keys and each adapted to hold its key in its two extreme positions and prevent it from resting in an intermediate position, whereby an entire series of stop-keys may be instantly placed in their "on" or "off" positions by a light glissando movement of the performer's finger, substantially as described.

8. The combination with an oscillatory stop-key, of a flat spring h^3 approximately perpendicular thereto, and a pointed pin h^4 inserted between the free end of the spring and the adjacent end of the key in such a position that it points to opposite sides of the key-axis when the key is in its extreme positions, substantially as and for the purpose described.

9. In an electric organ, the combination of a coupler board D, a series of insulated pins D′ arranged in rows thereon as described and connected in circuit with the ordinary, *i. e.*, "own note," contacts of their respective manual or pedal keys, a second series of insulated pins D^2 arranged one in proximity to each pin D′ and each connected in circuit with the additional coupler contact of that key to which the note belonging to the adjacent pin D′ is to be coupled, a series of roller switches D^3 arranged one in proximity to each row of pins and each provided with insulated contacts adapted to connect each adjacent pair of pins D′ D^2 when the roller is turned, and operating devices for turning one or more of said rollers as desired, substantially as described.

10. In an electric organ, the combination, with a series of pedal or manual keys, of a pair of contact pins B^2 B^{2*} for each key, a contact piece B^6 for and movable with each key and rubbing against the adjacent pins B^2 B^{2*} when the key is depressed, wires d connecting the pins B^2 with the electric actions of the notes to be coupled to their respective keys, wire F^3 d^{12} connecting all the pins B^{2*} to battery, and switch H^* H'^* controlling wire F^3 d^{12}, substantially as described.

11. In an air-controlling device for an organ, the combination with an approximately flat faced valve; of a valve seat pierced with a series of fine openings, and provided also with a raised rim around each of said openings, substantially as and for the purpose described.

12. In an air-controlling device for an organ, the combination, with an approximately flat-faced valve capable of reciprocating to and from its seat, of a valve-seat pierced with a

series of fine port-holes each surrounded at its outer (or valve) end with a narrow projecting strip forming a bearing face for the valve, substantially as and for the purposes described.

13. In an air-controlling device for an organ, the combination of the reciprocating disk valve E^3, and the adjustable tube e^{13} having its closed end pierced with a series of fine perforations, each surrounded at its outer end by a narrow strip e^{26} forming a bearing face for the valve, substantially as described.

14. The combination of the horse-shoe magnet E^2, the supporting plate e^{12} having its surface flushed with the poles of the magnet, and provided with a wind aperture E^{13} between and partly surrounding the poles, the adjustable perforated valve-seat E^4 opposite the magnet poles, the light armature valve E^3 reciprocating bodily between the seat and the poles, and the valve guide-pins e^{14}, substantially as described.

15. In an electric organ, a stop slider and a pair of electro-pneumatic levers for operating the slider in opposite directions, in combination with a pair of contact devices connected respectively in circuit with the electro-pneumatic levers, and located in proximity to the slider, and a pair of insulated pieces on the slider adjacent to the said contact devices and adapted to open the same at or about the termination of the operative strokes of their respective pneumatic levers and to close them again on the return strokes of said levers, whereby undue consumption of electric energy while the slider is at rest is prevented, substantially as described.

16. In an organ, the combination, with a sound board and a concussion bellows communicating therewith, of an electrically-vibrated body mounted on the movable side of the said bellows and adapted to impart its vibrations to it and to the air contained in the bellows and the adjacent air spaces, substantially as and for the purpose described.

17. In combination with the concussion bellows M communicating with the sound board as described, an electro-magnet M′ and a vibratory armature M^2 therefor, both mounted upon the movable end of the bellows and arranged and electrically connected after the manner of an ordinary contact making and breaking device, substantially as described.

18. In an electric organ, the combination with the swell pedal, the swell shutters and electro-pneumatic levers for operating the shutters in either direction, of a single contact and a subdivided contact as described working one upon the other at or near the pedal, one of them being movable with the pedal and the whole being so arranged and connected that on the operation of the said pedal, each section of the subdivided contact is successively connected with and cut off from one pole of the electric supply; a second subdivided contact and a double contact as described working one upon the other within the organ, and one of them movable with the swell shutters, the various sections of the said second subdivided contact being electrically connected respectively with those of the first and the two sections of the double contact being connected each to one terminal of its respective electro-pneumatic lever, and separated from each other by an insulating space of a width not less than that of the widest section of the adjacent subdivided contact; and wires connecting the other terminals of the said electro-pneumatic levers with the other pole of the electric supply, whereby the swell shutters may be operated electrically from the swell pedal in a series of successive steps, substantially as described.

19. In an organ, the swell shutters and an electro-pneumatic device for operating the same, in combination with a brake working against some part movable with the shutters, and a pneumatic or electro-pneumatic device connected with the first named electro-pneumatic device and adapted to apply said brake automatically immediately after each movement of the shutters, whereby all undue movement of the shutters is prevented, substantially as described.

20. The combination with the swell shutters and an electro-pneumatic lever for operating the same, of a pneumatic brake working against some part movable with the shutters, and an air-controlling device adapted to admit a pressure of air into the brake and apply the same as soon as the circuit of the electro-pneumatic lever is broken, substantially as described.

21. The swell shutters N′, shutter-rod N^2 and electro-pneumatic levers E N^3 and E N^4 for operating the same in opposite directions respectively, in combination with a pneumatic brake applied to said rod, and an air-controlling device operated indifferently by either of said levers to apply wind pressure to the brake on the breaking of either of the lever-operating circuits, substantially as described.

22. The swell shutters N′, shutter-rod N^2, and electro-pneumatic levers E N^3 and E N^4 for operating the same in opposite directions respectively, in combination with the bellows Q Q having brake-blocks Q^2 on their movable sides bearing on opposite sides of the said rod, bellows Q^4 Q^5 communicating respectively with the main bellows N^3 N^4 of the electro-pneumatic levers, a valve operated by the opening or closing of either bellows Q^4 Q^5 to respectively open or close an exhaust for the bellows Q, and a valve operated by the closing or opening of either bellows Q^4 Q^5 to respectively open or close said bellows Q to a wind supply, substantially as described.

23. In an electric organ, the combination, with a series of electrically-operated actions for bringing on the stops of one department of the organ, of devices whereby an electric current, varying as the power, volume or tone of the stops of any predetermined series at

any time in action in a second department of the organ, is caused to operate such of said actions as will bring on a stop or stops, forming a suitable accompaniment to the stops of said series drawn on said second organ department, substantially as described.

24. In an electric organ, a series of keys governing the pipes of one department of the organ, a series of stops appertaining to said keys, and a series of electrically-operated devices for bringing said stops into action, in combination with an electric circuit conveying a current varying as the power, volume, or tone of the stops of said series at any time in action, a switch movable in accordance with the variations of current in said circuit and adapted according to its position to close the circuit or circuits of one or more of the electrically-operated devices belonging to a suitable stop or stops of another department of the organ, a switch adapted to break or make all the stop-key circuits of said last named department, and an operating device located conveniently to the performer and adapted to operate said last named switch to break its connected circuits and to simultaneously close said circuit having a varying current, whereby there may always be instantaneously or automatically obtained an accompaniment suitable for such stop or stops as may be drawn on or coupled to said keys, substantially as described.

25. In an electric organ, a series of keys governing the pipes of one department of the organ, a series of stops appertaining to said keys, a series of electrically-operated devices for bringing said stops into action, and a series of stop keys controlling the circuits of said devices, in combination with an electric circuit, a series of resistances arranged in parallel in said circuit and having the relative amounts of their resistances in inverse proportion to the volume, power, or tone of their respective stops, switches operated by the said stop keys in their "on" positions to bring their respective resistances into circuit, a switch movable in accordance with the varying amount of current in said circuit, a series of stops belonging to another department of the organ, a series of electrically-operated devices for bringing said stops into action, a series of contacts each connected with one or more of the last named devices as described and adapted to be successively connected with or cut off from the electric supply by the movement of said switch, a second switch arranged to break or make all the stop-key circuits of said last named department, and an operating device for actuating said second switch to break its connected circuits and for simultaneously closing said first named circuit, substantially as and for the purpose described.

26. In an electric organ, a series of keys governing the pipes of one department of the organ, a series of stops appertaining to said keys, a series of electrically-operated devices for bringing said stops into action, in combination with a series of stop keys H controlling the circuits of said devices, wires s^9 S^{10} connected to opposite poles of an electric supply, resistance coils S^9 of varying degrees of resistance as described connected in parallel to the wires s^9 S^{10}, a switch introduced into the circuit of each resistance coil and controllable by its respective stop key as described, a switch T^4 having one or more contact pieces connected to one pole of an electric supply, a series of contacts over which said switch T^4 works, wires connecting said contacts with the supply terminals of one or more electrically-operated devices for bringing into action a suitable stop or stops belonging to another department of the organ as described, wires connecting the opposite terminals of said devices with the other pole of the said electric supply, means for operating the switch T^4 in accordance with the variations in the amount of current passing through the wire S^{10}, a switch T capable of breaking all the stop-key circuits of the last named organ department, an electrically-operated device for operating said switch keys to break its connected circuits, and a push button S for simultaneously closing the circuits of said last named device and of the wire S^{10}, substantially as described.

27. In an electric organ, the finger keys A and the stop keys H appertaining to one department of the organ, and a series of electrically operated stop actions controlled by said keys H respectively, in combination with the switch S^{11} S^8 S^{12} operated by each stop-key as described, the wire s^9 connecting all the switch contacts S^{12} with one pole of the battery F, resistance coils S^9 of varying strength as described, each connected at one end to one of the switch contacts S^{11}, a wire S^{10} connecting the opposite end of all the coils with the other pole of the battery F, a polarized relay having one of its coils connected in circuit with the wires s^9 and S^{10} and its other coil connected in circuit with a variable resistance P′ as described, electro-pneumatic devices for operating said resistance P′ in either direction, wire p^6 connecting the relay armature with one pole of the battery F, armature contacts P^5 P^6 connecting the armature through their respective electro-pneumatic devices with the other pole of the said battery, switch T^4 having contacts t^8 t^9 movable with the resistance P′ and connected to one pole of the battery F, two series of adjacent contacts t^6 t^7 connected respectively with the supply terminals of the "on" and "off" electro-pneumatic levers of the stops of another organ department, as described, wire t^{13} connecting the opposite terminals of said levers to the other pole of the battery, switch T for breaking all the circuits of the stop keys H, electro-pneumatic lever E operating said switch as described, and push button S

adapted to simultaneously close the circuits of said lever E and of the wire S^{10}, substantially as described.

28. In an electric organ, the combination with a series of stop keys controlling the stops of one department of the organ, of an electric circuit, resistances of suitable strength adapted to be introduced into or cut out of said circuit on the operation of their respective stop keys, a switch movable in accordance with the varying amount of current passing through said circuit and adapted to bring on or take off a suitable stop or stops in another organ department, and an operating device for closing said circuit at will, substantially as described.

29. In an electric organ, the combination with a series of stop keys controlling the stops of one department of the organ, of an electric circuit, a series of resistance coils S^9 of suitable strength as described, connected in parallel in said circuit and corresponding in number to the stop keys, a switch S^{11} S^8 S^{12} connected with each stop key and adapted to bring its respective resistance coil into circuit when the stop key is operated to bring on its stop, contacts S^5 S^7 in said circuit, operating device S controlling said contacts, and a switch movable in accordance with the varying amount of current passing through said circuit and adapted to bring on or take off a suitable stop or stops in another organ department, substantially as described.

30. In an electric organ, an electric circuit conveying a current varying in amount as the power, volume or tone of the stops at any time in action in one organ department, in combination with a switch movable in accordance with the variations in the amount of said current, one or more contacts on said switch connected to one pole of an electric supply, an adjacent series of contacts over which the switch works, a series of electrically operated actions, belonging to the stops of another organ department, and wires connecting said actions in a suitable manner on the one hand with the said series of contacts, and on the other hand with the other pole of said electric supply, substantially as described.

31. In an electric organ, a series of stop-keys controlling the electrically-operated stop actions of one organ department, an electric circuit conveying a current varying in amount as the power, volume, or tone of the stops at any time in action in said department, and a switch movable in accordance with the variations in the amount of said current, and adapted as described to bring into action a suitable stop or stops in another organ department, in combination with a series of contacts T^2 arranged in pairs as described and each pair connected in the circuit of one of said stop keys, a roller switch T T′ adapted to connect or disconnect said pairs of contacts simultaneously, an electro-pneumatic lever E for operating said switch T T′, contact S^6 connected to one terminal of said lever E, wire *f* connecting the opposite terminal to one pole of the battery F, contact S^7 in the first named circuit, contact S^5 connected to the opposite pole of the battery, and operating device S adapted to open and close the contacts S^5 S^6 and S^7, simultaneously, substantially as described.

32. In an organ, an operating rod S S′ having a limited longitudinal movement, a spring for holding the rod in one of its extreme positions and a detent for holding it in its other extreme position, in combination with a second rod I I′ similarly furnished with a spring and detent, and a device whereby the operating of either of the rods releases the other and permits its spring to act, substantially as described.

33. In an organ, a series of operating rods S S′, one for each manual and each having a limited longitudinal movement, a similar series of rods I I′ arranged conveniently to the rods S S′, and a spring and detent for each rod for holding the same in its two extreme positions respectively, in combination with a device whereby the rods I I′ move as a whole, and means whereby the operation of any one of the rods S S′ effects the release of the others and of the rods I I′ and whereby the operation of any one of the rods I I′ effects the release of that rod S S′ which has been previously operated, substantially as and for the purpose described.

34. The combination with the operating rods S S′ located one at each manual, and each provided with a spring and detent for the purposes described, of the rods I I′ located in proximity to their respective rods S S′ and one at least provided in a similar manner with a spring and detent, the shaft S^2 having arms S^3 engaging respectively the rods I I′, and a vertically movable board S^4 having holes *s′* adapted to engage all the detents of the rods S S′ and I I′ and to be raised by the operation of any one of said rods, substantially as described.

35. In an electric organ, a series of rods S S′ located one at each manual, and electrically operated devices as described whereby the operation of any one of said rods secures a suitable accompaniment on another organ department for the stops at any time in action in its own department, in combination with a similar series of rods I I′ located in proximity to their respective rods S S′, means whereby the operation of any one of the rods S S′ effects the release of all the rods I I′ and the remainder of the rods S S′, and a device whereby the operation of any one of the rods I I′ releases that rod S S′ which has been previously operated, substantially as described.

36. In an electric organ, an electric circuit conveying a current varying in amount as the power, volume or tone of the stops of a predetermined series at any time in action in one department of the organ, a switch movable in accordance with the variations in the amount of said current and adapted as described to

bring into action one or more suitable stops in another organ department, in combination with a second circuit including said first named circuit, and adapted to be closed on the operation of the swell pedal to open the swell shutters, whereby an additional current is passed through the first circuit on the opening of said shutters and imparts such an additional movement to the said switch as will bring into action an additional stop or stops on said second organ department, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ROBT. HOPE-JONES.

Witnesses:
W. H. BEESTON,
JAS. CLELAND.