No. 795,851. PATENTED AUG. 1, 1905.

A. D. NEAL.

SYSTEM FOR SELECTING ELECTRICAL CIRCUITS.

APPLICATION FILED OCT. 18, 1901.

6 SHEETS-SHEET 1.

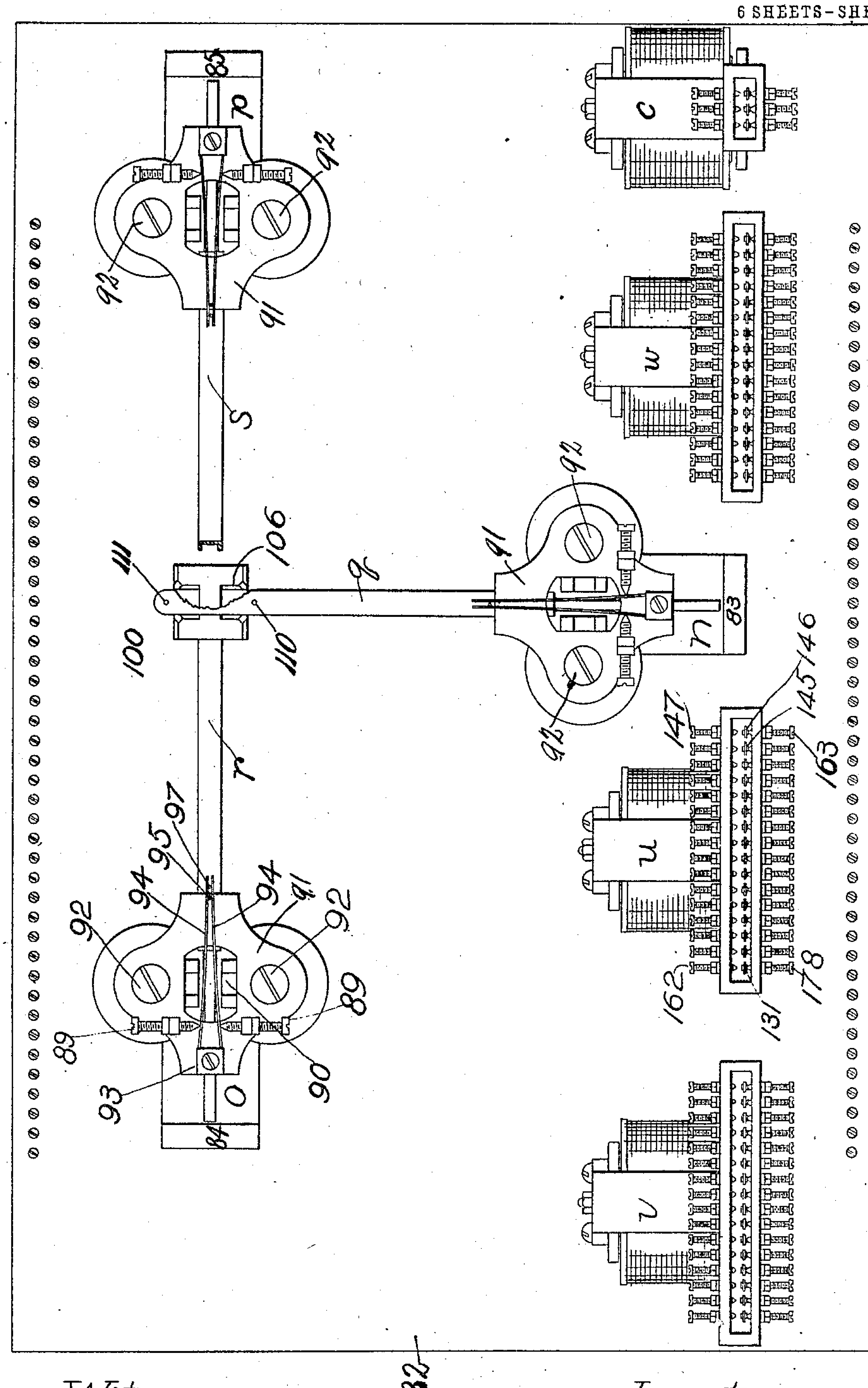

Fig. 1

Witnesses
Wm. C. Richardson.
H. M. Kelso.

Inventor
Albert D. Neal
per Richard P. Elliott
Attorney.

ANDREW B. GRAHAM CO., PHOTO-LITHOGRAPHERS, WASHINGTON, D.C.

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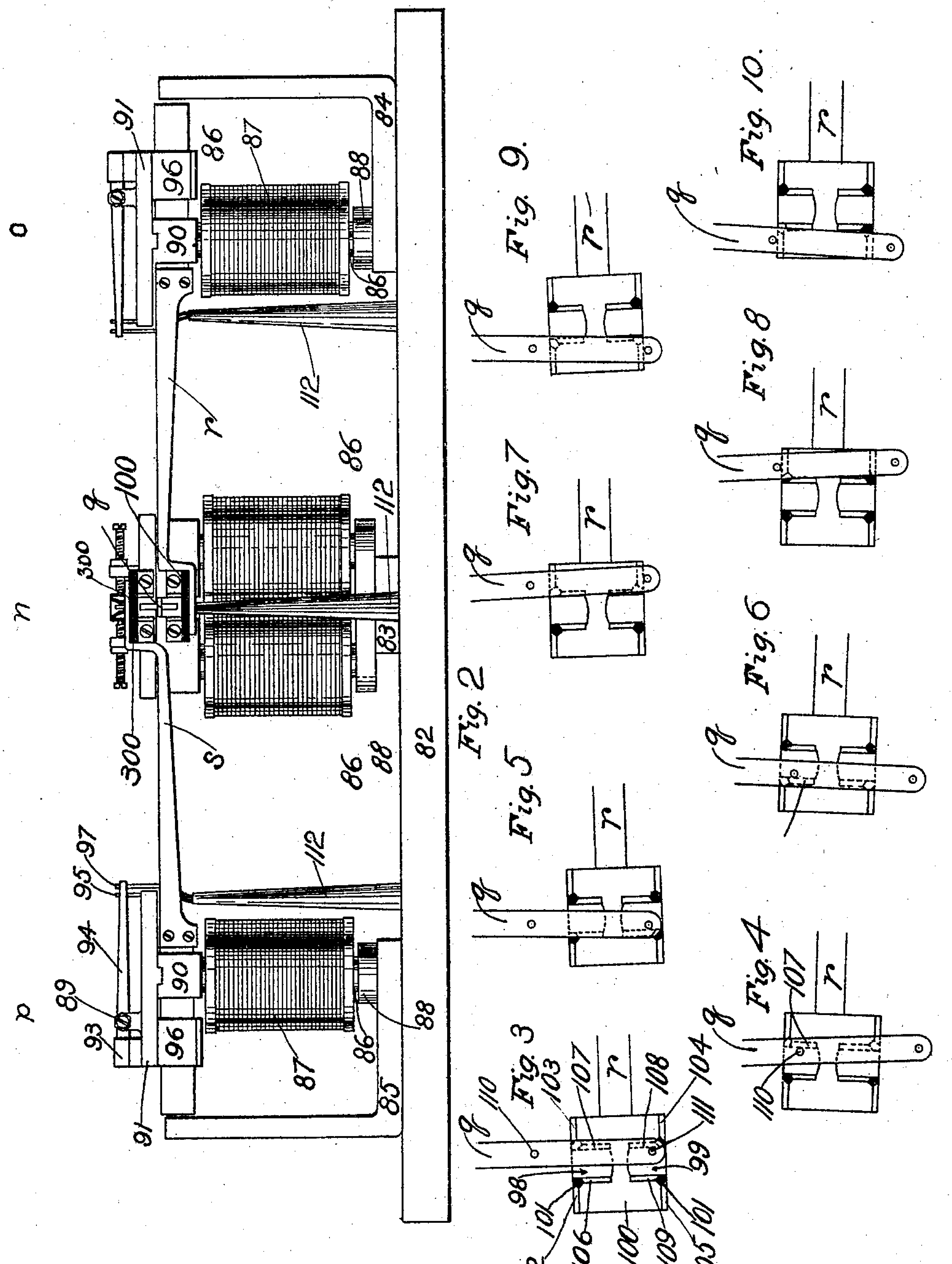
6 SHEETS—SHEET 2.



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Wm C. Richardson
H. M. Kelso.

Inventor
Albert D. Neal
per
Richard P. Elliott
Attorney

ANDREW B. GRAHAM CO., PHOTO-LITHOGRAPHERS, WASHINGTON, D. C.

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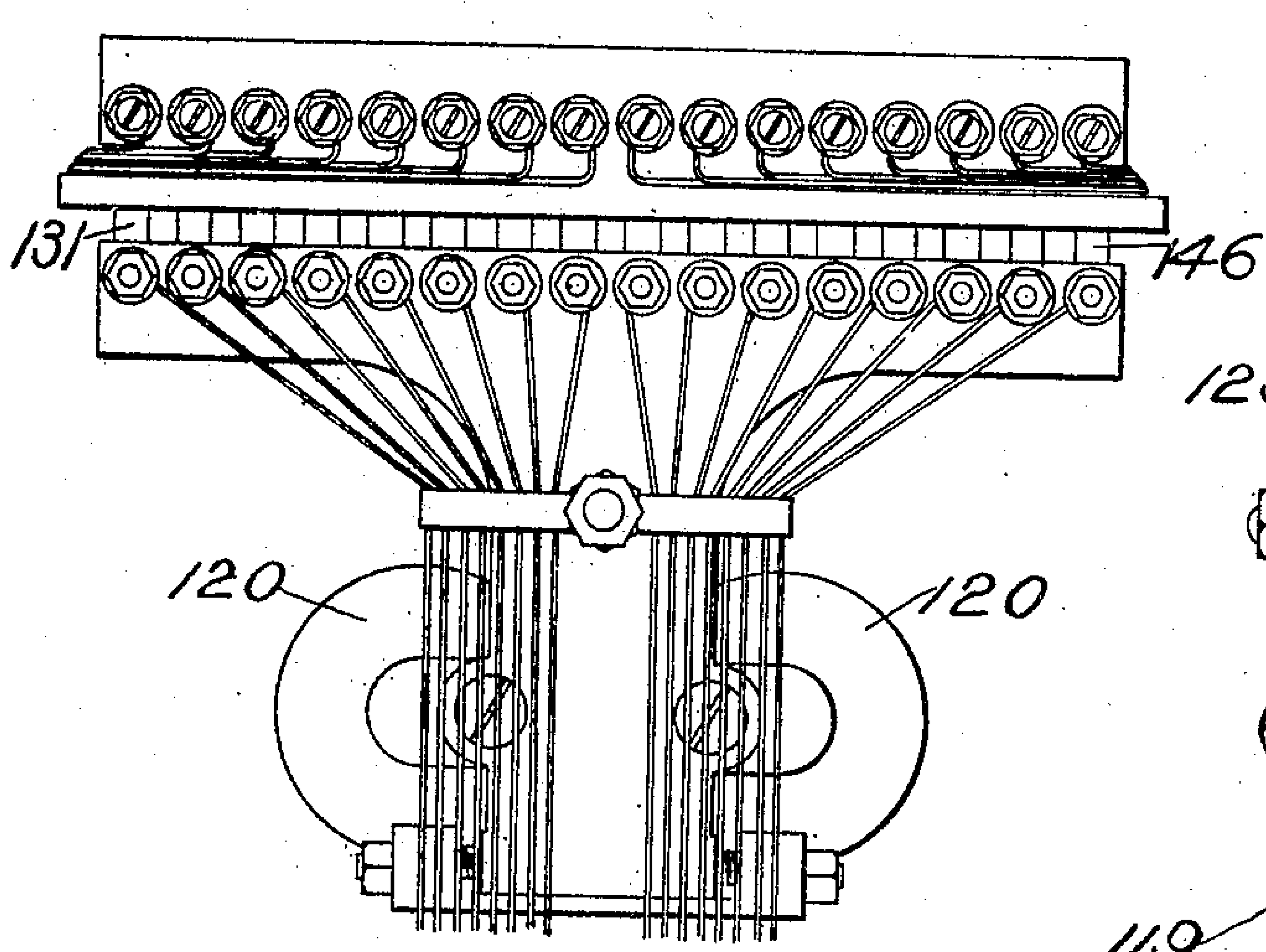

Fig. 12

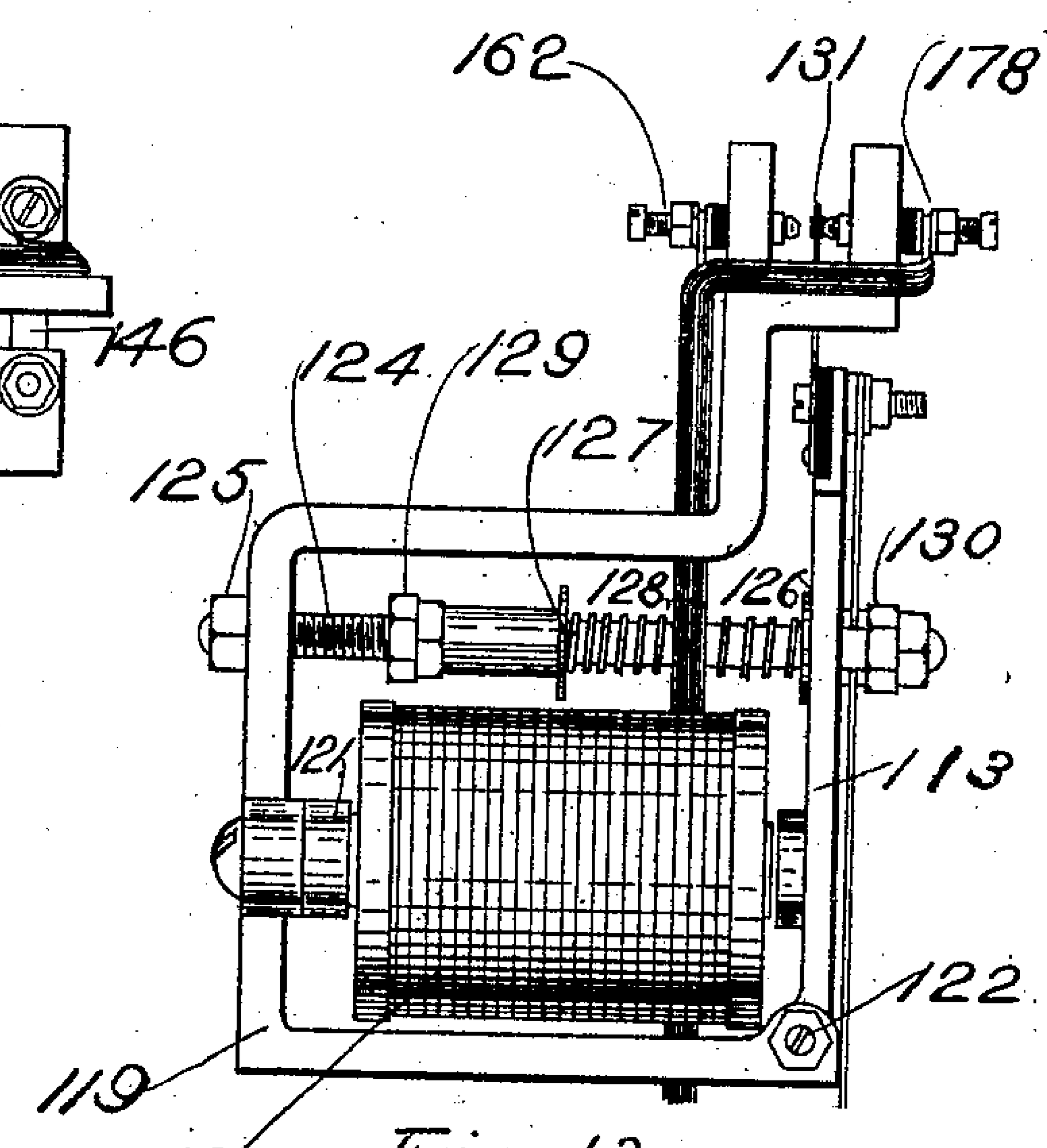

Fig. 13

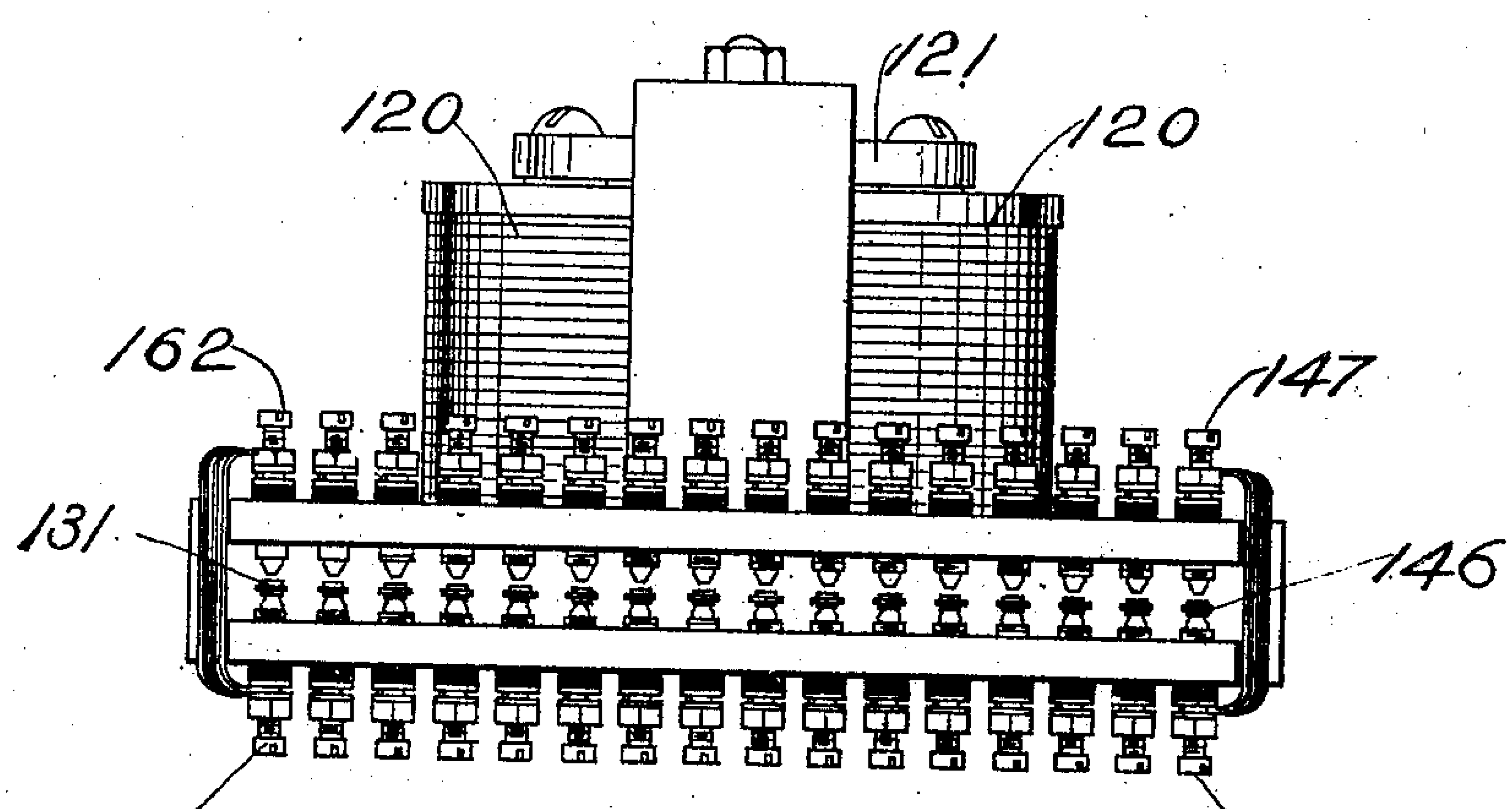

Fig. 11.

Witnesses

Wm C. Richardson.

H. M. Kelso.

Inventor

Albert D. Neal

per

Richard P. Elliott

Attorney

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A. D. NEAL.

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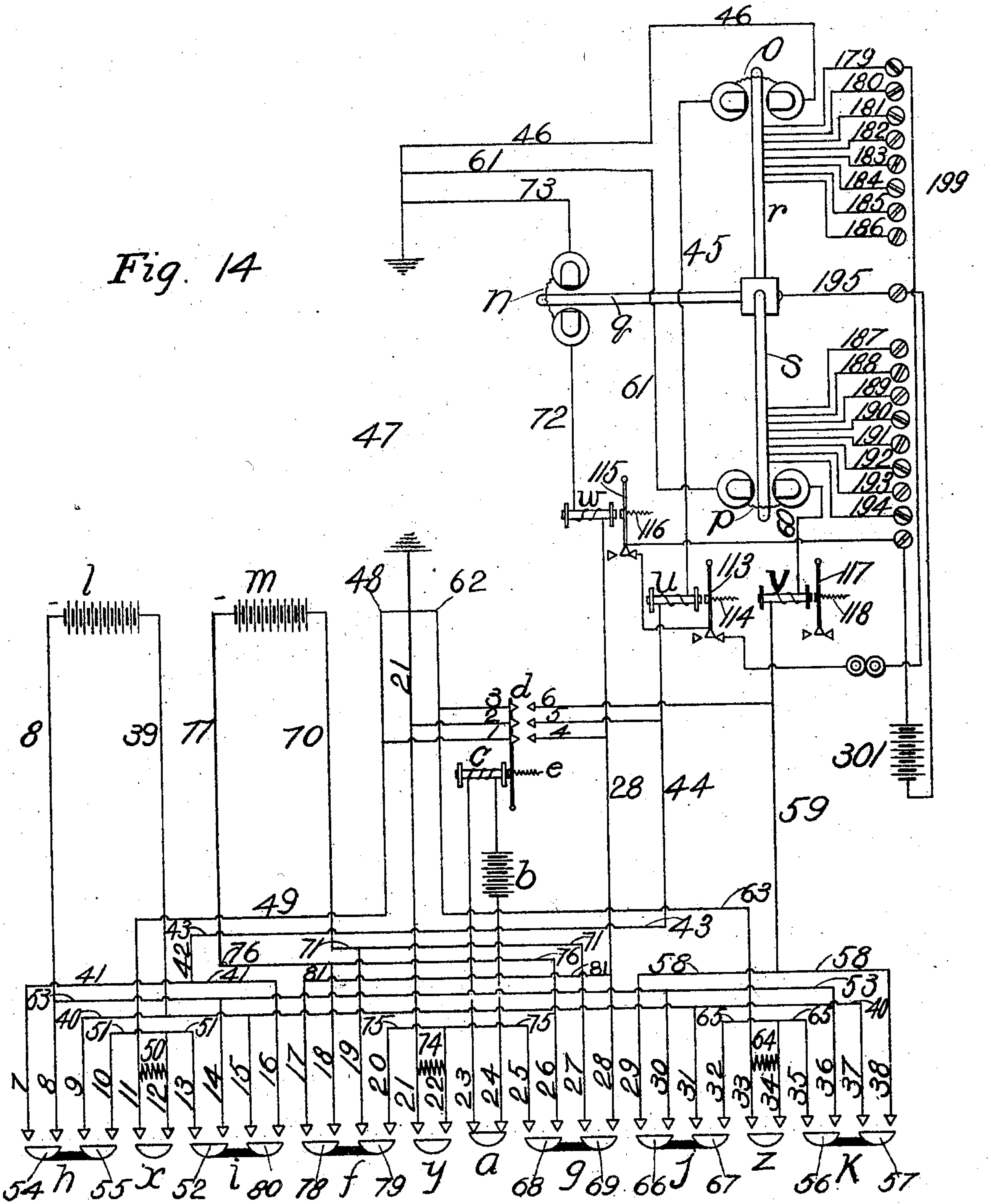
6 SHEETS—SHEET 4.

Fig. 14



WITNESSES:

Wm C. Richardson.

H. M. Kelso

INVENTOR.

Albert D Neal

BY

Richard P. Elliott

ATTORNEY.

No. 795,851. PATENTED AUG. 1, 1905.

A. D. NEAL.

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6 SHEETS—SHEET 5.

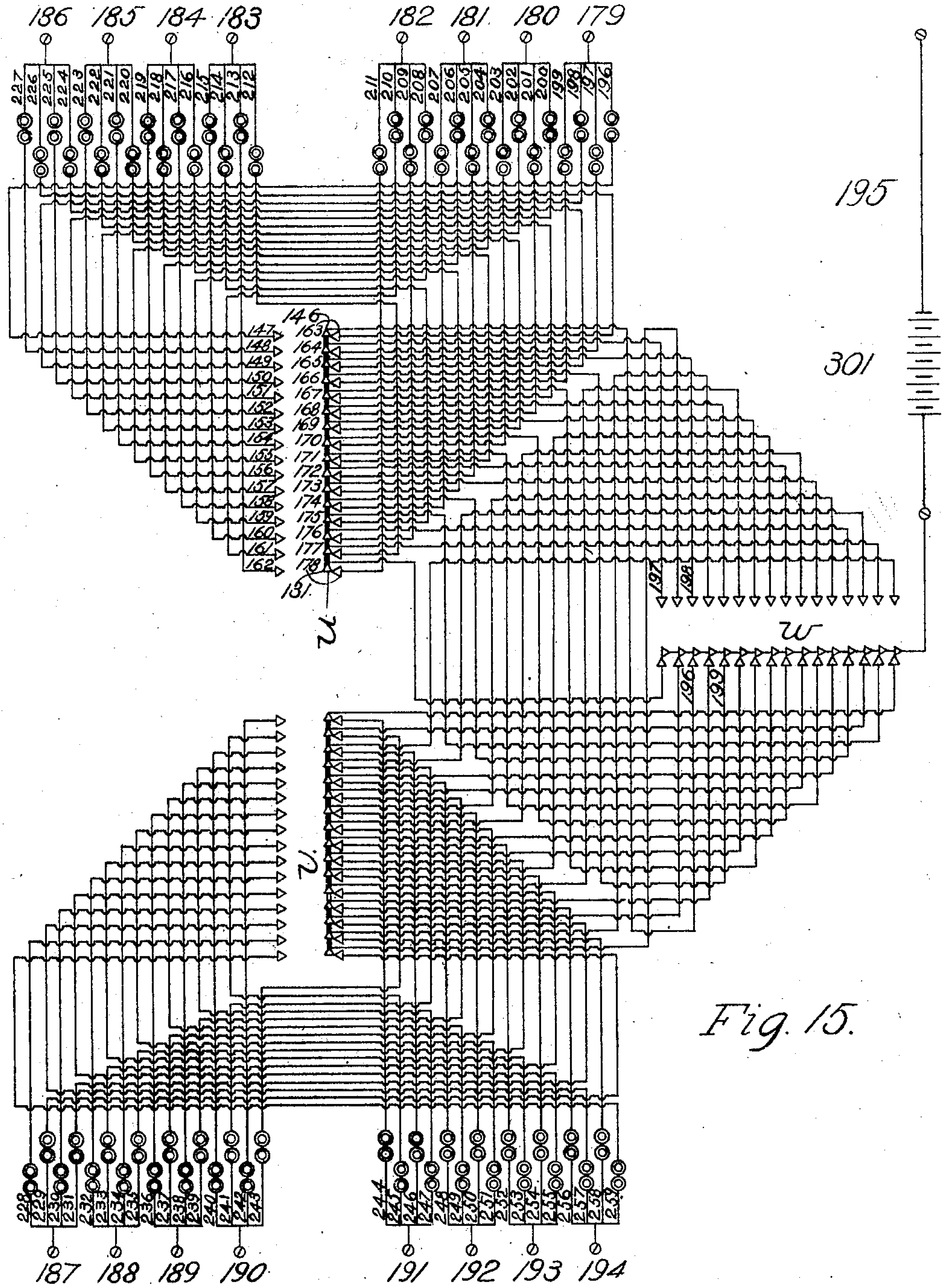

Fig. 15.

Witnesses
Wm C. Richardson.
H. M. Kelso.

Inventor
Albert D. Neal
per Richard P. Elliott
Attorney

ANDREW B. GRAHAM CO. PHOTO-LITHOGRAPHERS, WASHINGTON, D. C.

No. 795,851. PATENTED AUG. 1, 1905.

A. D. NEAL.

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6 SHEETS—SHEET 6.

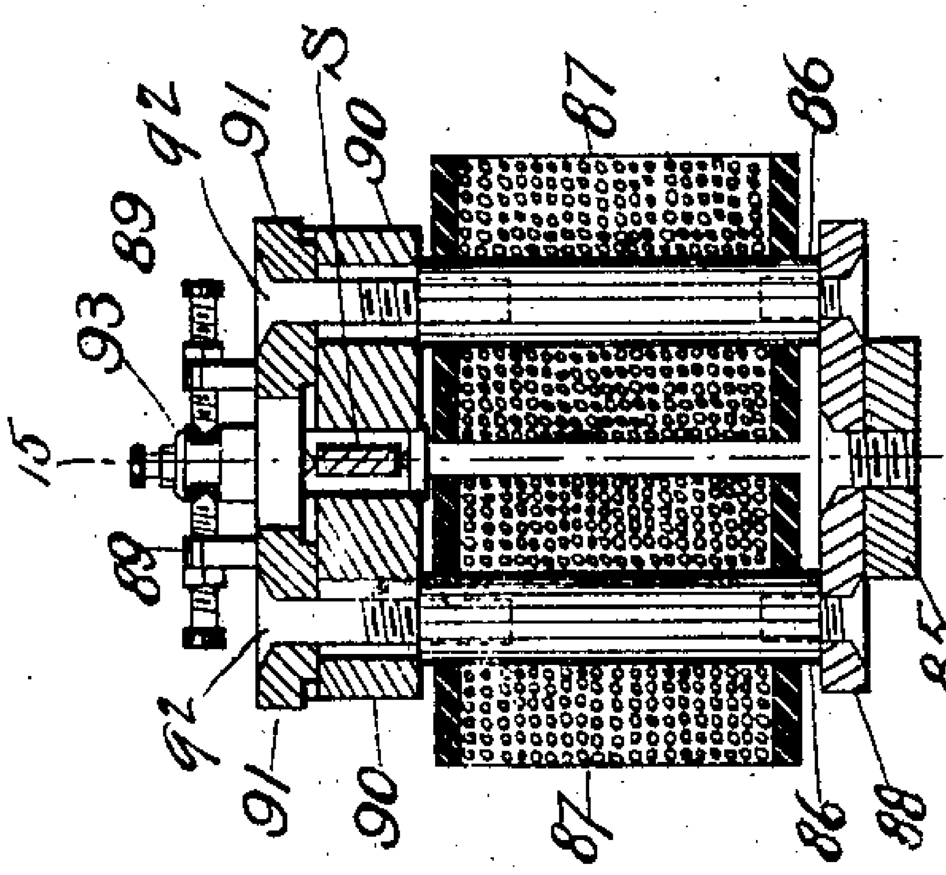

Fig. 17.

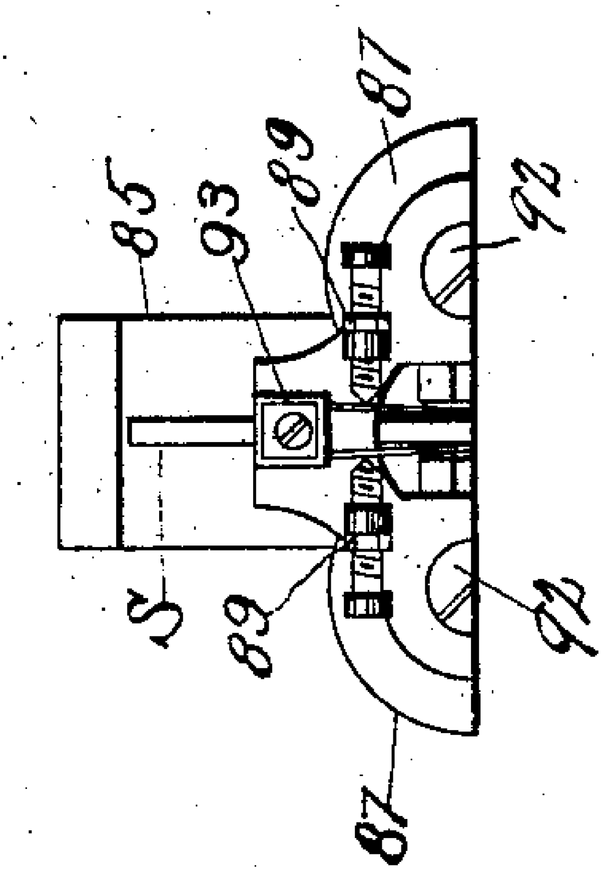

Fig. 19.

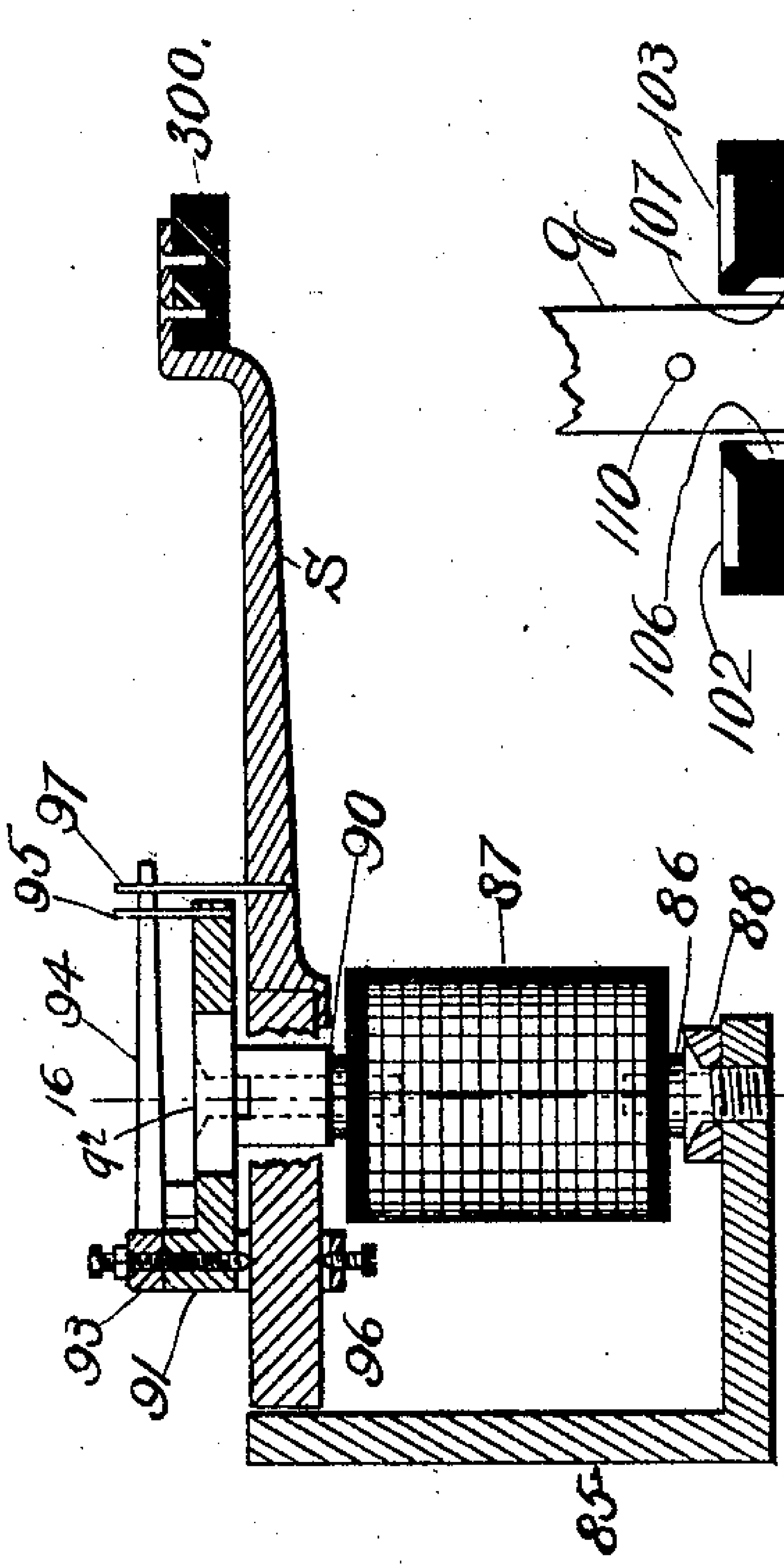

Fig. 16.

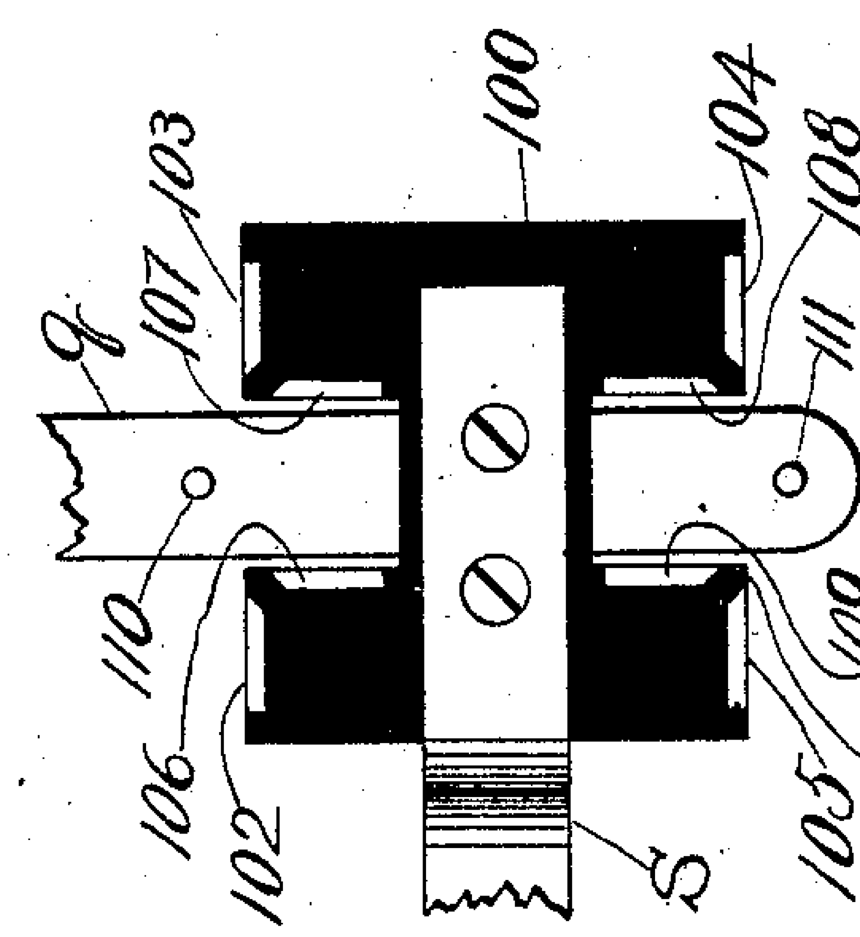

Fig. 20.

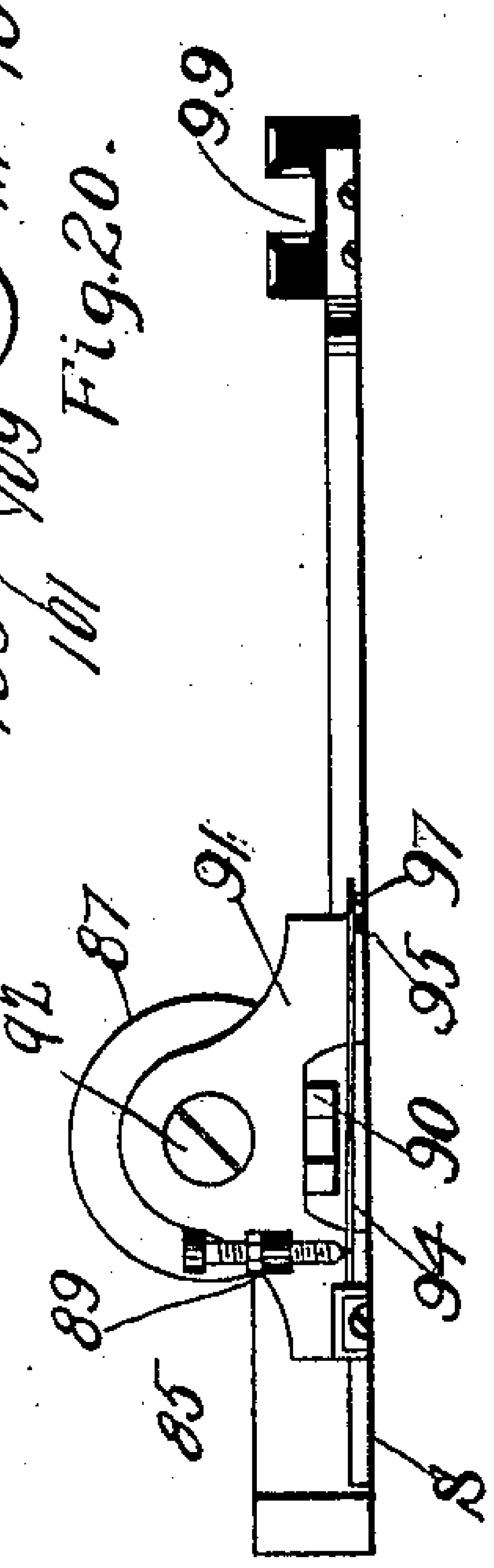

Fig. 18.

Witnesses

S. E. Walker.

H. M. Kelso.

Inventor

Albert D. Neal

by Richard P. Elliott

Attorney

UNITED STATES PATENT OFFICE.

ALBERT D. NEAL, OF SOUTH BOSTON, MASSACHUSETTS, ASSIGNOR TO SPENCER W. RICHARDSON AND RICHARD P. ELLIOTT, TRUSTEES.

SYSTEM FOR SELECTING ELECTRICAL CIRCUITS.

No. 795,851. Specification of Letters Patent. Patented Aug. 1, 1905.

Application filed October 18, 1901. Serial No. 79,122.

To all whom it may concern:

Be it known that I, Albert D. Neal, of South Boston, in the county of Suffolk and State of Massachusetts, have invented a new and useful Improvement in Systems for Selecting Electric Circuits, of which the following is a specification.

My invention relates to improvements in systems by which an operator is enabled to select any one of a large number of circuits with the object of doing work in the circuit selected.

One object of my invention is to provide a system by which the operator is enabled to select from a maximum number of circuits by the use of a minimum number of current strengths and line-wires.

Another object of my invention is to provide a system of the class described in which the smallest number of instruments and wires is used, and in accomplishing this object I attain simplicity and economy of construction.

My new system may be put to a variety of uses, among which may be mentioned the selecting of any one of a number of telephones on a line, the throwing into and out of operation any one of a number of motors, the cutting in and out of electric lamps, and the operation of type-writing and printing-telegraph instruments.

My new system embraces the use of relays of a new and improved type invented by me. By the use of pole-changing keys I am enabled to reverse the electrical connection between the terminals of a polarized relay and the poles of a battery, first joining one pole—say the positive pole—to one relay-terminal (and the negative pole to the other relay-terminal) and then reversing the connection so as to present the positive pole of the battery to the terminal with which the negative pole was previously connected and the negative pole to the terminal with which the positive pole had previously been connected. In other words, I reverse the direction of flow of the current. The mechanical construction of a set of two coöperating relays invented by me and now for the first time described is such that by operating the pole-changing keys controlling one relay before operating the pole-changing keys controlling the other relay any one of four circuits may be selected, and then by reversing the order (as regards time) of operation of said pole-changing keys any one of four other and different circuits may be selected. Hence by the use of a set of two coöperating polarized relays any one of eight circuits may be selected. Then by introducing another polarized relay identical in construction with one of the polarized relays forming one of the set of two just referred to and operating this new instrument in combination with the other of said set of two (said other relay differing in construction) I form a set of three polarized relays, two of which are identical in construction and by the operation of which separately in combination with the other (but never the three together) I am enabled to select any one of sixteen circuits. I then form in each circuit of said sixteen circuits a divided circuit of, say, four branches, and place the magnet-coils of a non-polarized relay in circuit with each of said polarized relays. Each of said non-polarized relays is provided with two sets of sixteen contact-screws. The armature of each of the said non-polarized relays is provided with sixteen contact-plates held against one set of contact-screws of the relay by a spring or other equivalent means when a weak current flows through the coils of its magnets and drawn out of contact therewith and against the other set of contact-screws by the passage of a strong current through said coils. From the contact-plates on the armatures of the two non-polarized relays, the magnet-coils of which are in circuit with the magnet-coils of the polarized relays of identical construction, extend wires which electrically connect said contact-plates with contact-screws on the non-polarized relay, the magnet-coils of which are in circuit with the magnet-coils of the other polarized relay, (the one which differs in construction from the other two of the set of three polarized relays.) The contact-plates on the armature of the latter non-polarized relay are joined together and electrically connected with the armature of the polarized relay, the magnet-coils of which are in circuit with the magnet-coils of said non-polarized relay. The contact-screws of each of the other non-polarized relays are connected electrically with the wires which form parts of the branch circuits before referred to. Two wires of each set of four wires which branch from the circuit leading from the armature of a polarized relays are connected each to a contact-screw of one set on the non-polarized relay, the magnet-coils of which are in circuit with the magnet-coils of said polarized relay, while the other two wires are connected to a contact-screw of the other set of the same non-polarized relay. Thus by reversing the direction of flow of current through the magnet-coils of the polarized relays, by varying the strength of said current, and by reversing the order in which the polarized relays are energized any one of sixty-four different circuits may by means of my new system be selected.

I do not claim in this application the specific construction of polarized relays employed in my selective system, since this forms the subject-matter of my application, Serial No. 96,636, filed March 4, 1902, and is therein fully illustrated and described.

Figure 1 is a plan view of the polarized relays. Fig. 2 is an elevation of the same. Figs. 3, 4, 5, 6, 7, 8, 9, and 10 are details showing the operation of said relays. Fig. 11 is a plan view of one of the non-polarized relays. Fig. 12 is an elevation of the same. Fig. 13 is a side elevation of the same. Fig. 14 is a diagrammatic view of the wiring of a part of my new system. Fig. 15 is a diagrammatic view of the wiring of the branch circuits in my new system. Fig. 16 is a longitudinal sectional elevation taken through relay *p*, Fig. 1, showing the method of mounting and securing together the different parts of the relay. Fig. 17 is a sectional elevation transversely through relay *p*, Fig. 1, on line 16 16, Fig. 16. Fig. 18 is a plan view of the sectional elevation, Fig. 16. Fig. 19 is a plan view of sectional elevation, Fig. 17. Fig. 20 is an enlarged view of the outer end of the armatures *s* and *q*, showing the parts enlarged.

In the drawings illustrating the principle of my invention and the best mode in which I have contemplated applying that principle, Fig. 14 is a diagrammatic view of the wiring of the part of my new system at what may be called the "home station," in which *a* represents a key of the home-station transmitter or keyboard, (see Fig. 14,) which is operated with each combination produced on said keyboard. The key *a* closes a circuit from the battery *b* through the magnet *c*, drawing the armature *d*, with its contacts 1, 2, and 3, away from the contacts 4, 5, and 6 against the tension of the spring *e*, by means of which spring said contacts 1, 2, and 3 are normally held against the contacts 4, 5, and 6, respectively. With the armature *d* in the position shown in Fig. 14 the system is in condition whereby electrical impulses may be sent from the home station both through the home relays *n*, *o*, and *p* and through corresponding relays at a distant station. When it is desired to operate the home instrument from a distant station, the armature *d* must be in its normal position with its contact-points 1, 2, and 3 against the contact-points 4, 5, and 6, respectively, so that impulses coming from the distant station over the line-wires 46, 61, and 73 will after passing through relays *o*, *p*, and *n*, respectively, return through contacts 2 5, 3 6, 1 4, wires 21, 62, and 48, respectively, and ground connection 47. By operating the key *a* my new system is put in a condition in which by the operation of the pole-changing keys *f*, *g*, *h*, *i*, *j*, and *k* I am enabled to select different circuits. The keys *f*, *g*, *h*, *i*, *j*, and *k* are what may be termed "pole-changing" keys, inasmuch as by the operation of said keys the terminals of the batteries *l* and *m* may be presented to the terminals of the polarized relays *n*, *o*, and *p*. To illustrate a particular case, in Fig. 14 the terminals of the battery *m* are presented to the terminals of the polarized relay *n*, and the terminals of the battery *l* may at will be presented either to the terminals of the polarized relay *o* or to the terminals of the polarized relay *p*, but not of both. In my improved system, as shown in the drawings, I shall first describe the operation of the instruments by the use of one strength of current—a weak current. However, in its preferred form shown in the drawings my new system contemplates the use of two strengths of current; but any number of strengths may be used without departing from the spirit of my invention, and by multiplying the number of strengths the number of circuits that may be selected may be increased indefinitely. The pole-changing keys *f* and *g* operate the polarized relay *n*. The pole-changing keys *h* and *i* operate the polarized relay *o*, while the pole-changing keys *j* and *k* operate the polarized relay *p*. The pole-changing key *i* produces by its operation what I term a "plus" effect upon the polarized relay *o*, causing its armature *r* to move, say, to the right, while the pole-changing key *h* by its operation produces upon the polarized relay *o* what I term a "minus" effect, causing its armature *r* to move to the left—*i. e.*, in a direction opposite to that in which its armature *r* was moved by the operation of the pole-changing key *h*. Similarly the operation of the pole-changing key *g* produces upon the polarized relay *n* a plus effect, while the operation of the pole-changing key *f* produces upon the said relay *n* a minus effect, and the operation of the pole-changing key *k* produces upon the polarized relay *p* a plus effect, while the operation of the pole-changing key *j* produces upon the polarized relay *p* a minus effect. For example, let us assume that the pole-changing key *i* has been operated, bringing it in contact with the ends of the wires 13, 14, 15, and 16. The current may now be traced as follows: Beginning at the positive pole of the battery *l* the current flows through the wires 39, 40, and 15, contact-plate 80 of the pole-changing key *i*, wires 16, 41, 42, 43, and 44, relay *u*, wire 45, the polarized relay *o*, wire 46, the ground-wire 47, the wires 48, 49, and 11, resistance 50, wires 12, 51, and 13, contact-plate 52 of the pole-changing key *i*, wires 14, 53, and 8 to the negative pole of the battery *l*, thus producing a plus effect upon the polarized relay *o*, causing its armature *r* to move to the right. When the pole-changing key *h* is operated, bringing its contact-plate 55 against the ends of wires 9 and 10, a circuit may be traced through the polarized relay *o* from the battery *l* as follows: The current flows from the positive pole of the battery *l* over the wires 39, 40, and 9, the contact-plate 55 of the pole-changing key *h*, wires 10, 51, and 12, resistance 50, wires 11, 49, and 48, ground-wire 47, wire 46, polarized relay *o*, wires 45, relay *u*, wires 44, 43, 42, 41, and 7, contact-plate 54 of the pole-changing key *h*, wire 8 to the negative pole of the battery *l*, thereby producing a minus effect on the polarized relay *o*, which throws its armature *r* to the left. When pole-changing key *k* is operated, bringing its contact-plate 56 against the ends of the wires 35 and 36 and its contact-plate 57 against the ends of the wires 37 and 38, a circuit may be traced through the polarized relay *p* from the battery *l* as follows: The current flows from the positive pole of the battery *l* over the wires 39, 40, and 37, contact-plate 57 of the pole-changing key *k*, wires 38, 58, and 59, through the relay *v*, wire 60, polarized relay *p*, wire 61, ground-wire 47, wires 62, 63, and 33, through resistance 64, wires 34, 65, and 35, contact-plate 56 of the pole-changing key *k*, wires 36, 53, and 8 to the negative pole of the battery *l*, thereby producing a plus effect upon the polarized relay *p*, which throws its armature *s* to the right. When the pole-changing key *j* is operated, bringing its contact-plate 66 against the ends of the wires 29 and 30 and its contact-plate 67 against the ends of the wires 31 and 32, a circuit may be traced through the polarized relay *p* from the battery *l* as follows: The current flows from the positive pole of said battery *l* over the wires 39, 40, and 31 to contact-plate 67 of the pole-changing key *j*, over wires 32, 65, and 34 through resistance 64, wire 33, 63, and 62 to the ground-wire 47, wire 61, through the polarized relay *p*, wire 60, relay *v*, wires 59, 58, and 29, contact-plate 66 of the pole-changing key *j*, wires 30, 53, and 8 to the negative pole of the battery *l*, thus producing a minus effect in the polarized relay *p* and throwing its armature *s* to the left. When the pole-changing key *g* is operated, bringing its contact-plate 68 against the ends of the wires 25 and 26 and its contact-plates 69 against the ends of the wires 27 and 28, a circuit may be traced through the polarized relay *n* from the battery *m* as follows: The current flows from the positive pole of the battery *m* over wires 70, 71, and 27, contact-plate 69 of the pole-changing key *g*, wire 28, relay *w*, wire 72, polarized relay *n*, wire 73, the ground-wire 47, wire 21, through resistance 74, wires 22, 75, and 25, contact-plates 68 of the pole-changing key *g*, wires 26, 76, and 77 to the negative pole of the battery *m*, thereby producing a plus effect in the polarized relay *n*, which throws its armature *q* to the right. When the pole-changing key *f* is operated, thereby bringing its contact-plate 78 against the ends of the wires 17 and 18 and its contact-plate 79 against the ends of the wires 19 and 20, a circuit may be traced through the polarized relay *n* from the battery *m* as follows: The current flows from the positive pole of the battery *m* over the wires 70, 71, and 19 to the contact-plate 79 of the pole-changing key *f*, wires 20, 75, and 22, through the resistance 74, wire 21, ground-wire 47, wire 73 through the polarized relay *n*, wire 72, relay *w*, wires 28, 81, and 17, contact-plate 78 of the pole-changing key *f*, wires 18, 76, and 77 to the negative pole of the battery *m*, thereby producing a minus effect upon the polarized relay *n*, which throws its armature to the left.

I shall now describe the details of the polarized relays *n*, *o*, and *p*. (Shown in detail in Figs. 1 and 2.) Upon the hard-rubber base 82 are mounted the permanent magnets 83, 84, and 85 of the polarized relays *n*, *o*, and *p*, respectively. A description of one of these polarized relays will suffice. The cores 86 of the coils 87 are joined by the yoke 88, which is mounted upon the permanent magnet of the relay and attached by screws in the usual manner. Upon the ends of the cores are adjustably secured by screws 92 the pole-pieces 90, above which is the frame 91, the screws extending through the frame 91 and the adjustable pole-pieces 90 into the cores 86, as shown in detail in Figs. 16 to 19, inclusive. At the rear end of the frame 91 upon its upper face is a block 93, which carries two flat springs 94, between which projects upwardly from the frame 91 a stop-pin 95. A pair of screws 89 serve to adjust the tension of the flat springs 94. The armature is pivotally mounted in the frame 91 between lugs 96, which project from its lower face at the rear end. Projecting upwardly from the armature of each of said polarized relays is a pin 97, which engages between the flat springs 94 in front of the stop-pin 95. In order to preserve lightness, and thereby quickness of action, the part of the armatures *q*, *r*, and *s* which carries the contacts and which projects beyond the pole-pieces of their respective relays may be made of aluminium. The armatures of the polarized relays *o* and *p* are similarly constructed near their free ends, while the free end of the armature of the polarized relay *n* differs therefrom in the following particulars: In the free end of the armature *q* are the contact-pins 110 and 111, whereas to the free ends of the armatures *s* and *r* I attach the hard-rubber blocks 300 and 100, said blocks being identical in construction. As shown in Fig. 2, the block 100 of the armature *r* is under the block 300 of the armature *s*, while the free end of the armature *q* moves between these two blocks. The opposing faces of the blocks 100 and 300 are each formed with two recesses 98 and 99, Figs. 3 to 10, inclusive. It will be necessary to describe only one of these blocks, since, as before stated, they are identical in construction. At the corners formed at the junction of the side faces of the block 100 (see Figs. 3 to 10) with the side walls of its recesses 98 and 99 are placed pieces of ivory insulation 101, which serve to separate and insulate from each other contact-plates 102, 103, 104, and 105, which are secured upon the side faces of the block 100, contact-plates 106 and 107, which are secured to the side walls of the recess 98, and contact-plates 108 and 109, which are secured to the side walls of the recess 99. Electrically connected with each of the said contact-plates, secured to the block 100, is a wire, which wires are gathered together and pass in a groove on the under face of the aluminium part of the armature *r*, and thence through the hard-rubber tube 112, mounted upon the base 82. (See Fig. 2.) Another set of eight wires is connected one to each of the contact-plates of the block 300, and these wires are similarly connected and led through a tube 112. The free end of the armature *q* of the polarized relay *n* is provided with contact-pins 110 and 111, which pass through the armature so as to project from its upper and lower faces. The contact-pins 110 and 111 are connected by a common wire 195. (See Figs. 14 and 15.)

The operation of the relays *n* and *o* is illustrated in detail in Figs. 3 to 10, inclusive. In Fig. 3 the lower right-hand contact-plate 108 is brought against the contact-pin 111, as follows: The polarized relay *o* is operated before the polarized relay *n*, so that the armature *r* moves before the armature *q*. By operating the pole-changing key *h*, as previously described, a minus effect is produced upon the polarized relay *o* and its armature *r* is thrown into the position shown in Fig. 3. Subsequently the pole-changing key *f* is operated, thereby producing a minus effect upon the polarized relay *n*, which throws its armature *q* into the position shown in Fig. 3. From this it will be seen that the contact-plate 108 is brought in contact with the pin 111, thereby selecting a circuit. In Fig. 4 the polarized relay *o* has been operated before the polarized relay *n* and its armature *r* has therefore been moved before the armature *q*. In this figure, however, the armature *r* has by operating the pole-changing key *i* been moved in a direction opposite to that shown in Fig. 3, and the armature *q* of the polarized relay *n* has been moved in the same direction, as shown in Fig. 3, by operating the same pole-changing key *f* as before. In this way the contact-plate 107 is brought against the contact-pin 110 and a circuit is thereby selected. Similarly, in Figs. 5 and 6 the armature *r* is caused to move first in Fig. 5 by a minus effect being produced upon the polarized relay *o* by the operation of the pole-changing key *h* and in Fig. 6 by a plus effect being produced upon the same relay by the operation of the pole-changing key *i*. In both said views, Figs. 5 and 6, the armature *q* is moved by producing a plus effect upon the polarized relay *n* by the operation of the pole-changing key *g*, as previously described. Hence it may be said that where a circuit is selected by means of the contact-plates 106, 107, 108, or 109, (which are upon the side walls of the recesses 98 and 99,) the polarized relay *o* is operated before the polarized relay *n*. In Figs. 7, 8, 9, and 10 the polarized relay *n* is operated before the polarized relay *o*, and in Fig. 7 the armature *q* of said polarized relay *n* is moved by a minus effect being produced by the operation of the pole-changing key *f*, while in Fig. 9 the same armature is moved in the opposite direction by a plus effect being produced by the operation of the pole-changing key *g*. In Figs. 7 and 9 the armature *r* is moved by the production of a minus effect by the operation of the pole-changing key *h*. In Fig. 8 the armature *q* is moved by the minus effect produced by the operation of the pole-changing key *f*, while in Fig. 10 the same armature is moved in an opposite direction by the plus effect produced by the operation of the pole-changing-key *g*. In Figs. 8 and 10 the armature *r* is moved in direction opposite to that shown in Figs. 7 and 9 by the production of a plus effect by the operation of the pole-changing key *i*.

What has just been stated with regard to the operation of the armature *r* applies equally well to the armature *s*. Hence by operating the pole-changing keys *j* and *k* instead of the pole-changing keys *h* and *i* the polarized relay *p* is energized, thereby throwing its armature *s* to the right or left, depending upon which pole-changing key (*j* or *k*) is actuated. The relay *n* is energized and its armature *q* is actuated by the operation of the pole-changing key *f* or *g*. By energizing the relays *n* and *p* the contact-plates on the block 300 and the contact-pins of the armature *q* are brought into electrical connection, so as to select eight more or different circuits. From what precedes it will be understood that the polarized relays *o* and *p* are never simultaneously energized, and the polarized relay *n* is energized before or after either the polarized relay *o* or the polarized relay *p*. Two polarized relays, and only two, must be energized to select a circuit, and the relay *n* must always be one of the two.

The preceding description is that of the operation of this system by a current too weak to move the armatures of the relays *u*, *v*, and *w*, Fig. 1. The relays *u*, *v*, and *w* differ from the relays *n*, *o*, and *p* in not being polarized relays. I shall now proceed to describe the operation of this system by a current of strength sufficient to move the armatures of said relays *u*, *v*, and *w*. The operation of the key *x*, Fig. 14, short-circuits the resistance 50, the key *y*, the resistance 74; the key *z*, the resistance 64. The key *x* is operated simultaneously with either the pole-changing key *h* or the pole-changing key *i* when it is desired to send a strong current through the polarized relay *o* and the relay *u*, the key *y* is operated simultaneously with either the pole-changing key *f* or the pole-changing key *g* when it is desired to send a strong current through the polarized relay *n* and the relay *w*, and the key *z* simultaneously with either the pole-changing key *j* or the pole-changing key *k* when it is desired to send a strong current through the polarized relay *p* and the relay *v*. The operation of the key *x* with either of the pole-changing keys *h* or *i* in no wise affects the direction of flow of the current through the polarized relay *o*, but by short-circuiting the resistance 50 simply serves to pass a current through the relay *u* of strength sufficient to attract the armature 113 against the tension of the spring 114, thereby breaking its electrical connection with one set of contacts and making electrical connection with another, as will be readily understood by reference to Figs. 1 and 14. Similarly, the operation of the key *y* with either of the pole-changing keys *f* or *g* in no wise affects the direction of flow of the current through the polarized relay *n*, but by cutting out the resistance 74 simply serves to pass a current through the relay *w* of a strength sufficient to attract its armature 115 against the tension of the spring 116, thereby breaking electrical connection with one set of contacts and making electrical connection with a new set, as did the operation of the key *x* in the case of the relay *u*. Similarly, the operation of the key *z* causes a current to be passed through the relay *v* of sufficient strength to attract its armature 117 against the tension of the spring 118, thereby breaking electrical connection with one set of contacts and making such connection with a new set.

I shall now proceed to describe the details of construction of the relays *u*, *v*, and *w*, shown in Figs. 11, 12, and 13. As shown in Fig. 1, these relays are mounted upon the hard-rubber base 82. A description of one of these relays will suffice for them all, since they are similar in construction. In the frame 119 is mounted a pair of magnets 120, joined by the usual yoke 121. Pivoted at 122 is the armature 113, through which passes the bolt 124, screwed into frame 119 and secured by the check-nut 125 outside of the frame 119. Sliding upon the bolt 124 is a washer 126 and the flanged sleeve 127, interposed between which is a spiral spring 128. The nut 129 serves to adjust the tension of the spring 128, while the nut 130 serves to limit the outward movement of the armature 113. Screwed to the armature 113 are sixteen spring contact-plates (numbered 131 to 146, inclusive) adapted to be moved against a set of contact-screws, sixteen in number and numbered in the drawings 163 to 178, inclusive, on one side and against another set of contact-screws, sixteen in number and numbered in the drawings 147 to 162, inclusive. This construction permits a constant tension to be placed upon the spring contact-plates, for the outward swing of the armature 113 is limited by the nut 130 and its inward swing by the cores of the magnets 120. Hence the swing of the armature is the same no matter what may be the tension placed upon the spring contact-plates, said tension being wholly determined by the adjustment of the contact-screws. Wires lead from the contact-screws and contact-plates, as shown in Figs. 12 and 13. This wiring is shown in a diagrammatic form in Fig. 15.

As previously stated in the detailed description of the relays *o* and *p*, the wires which lead from the contact-plates on the hard-rubber blocks 100 and 300 on the free end of the armatures *r* and *s* are gathered together and led through the tubes 112, the two sets of wires being kept separate as sets. This is shown in its mechanical construction in Fig. 2 and in diagrammatic sketch or form in Fig. 14. The wires which lead from the contact-plates of the armature *r* are numbered 179 to 186, inclusive, while the wires which lead from the armature *s* are numbered in said figure from 187 to 194, inclusive. These wires are again shown in diagrammatic sketch in Fig. 14. The single wire which connects the two contact-pins 110 and 111 on the armature *q* of the polarized relay *n* is numbered 195. As shown in Figs. 14 and 15, each of the wires connected to the contact-plates of the armature *r* lead to the junction-point of four wires, and each of these four wires is electrically joined to one of the contact-screws of the relay *u*. Similarly, each contact-plate on the block 300 of the armature *s* is electrically connected with a set of four wires, and each of these thirty-two wires (eight sets of four wires each) is electrically connected with one of tne contact-screws of the relay *v*. Thus the wire 179 leads from the contact-plate 108 of the block 100 (on the armature *r*) to the junction of the four wires 196, 197, 198, and 199; wire 180 leads from contact-plate 109 of the block 100 to the junction-point of wires 200, 201, 202, and 203; wire 181 from contact-plate 107 of the block 100 to the junction of wires 204, 205, 206, and 207; wire 182 from contact-plate 106 of the same block 100 to the junction of wires 208, 209, 210, and 211;

wire 183 from contact-plate 105 of the same block 100 to the junction of wires 212, 213, 214, and 215; wire 184 from contact-plate 104 of the block 100 to the junction of wires 216, 217, 218, and 219; wire 185 from the contact-plate 103 of the block 100 to the junction of wires 220, 221, 222, and 223; wire 186 from the contact-plate 102 of the block 100 to the junction of wires 224, 225, 226, and 227; wire 187 from the contact-plate 108 of the block 300 on the armature *s* to the junction of wires 228, 229, 230, and 231; wire 188 from the contact-plate 109 of the block 300 to the junction of wires 232, 233, 234, and 235; wire 189 from the contact-plate 107 of the block 300 to the junction of wires 236, 237, 238, and 239; wire 190 from the contact-plate 106 of the block 300 to the junction of wires 240, 241, 242, and 243; wire 191 from the contact-plate 105 of the block 300 to the junction of wires 244, 245, 246, and 247; wire 192 from the contact-plate 104 of the block 300 to the junction of wires 248, 249, 250, and 251; wire 193 from the contact-plate 103 of the block 300 to the junction of wires 252, 253, 254, and 255, and wire 194 from the contact-plate 102 of the block 300 to the junction of wires 256, 257, 258, and 259. Each of these sets of four wires is subdivided into two sets of two wires each. The wires of the sets which are electrically connected with the polarized relay *o* lead from their junction-points to the relay *u*, two wires of each set of four being connected each to a contact-screw on one side of the relay—that is, belonging to one of the two sets of sixteen contact-screws of said relay—while the other two wires of the set of four are connected each to a contact-screw on the opposite side of the same relay (that is, to contact-screws belonging to the other set of sixteen of said relay.) The wires of the sets of four which are electrically connected with the polarized relay *p* lead from the junction-points to the contact-screws of the relay *v*, while the other two wires (of the same set of four) are electrically connected each with a contact-screw on the opposite side of the said relay *v*. This will be readily understood by a reference to Fig. 15. Thus of the set of four wires connected with the wire 179 wires 196 and 198 lead each to one of the set of sixteen contact-screws upon the left of the relay *u* in Fig. 15, while wires 197 and 199 lead each to one of the set of sixteen contact-screws upon the right side of the same relay in said figure. The wires are therefore connected as follows: wire 196 with contact-screw 147 of the relay *u*, wire 197 with contact-screw 164 of the relay *u*, wire 198 with contact-screw 149 of the relay *u*, wire 199 with contact-screw 166 of the relay *u*, wire 200 with contact-screw 151 of the relay *u*, wire 201 with contact-screw 168 of the relay *u*, wire 202 with contact-screw 153 of the relay *u*, wire 203 with contact-screw 170 of the relay *u*, wire 204 with contact-screw 155 of the relay *u*, wire 205 with contact-screw 172 of the relay *u*, wire 206 with contact-screw 157 of the relay *u*, wire 207 with contact-screw 174 of the relay *u*, wire 208 with contact-screw 159 of the relay *u*, wire 209 with contact-screw 176 of the relay *u*, wire 210 with the contact-screw 161 of the relay *u*, wire 211 with the contact-screw 178 of the relay *u*, wire 212 with the contact-screw 177 of the relay *u*, wire 213 with the contact-screw 162 of the relay *u*, wire 214 with the contact-screw 175 of the relay *u*, wire 215 with the contact-screw 160 of the relay *u*, wire 216 with the contact-screw 173 of the relay *u*, wire 217 with the contact-screw 158 of the relay *u*, wire 218 with the contact-screw 171 of the relay *u*, wire 219 with the contact-screw 156 of the relay *u*, wire 220 with the contact-screw 169 of the relay *u*, wire 221 with the contact-screw 154 of the relay *u*, wire 222 with the contact-screw 167 of the relay *u*, wire 223 with the contact-screw 152 of the relay *u*, wire 224 with the contact-screw 165 of the relay *u*, wire 225 with contact-screw 150 of the relay *u*, wire 226 with contact-screw 163 of the relay *u*, and wire 227 with contact-screw 148 of the relay *u*. The following combinations are therefore obtainable: a strong current through relay *w* with a weak current through relay *u*, a strong current through relay *w* with a weak current through relay *v*, a weak current through relay *w* with a weak current through relay *u*, a weak current through relay *w* with a weak current through relay *v*, a strong current through relay *w* with a strong current through relay *u*, and a strong current through relay *w* with a strong current through relay *v*. By the use of these combinations I am enabled to select any one of sixty-four different circuits. Suppose by the energizing of the polarized relays *o* and *n* by the actuation of the pole-changing keys *h* and *f* the wire 179 has been selected, the contact-plate 108 of the block 100 of the armature *r* having been brought into electrical connection with the contact-pin 111 of the armature *q*, as previously described. The current which has energized the polarized relay *o*, and therefore the relay *u* in circuit with it, may have been either a weak or a strong current. The current which has energized the polarized relay *n*, and therefore the relay *w* in circuit with it, may have been either a weak or a strong current, and, as before stated, the strengths of the two currents are absolutely independent of each other. Which one of the four circuits joined to the wire 179 will be selected depends upon the strength of the currents which have energized the relays *u* and *w*. If a weak current has energized the relay *w* and a strong current the relay *u*, a condition produced by the actuation of the keys *x* in conjunction with the pole-changing key *h*, it will be seen from the following considerations and by reference to Fig. 15 that wire 196 will be selected. It is the left set of contact-screws of the relay *u* which is brought into electrical connection with contact-plates of the armature of said relay by the passage of a strong current through the coils of its magnets. Of the four wires 196, 197, 198, and 199 joined to the wire 179 only two (wires 196 and 198) are connected to contact-screws of said left set, and of these two wire 198 leads through the contact-plate of the relay *u* and its connected wire to the left set (in Fig. 15 the upper set) of contact-screws of the relay *w*, which set is brought into electrical connection, as before stated, only when a strong current energizes the relay *w*. Hence in the case supposed (that of a weak current energizing the relay *w*) the wire 198 cannot form part of the circuit. The wire 196 leads through the contact-plate of the relay *u* and its connected wire to the right-hand set (in Fig. 15 the lower set) of contact-screws of the relay *w*, and since the contact-plates of the armature of the relay *w* are by its spring 116 held in electrical connection with the lower or right-hand set of contact-screws during the passage of a weak current through said relay (the case supposed) the wire 196 will form a part of the circuit, through the contact-plates on the armature of the said relay *w*, to a pole of the battery 301. The wires which are joined to the wires 187, 188, 189, 190, 191, 192, 193, and 194 (which lead from the polarized relay *p*) are electrically connected with the contact-screws of the relay *v*, two wires of each set of four being secured each to a contact-screw on one side of said relay, while the other two wires of each set of four are secured each to a contact-screw on the other side of said relay. The wires which are electrically connected at one end to the spring contact-plates on the armatures 113 and 117 of the relays *u* and *v* are electrically connected at the other end to contact-screws of the relay *w*—that is, each contact-plate of the relays *u* and *v* is electrically connected with a contact-screw of the relay *w*. There are, as before stated, sixteen contact-plates in each of the relays *u* and *v*. Each of these sets of sixteen contact-plates is subdivided into two sets of eight. A set of eight contact-plates of the relay *u* and a set of eight contact-plates of the relay *v* are connected to the set of sixteen contact-screws on one side of the relay *w*, and the other two sets of eight contact-plates of the relays *u* and *v* are connected to the other set of sixteen contact-screws on the opposite side of the relay *w*. It will be understood from Figs. 14 and 15 that the contact-screws of the relays *u*, *v*, and *w* and the contact-plates of the relays *u* and *v* are insulated from one another; but the contact-plates of the relay *w* are electrically connected with one pole of the battery 301, the other pole of which is joined to the wire 195, which connects the contact-pins 110 and 111 of the armature *q* of the polarized relay *n*.

From the preceding description it will be understood that while the polarized relay *n* operates in combination with either the polarized relay *o* or the polarized relay *p* (but never with said relays *o* and *p* together, for the three relays *n*, *o*, and *p* never operate together) the armature 115 of the relay *w* may or may not be moved, depending upon whether the current which energizes the polarized relay *n* in circuit with said relay *w* is a weak or a strong current, and this is true irrespective of the strength of the current which energizes the polarized relay *o* and the relay *u* in circuit with said polarized relay *o* or the strength of the current which energizes the polarized relay *p* and the relay *v* in circuit with said polarized relay *p*. The contact plates of the armatures 113, 115, and 117 of the relays *u*, *w*, and *v* are by means of their respective spiral springs 114, 116, and 118 kept in contact with the set of sixteen contact-screws shown on the right of Fig. 15 and numbered 163 to 178, inclusive, when a weak current flows through the coils of the magnets 120 of said relays, and this is the position of these contact-plates, as shown in Figs. 11 and 13. When a strong current flows through the coils of the magnets 120, the contact-plates of the armatures 113, 115, and 117 of the relays *u*, *w*, and *v* are against the tension of the springs 114, 116, and 118 brought into electrical connection with the opposite set of contact-screws numbered 147 to 162, inclusive. In the diagrammatic plan of Fig. 15 the right-hand set of contact-screws is in the case of the relay *w* the lower set and the left-hand set the upper set of said Fig. 15. The relay *w* may be energized by a weak current, while the relay *u* (or the relay *v*) is energized by a strong current, and from this it follows that the contact-plates of armature 115 of the relay *w* may be in the position shown in Fig. 15 while the contact-plates of the armature 113 of the relay *u* (or 117 of the relay *v*) are brought into electrical connection with the set of sixteen contact-screws shown on the left of Fig. 15. (See Figs. 11 and 13.) The other pole of the battery is connected to said wire 196 through the wire 195, the contact-pin 111 of the armature *q*, the contact-plate 108 of the block 100 on the armature *r*, and the wire 179, connected to said contact-plate 108. Had a strong current energized the relay *w*, a condition produced by the operation of the key *y* in conjunction with the pole-changing key *f*, the wire 198 would have formed a part of the circuit from the battery 301, since in that case the contact-plates of the armature of the relay *w* would have been brought into electrical connection with the contact-screws of the upper (or left) set of the said relay. When the relay *u* is energized by a weak current and the relay *w* by a strong current, a condition which is produced by actuating the pole-changing key *h* and the pole-changing key *f* in conjunction with the key *y*, the wire 197 will form a part of the circuit from the pole of the battery 301, for it will be noted by reference to Fig. 15 that of the four wires 196, 197, 198, and 199, joined to the wire 179, only two wires—namely, 197 and 199—are electrically connected with the right-hand set of contact-screws of the relay *u*, and that the contact-plates of the armature of said relay *u* are electrically connected with said right-hand set when the current which energizes said relay *u* is a weak current. One of these wires—namely, 199—leads through a contact-plate of the armature of the relay *u* and its connected wire to one of the lower (or right-hand) set of contact-screws of the relay *w*, while the other wire—namely, 197—leads similarly through a contact-plate of the relay *u* and its connected wire to one of the upper (or left) set of contact-screws of the relay *w*; but as the relay *w* is in this case energized by a strong current the armature of the said relay *w* is in electrical connection with the upper (or left) set of contact-screws of said relay. From this it follows that the wire 197 will form a part of the circuit from the battery 301. When both the relay *u* and the relay *w* are energized by weak currents, a condition which is produced by actuating the pole-changing keys *h* and *f*, (and omitting to actuate the keys *x* and *y*) the wire 199 will form a part of the circuit from the battery 301. This is the circuit shown in Fig. 14 and may be traced in Fig. 15, which shows the contact-plates of the armatures in the position due to a passage of a weak current through the magnets of the relays. In the same way it may be shown that any one of the wires 200, 204, 208, 213, 217, 221, and 225 may be selected when the relay *w* is energized by a weak current and the relay *u* by a strong current, and which one of the aforesaid wires will, in fact, be selected depends, first, upon whether the pole-changing key *h* or the pole-changing key *i* is operated to energize the polarized relay *o*; second, upon whether the pole-changing key *f* or the pole-changing key *g* is operated to energize the polarized relay *n*, and, third, upon whether the polarized relay *n* or the polarized relay *o* is energized first, for upon the three conditions just mentioned depends, as previously described, which one of the contact-plates on the block 100, and therefore which one of the wires 180, 181, 182, 183, 184, 185, and 186, is selected. Any one of the wires 201, 205, 209, 212, 216, 220, and 224 may be selected when the relay *w* is energized by a strong current and the relay *u* by a weak current, and which one of these wires will be selected depends, as before, upon the above three conditions, which determine which of the wires 180, 181, 182, 183, 184, 185, and 186 is selected. Any one of the wires 202, 206, 210, 215, 219, 223, and 227 may be selected in case the relay *w* is energized by a strong current and the relay *u* also by a strong current, and wires 203, 207, 211, 214, 218, 222, and 226 when both of said relays are energized by a weak current. Thus any one of thirty-two circuits may be selected by the operation of the polarized relays *n* and *o* and the relays *w* and *u* and thirty-two circuits by the operation of the polarized relays *n* and *p* and the relays *w* and *v*, making in all sixty-four circuits. From this it follows that my invention comprehends the use of the polarized relay *n* with one coacting polarized relay *o* in combination with relays *w* and *u* to form a complete and operative system. Such a system would be operated on a less number of main-line wires than three.

I do not desire to be understood as limiting my invention to the particular devices and arrangements herein described, for they may be modified and changed without departure from the spirit of my invention, which I claim in the broadest legally-permissible manner.

What I claim is—

1. In a selective system, a source of electrical energy; a plurality of main-line circuits; a plurality of coacting polarized relays, one in each main-line circuit; a plurality of contacts on the armatures of said relays; means for reversing the direction of current through said polarized relays; and a plurality of local circuits attached to the contacts in the armatures of said polarized relays, any one of which local circuits may be closed at will by energizing said polarized relays.

2. In a selecting system, a plurality of main-line circuits, a source of electrical energy; a plurality of polarized relays, one in each main-line circuit; means for reversing the direction of current in said main-line circuits; contacts on the armatures of said polarized relays insulated from each other; said armatures; local circuits electrically connected with said contacts, one of which may be closed by the engagement of any two of said contacts.

3. In a system of the class described, a plurality of main-line circuits; a plurality of polarized relays, one in each main-line circuit; an armature for each polarized relay; a plurality of contacts on the armatures; means for bringing any one of the contacts on one armature in touch with any one of the contacts on the other of said armatures at will; and local circuits closed by the engagement of a pair of said contacts.

4. In a system of the class described, a plurality of main-line circuits; a source of electrical energy therefor; a plurality of polarized relays, one in each main-line circuit, having a plurality of contacts on their armatures; said armatures; means for energizing said polarized relays in succession to bring a desired pair of said contacts into engagement.

5. In a system of the class described, a source of electrical energy, a plurality of main-line circuits; a pair of relays in each of said circuits, one of said relays being adjustable to operate only by the passage of a given strength of current, while the other relay is operated by the passage of a current of different strength; means for varying the strength of current in said main-line circuit; local circuits closed by the engagement of contacts on the armatures of coacting relays, one in each main-line circuit; said armatures; circuits branching from said local circuits; and said branch circuits being closed through the armature of said adjustable relay.

6. In a selective system, a pair of polarized relays, the armature of one of which is provided with a plurality of contact-plates, and the armature of the other of which has contacts which coact to make electrical connection between itself and any one of said first-named contact-plates; said armatures mounted to swing; magnet-coils of said polarized relays in circuit with a source of electrical energy; said source of electrical energy; and means for energizing said magnets in succession and independently.

7. In a selective system for electrical circuits, main-line circuits; a source of electrical energy for each; two or more polarized relays, one in each of said main-line circuits; a plurality of contacts on the armatures thereof; said armatures; means for reversing the current in said main-line circuits to select and engage a pair of contacts, one on each of said polarized relays.

8. In a selective system of the class described, main-line circuits; a source of electrical energy; polarized relays, one in each of said main-line circuits actuated by different strengths of current flowing in said main-line circuits; contact plates and pins secured to the armatures of said polarized relays, said contact-plates being insulated from each other; said armatures; switch-magnets having their magnets in circuit in the main-line circuits and adjustable to be actuated by given current strengths; and means for closing the main-line circuits, varying the strength of electrical current therein, and changing the direction of current-flow.

9. In a selective system, a plurality of polarized relays; armatures for said polarized relays, said polarized relays arranged with the armatures at right angles to each other; a plurality of contacts on the ends of said armatures, the contacts on one of said armatures arranged to engage the contacts on the other; means for causing the armatures of said polarized relays to oscillate to the right or left from a normal central position; means for causing one of said armatures to oscillate before the other as desired, in order that any one of the contacts on one of said armatures may be brought into engagement with any one of the contacts on the other of said armatures.

10. In a circuit-selecting system of the class described, a source of electrical energy main-line circuits having a plurality of polarized relays in circuit therein; a plurality of contacts on the ends of the armatures of said relays each insulated from the other; said armatures; means for closing an electrical circuit through any pair of said contacts one on each of said armatures; local circuits attached to said contacts; branch circuits branching from said local circuits; switches connected in the main-line circuits to the armatures and contact-screws of which the branch circuits are attached.

11. In a system of the class described, main-line circuits; a source of electrical energy and polarized relays in said main-line circuits, of automatic switches, the magnet-coils of which are in said main-line circuits; said magnet-coils; armatures for said automatic switches; means for varying the current in said main-line circuit to actuate said armatures; local lines selected and controlled by said polarized relays; branch lines extending from said local lines to contacts on one of said automatic switches; means for electrically connecting the armature of said automatic switch with contacts on the other automatic switch; an armature for said other automatic switch; and a source of electrical energy in circuit with the armature of said other automatic switch.

12. In a system of the class described, main-line circuits; a source of electrical energy therein; a pair of polarized relays, the magnet-coils of which form part of said main-line circuits; said magnet-coils; armatures for said polarized relays, said armatures coacting to select and control local lines; said local lines; a pair of coacting automatic switches, the magnet-coils of which are in said main-line circuits; said magnet-coils; spring-controlled armatures for said automatic switches; means for varying the current in said main-line circuit to actuate said armatures; branch lines extending from said local lines to contacts on one of said automatic switches; means for electrically connecting the armature of said automatic switch with contacts on the other coacting switch; an armature for said other coacting switch; and a source of electrical energy in circuit with the armature of said other automatic switch.

13. In a selective system, main-line circuits; a source of electrical energy for each; a polarized relay in each of said main-line circuits; means whereby contacts on the armatures of said polarized relays will engage and select a given local circuit; branch circuits of said local circuits; and means in said main-line circuits coöperating with the polarized relays to select any one of said branch circuits.

14. In a selective system, main-line circuits; a source of electrical energy; a plurality of re-

lays, one in each of said main-line circuits; armatures for said relays, having a plurality of contacts thereon, arranged so that one of the contacts on one of said armatures may engage any one of the contacts on the other of said armatures; local circuits terminating in said contacts; means whereby any one of said local circuits may be selected by varying the sequence of the impulses over each of said main-line circuits; and means whereby any one of the branch circuits of said local circuits may be selected by the varying of the sequence of the impulses over each of said main-line circuits.

15. In a selective system, main-line circuits; local circuits; a polarized relay in each of said main-line circuits; armatures for said relays; a plurality of contacts on said armatures, said contacts being so arranged that a pair, one on each of said polarized relays, may be selected and engaged to select one of said local circuits by varying the sequence of single impulses over two of said main-line circuits.

16. In a selective system, main-line circuits; a source of electrical energy for each; polarized and non-polarized relays in each of said main-line circuits; means whereby said polarized relays will coact to bring into engagement a pair of contacts, one on the armature of each; said armatures; said contacts; means whereby the sequence of the impulses over the main-line circuits may be varied; and means whereby the strength of the impulses over the main-line circuits may be varied to select any one of a plurality of local circuits and any one of a plurality of branch circuits of said local circuits.

17. In a selective system, coöperating main-line circuits; local circuits; a pair of polarized relays, one in each of two of said main-line circuits; armatures for said relays; contact-points on said armatures, so arranged that the engagement of the contact-points of one armature with the contact-points of the other may be varied by reversing the direction of current through either of said main-line circuits, whereby a plurality of local circuits may be selected.

18. In a selective system, coöperating main-line circuits; local circuits; a pair of polarized relays, one in each of two of said main-line circuits; armatures for said relays; contact-points on said armatures, so arranged that the engagement of the contact-points of one armature with the contact-points of the other may be varied by reversing the sequence of the impulses through said main-line circuits, whereby a plurality of local circuits may be selected.

19. In a selective system comprising three main-line circuits, a polarized relay in each of said main-line circuits; a source of electrical energy for same; armatures on said polarized relays; a plurality of contacts on the ends of each armature, said contacts being insulated from each other; said armatures being so arranged that upon energizing two of said main-line circuits the contacts on two of the armatures will be brought into engagement by single characteristic impulses sent over two of said main-line circuits.

20. In a selective system, main-line circuits; local circuits; a common relay in one of said main-line circuits; an armature for said relay; contact-points on said armature; complemental relays in each of the other of said main-line circuits; armatures for said relays; contact-points on said armatures, so arranged as to coact with the contact-points on the armatures of said common relay to select one of said local circuits upon the passage of a single electrical impulse over two of each of their respective main-line circuits.

21. In a selective system, main-line circuits; local circuits; means in one of said main-line circuits adapted to engage with means in any of the other main-line circuits whereby the selection of local circuits may be varied by varying the direction of a single impulse through each of said main-line circuits.

22. In a selective system, main-line circuits; local circuits; relays in each of a plurality of said main-line circuits; armatures for said relays; insulated contact-points on said armatures; a relay in another of said main-line circuits; an armature for said relay; contact-points on said armature adapted to engage the contact-points on the armatures of any of the first-named relays, and so arranged that such engagement may be varied by varying the direction of the current through either of the relays excited, whereby a plurality of local circuits may be selected.

23. In a selective system, main-line circuits; local circuits; branch circuits of said local circuits; means in each of said main-line circuits coacting to select one of said local circuits by their engagement; and means also in each of said main-line circuits to simultaneously select one of said branch circuits, said last-named means being so constructed that the selection of branch circuits may be varied by varying the strength of current passing through said means.

24. In a selective system, coöperating main-line circuits; local circuits; branch circuits of said local circuits; a plurality of relays in each of said main-line circuits; armatures for said relays; a plurality of contact-points on said armatures, the contact-points on one of said armatures adapted to engage with the contact-points on the other; means whereby the selection of local circuits may be varied by varying the sequence of the impulses over a plurality of the main-line circuits; and means whereby the selection of branch circuits may be varied by varying the strength of said impulses.

25. In a selective system, main-line circuits; local circuits; branch circuits of said local cir-

cuits; a pair of relays, one in each of two main-line circuits; armatures for said relays; contact-points on said armatures the contact-points on one armature adapted to engage with the contact-points on the other armature, and so arranged that the selection of local circuits may be varied by varying the selection of single impulses over each of said main-line circuits; and means for varying the selection of branch circuits.

26. In a selective system, coöperating main-line circuits; local circuits; branch circuits of said local circuits; a pair of polarized relays, one in each of two of said main-line circuits; armatures for said relays; contact-points on said armatures, so arranged that the engagement of the contact-points of one armature with single contact-points of the other may be varied by reversing the direction of current through either of said main-line circuits, whereby a plurality of local circuits may be selected; and means whereby a plurality of branch circuits may be selected by varying the strength of said impulses.

27. In a selective system, coöperating main-line circuits; local circuits; branch circuits of said local circuits; a pair of polarized relays, one in each of two main-line circuits; armatures for said relays; contact-points on said armatures, so arranged that the engagement of the contact-points of one armature with the contact-points of the other may be varied by reversing the sequence of the impulses through said main-line circuits, whereby a plurality of local circuits may be selected; and means whereby a plurality of branch circuits may be selected by varying the strength of said impulses.

28. In a selective system, main-line circuits; local circuits; branch circuits of said local circuits; selecting means in one of said main-line circuits; complemental means in each of the other of said main-line circuits, so arranged that the means in the first-named main-line circuit will engage with the complemental means in any of the other main-line circuits to select any one of said local circuits by single electrical impulses over each of said main-line circuits; and means to select a corresponding branch circuit by varying the strength of said impulses.

29. In a selective system, main-line circuits; local circuits; branch circuits of said local circuits; a common relay in one of said main-line circuits; an armature for said relay; contact-points on said armature; complemental relays in each of the other of said main-line circuits; armatures for said relays; contact-points on said armatures so arranged as to coact with the contact-points on the armatures of said common relay to select one of said local circuits upon the passage of a single electrical impulse over each their respective main-line circuits; and means to select a corresponding branch circuit.

30. In a selective system, main-line circuits; local circuits; branch circuits of said local circuits; means in one of said main-line circuits arranged to contact with means in any of the other main-line circuits, whereby the selection of local circuits may be varied by varying the direction of a single impulse through each of said main-line circuits; and means for varying the selection of branch circuits by varying the strength of said impulses.

ALBERT D. NEAL.

Witnesses:
RICHARD P. ELLIOTT,
H. M. KELSO.