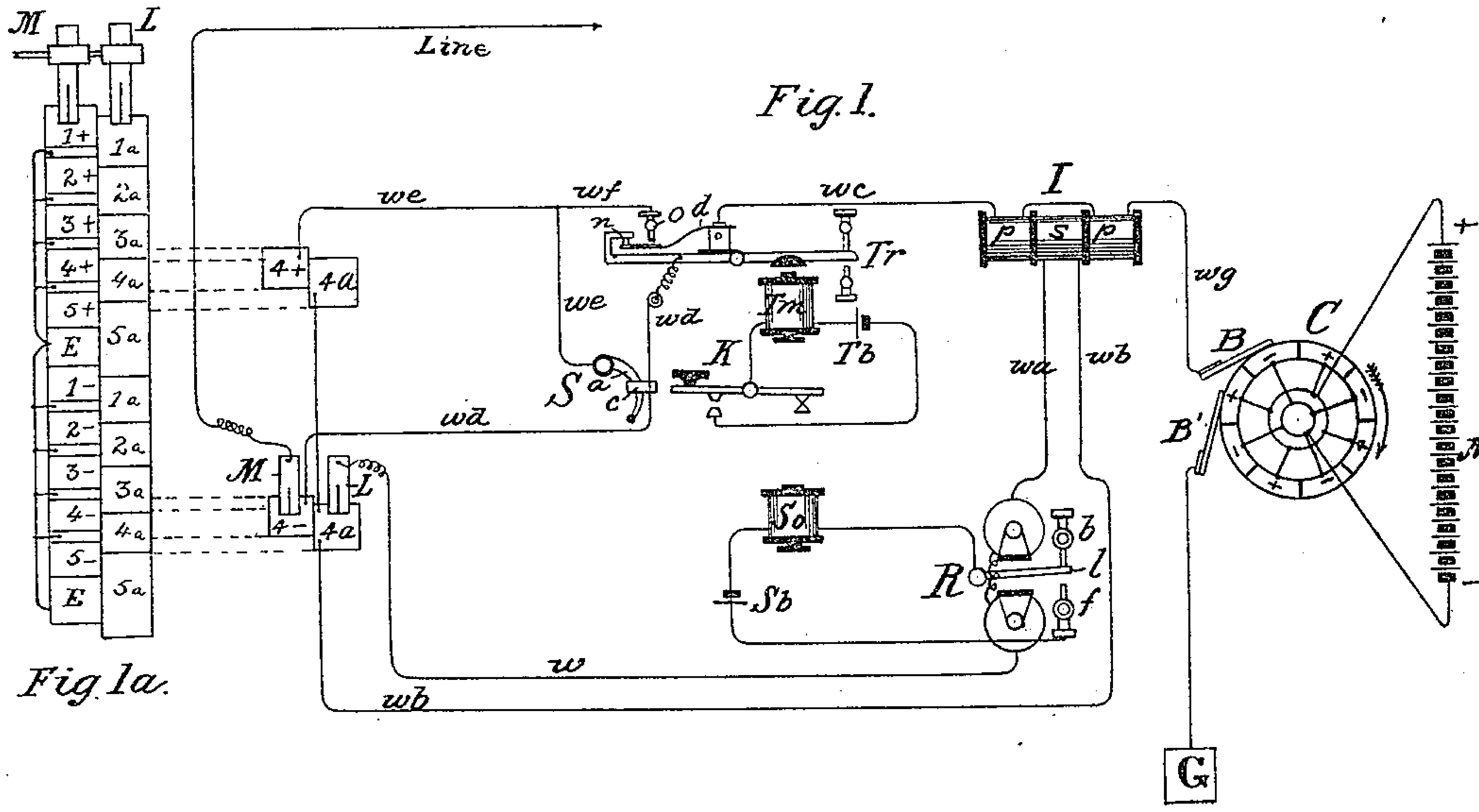
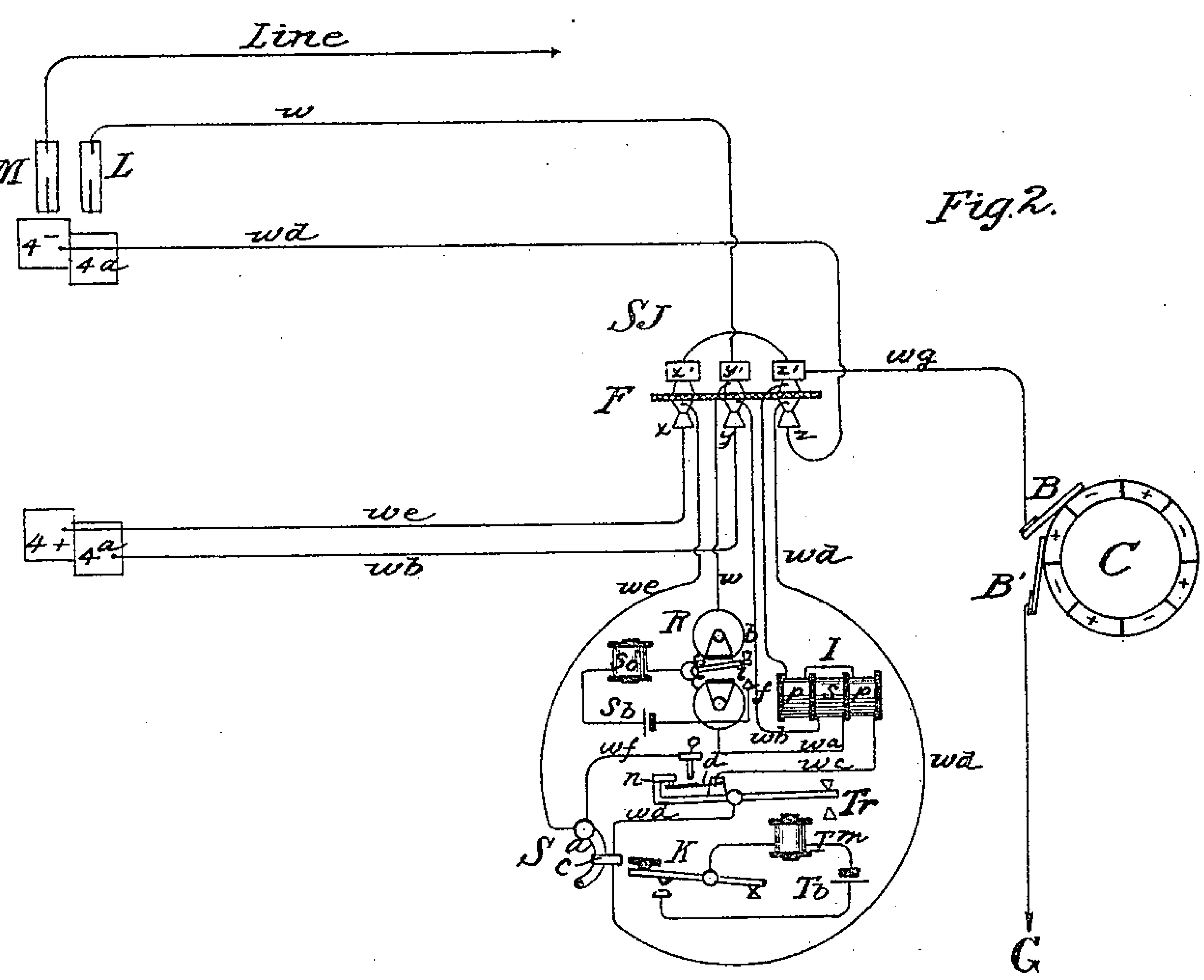
(No Model.) 4 Sheets—Sheet 1.

D. H. KEELEY.

MULTIPLEX TELEGRAPHY.

No. 440,165. Patented Nov. 11, 1890.





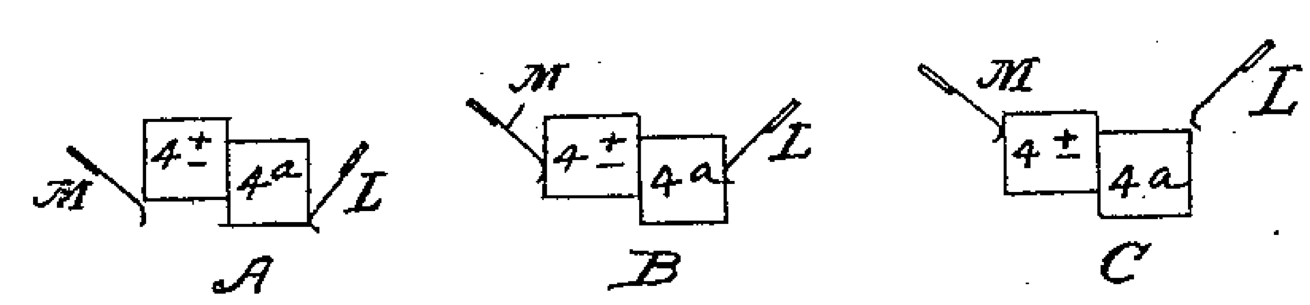


Fig. 3.

WITNESSES:

Frank A. Ober

Wm A. Rosenbaum

INVENTOR

David H. Keeley

BY

ATTORNEY.

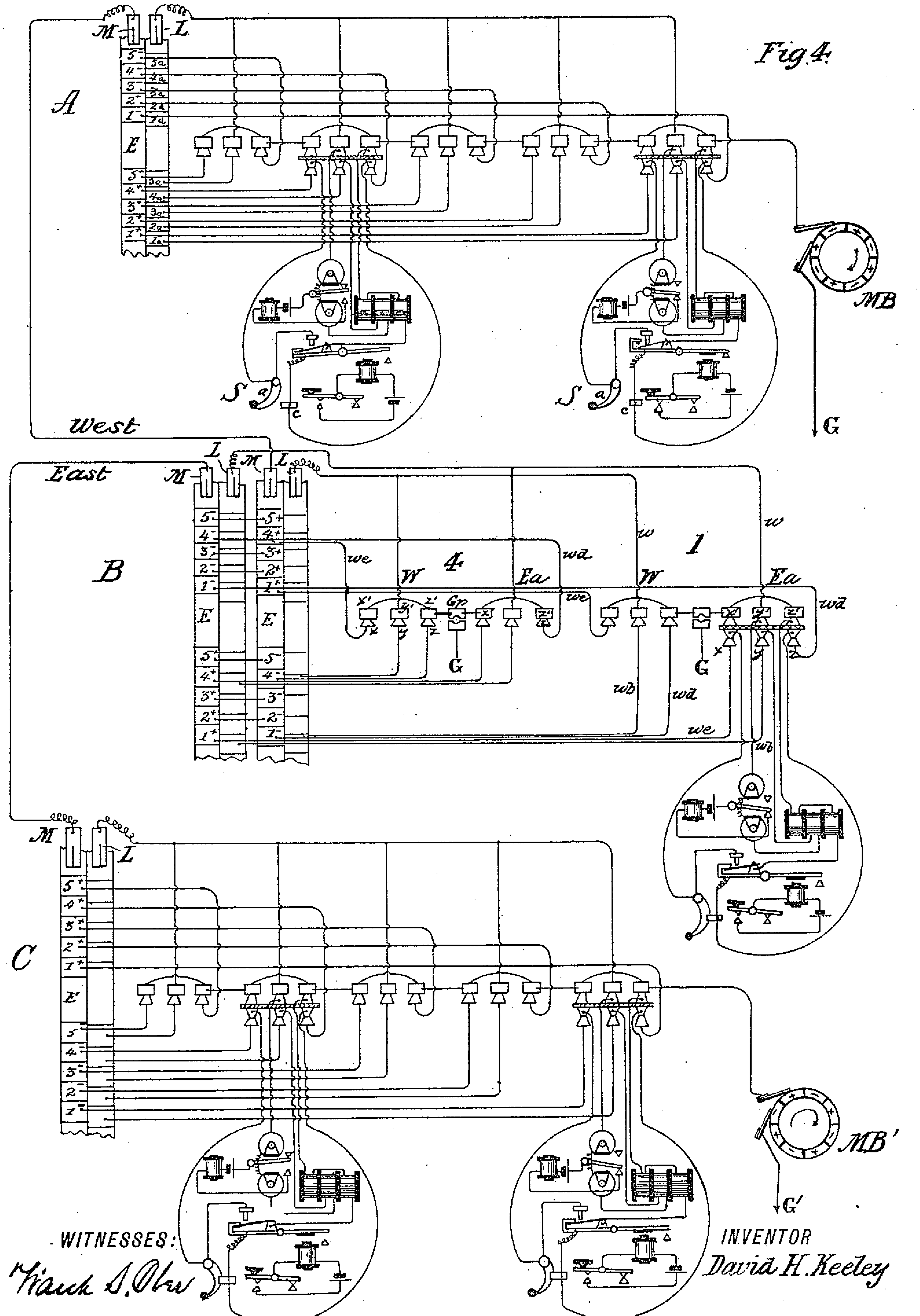
THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 4 Sheets—Sheet 2.

D. H. KEELEY.

MULTIPLEX TELEGRAPHY.

No. 440,165. Patented Nov. 11, 1890.



WITNESSES:

Frank S. Ober

Wm. A. Rosenbaum

INVENTOR

David H. Keeley

W. J. Johnston

ATTORNEY.

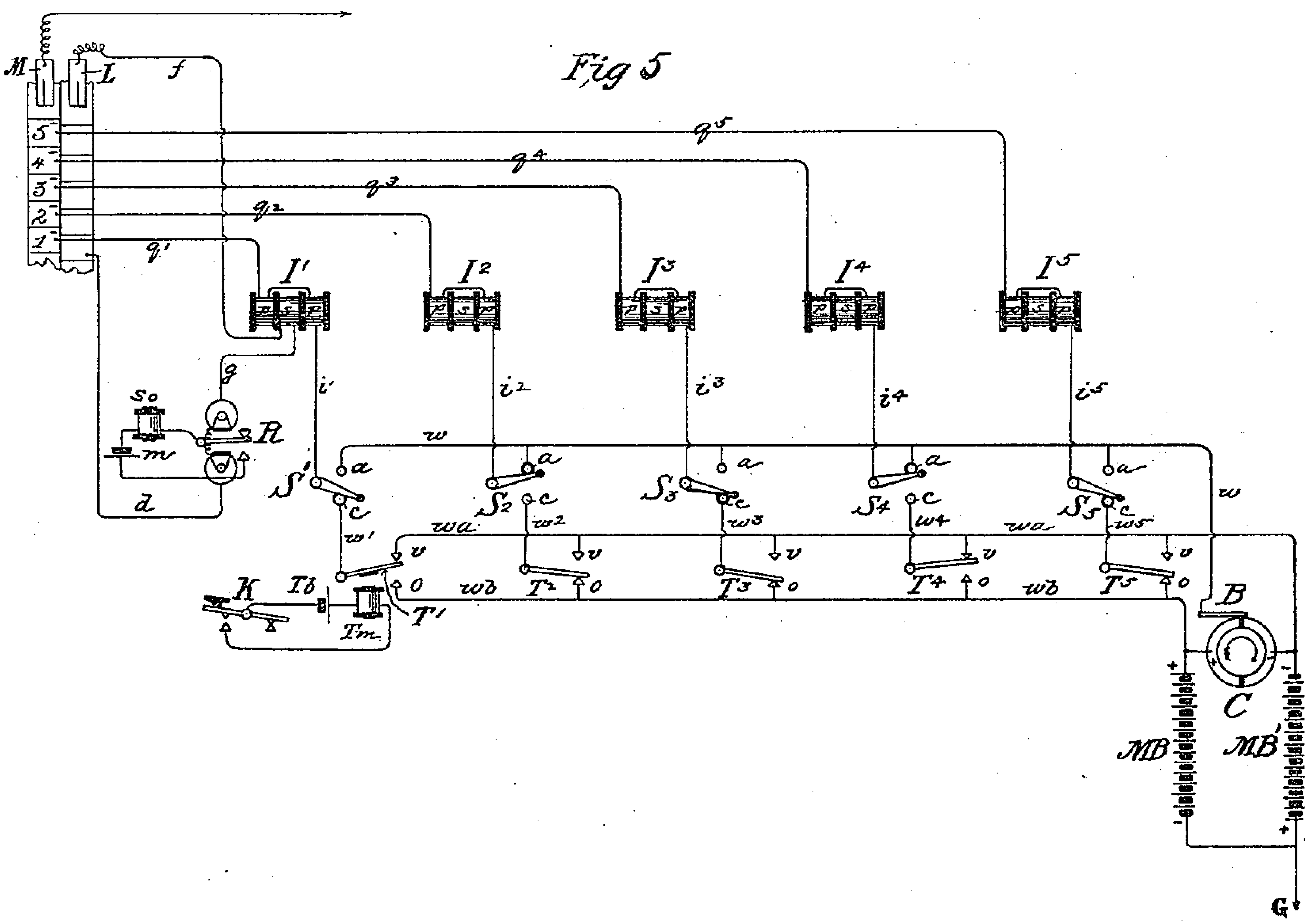
(No Model.) 4 Sheets—Sheet 3.

D. H. KEELEY.

MULTIPLEX TELEGRAPHY.

No. 440,165. Patented Nov. 11, 1890.

Fig 5



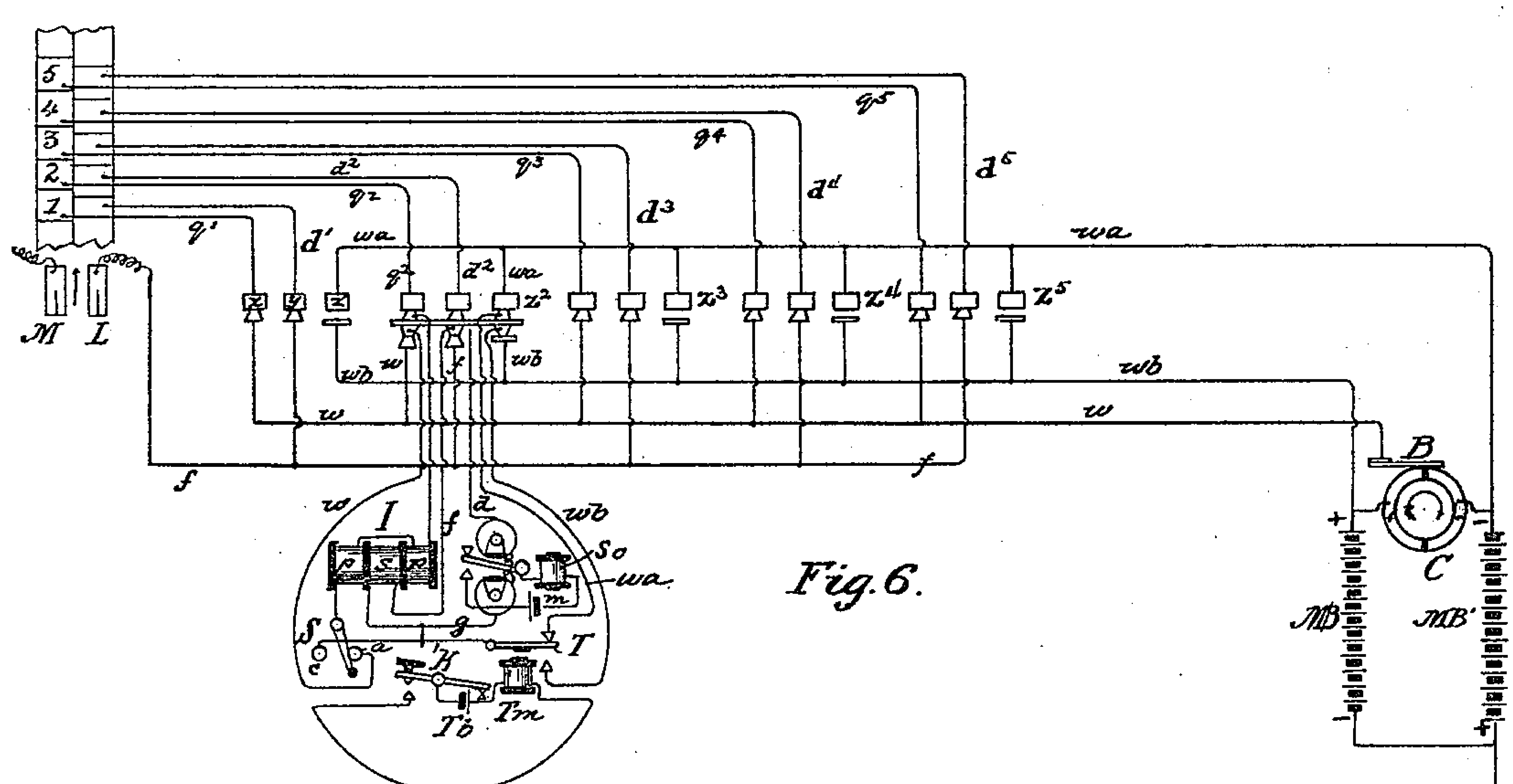


Fig.6.

WITNESSES:

Frank S. Ober

Wm. A. Rosenbaum

INVENTOR

David H. Keeley

BY

W. J. Johnston

ATTORNEY.

(No Model.) 4 Sheets—Sheet 4.

D. H. KEELEY.

MULTIPLEX TELEGRAPHY.

No. 440,165. Patented Nov. 11, 1890.

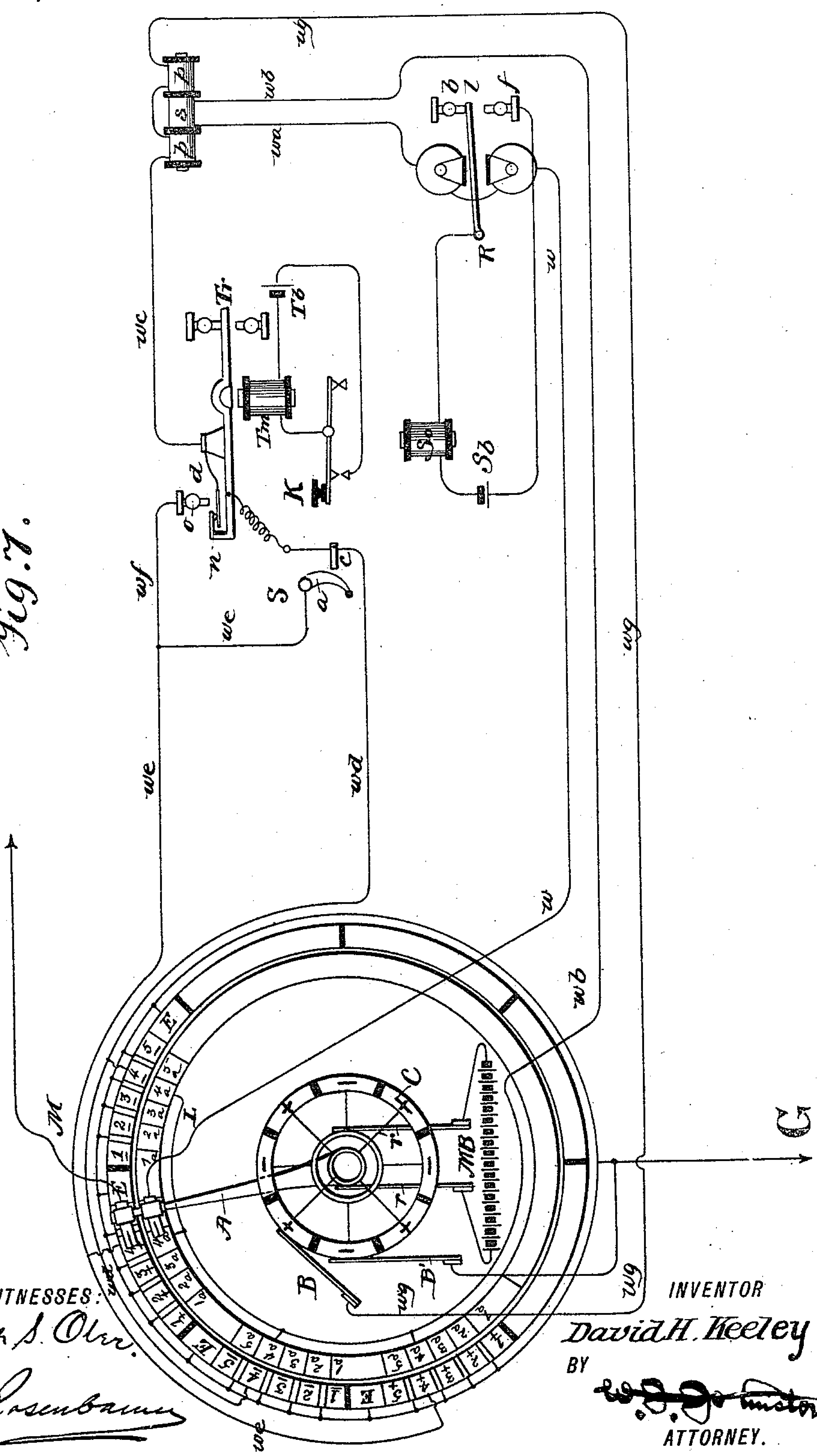


Fig. 7.

WITNESSES:

Frank S. Ober.

Wm A. Rosenbaum

INVENTOR

David H. Keeley

BY

W. S. Johnston

ATTORNEY.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

United States Patent Office.

DAVID HERBERT KEELEY, OF OTTAWA, CANADA.

MULTIPLEX TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 440,165, dated November 11, 1890.

Application filed November 4, 1889. Serial No. 329,198. (No model.)

To all whom it may concern:

Be it known that I, DAVID HERBERT KEELEY, a subject of the Queen of Great Britain, residing at Ottawa, in the county of Carleton, in the Province of Ontario, Canada, have invented certain new and useful Improvements in Multiplex Telegraphy, of which the following is a specification.

My invention consists in a new arrangement of signaling apparatus adaptable to any synchronous system that is designed to provide for the rapid transference of a line-wire from one set of apparatus to another simultaneously at all stations with which it is connected. It is well known that by such means a multiplication of circuits is obtainable in a single telegraph-wire. Hitherto the operation of the several circuits so obtained has been attempted by means of intermittent currents of one polarity, or by irregularly-reversed currents, applied at the transmitting end alone, and the apparatus employed has not been well adapted for the purpose intended, the consequence of which has been that the operations have been confined to terminal stations and the signaling capacity of a telegraph-wire has not been even fairly developed.

The invention herein described provides for the accommodation of intermediate as well as terminal stations, and utilizes the capacity of a telegraph-wire for the transmission of electrical effects to the fullest extent.

Figure 1 shows the signaling apparatus and plan of operation. Fig 1ª is a plan view of the contact-plates. Fig. 2 shows the same arranged in conjunction with a spring-jack switch. Fig. 3 shows a detail of the brush-contacts. Fig. 4 shows the arrangements for three stations on a line of ordinary length. Fig. 5 shows the apparatus and connections for a terminal station on a long line, and Fig. 6 shows the same in conjunction with spring-jack switches. Fig. 7 is a reproduction of Figs. 1 and 1ª, showing more comprehensively how the commutator C is associated with the circles of main line and local contact-plates 1+ 2+ 1ª 2ª, &c.

For my purpose the synchronous mechanism with which my signaling apparatus may be associated revolves the main-line brushes about the circle of contacts connected with the signaling apparatus at all of the stations in circuit with at least sufficient frequency to put the line in contact with each of the corresponding sets of apparatus once in every one twenty-fourth of a second; and it also rotates a commutator of a sufficient number of segments to produce at least twenty-four reversals per second of the main-line battery connected with it at each terminal station. For example, with the parts arranged as represented to the left in Fig. 7, an arm A is fixed on the shaft of an eight-part commutator C, and carries the brushes ML round about the circle of the periphery of a ring of eight series of main and local contact-plates 1+ 2+ 1ª 2ª, &c., at a rate of at least three revolutions per second, thus producing (8X3) twenty-four reversals of the battery MB under the brushes BB′, or 12+ and 12− currents, and an equal number of contacts of the brushes ML with any one set of the symmetrically-disposed main-line plates 1+ 1− or 2+ 2−, &c., and local plates 1ª or 2ª, &c.

The batteries, according to my invention, are reversely connected with the commutators. Consequently + presented to line at one end is met by — presented at the other end, the currents combine in the line, and as they are alternated by the revolving commutators the line is traversed by regularly-recurring + and — pulsations.

The passage of the main-line brush over the contact-plates connected with the signaling-instruments is concurrent with the transmission to line of any one phase + or — of the main-line current. Hence, if two equidistant contacts are provided for each set of signaling-instruments, as shown in Fig. 1, one contact-plate will regularly receive the + and the other the − pulsations; or, if but one contact is provided for each set of instruments, as shown in Fig. 5, it will receive the + and − currents alternately.

It will be understood from the context that the expression "one contact" comprehends any number of equidistant points in a circle electrically connected, and, similarly, the expression "two equidistant contacts" comprehends any number of equidistant points of which the alternations are electrically connected. In Fig. 7 the alternations of the main-line plates marked + and − are respectively in electrical connection, as indicated by the wire *we*, connecting the plates 4+, and the wire *wd*, connecting the plates 4−, the + alternating with the − plates, and it will be seen by the aid of the same drawing, Fig. 7, that when the brush M is on the plate 4+ the brush B is on a + section of the commutator C, which is connected with the battery MB by means of ring-contacts and brushes *r r′*, and when the brush M is by the arm A carried to the plate 4− the commutator C is also carried around, and when the brush M rests on 4− the brush B rests on a − section of the commutator.

In transmission from a terminal station by the means herein described, when the apparatus is arranged as in Figs. 1, 2, and 4 the receiving-instruments are operated by the batteries at both terminal stations conjointly. The keys operate to interrupt the continuity of the circuit, thus preventing the passage of the currents otherwise obtaining. On a very long line the apparatus at the terminal stations is arranged somewhat differently, for, it is elsewhere herein shown that at the receiving end of any one of the multiple circuits + and − currents are alternately presented to line, while at the sending end the path of the current + or − might, according to the position of the transmitting-key, be interrupted. This interruption, so far as the line is concerned, only exists during the passage of the line-brush over a single contact in each of the series in the cycle of its revolutions. It is therefore very brief, and on a very long line the current presented at the distant end during this brief period of interruption of the circuit at the transmitting end will electrify or charge the line sufficiently to affect the receiving-instruments at the end where the charge obtains. Now this charge at the distant end does not obtain where, instead of an interruption of the circuit at the transmitting end, a reversed current is put to line in the interval corresponding to an interruption of the path for a given current, because when like poles are opposed the potential is *nil*. In order, therefore, to obviate the above-described electrification or charge at the receiving ends, the apparatus at each terminal station is arranged for operation on a long line, as shown in Figs. 5 and 6. When the apparatus is arranged in this way, the superfluous charge at the distant ends is foiled and obviated, as the keys at the transmitting end in this case operate to determine (by the presentation of a like or unlike pole to line) whether a current of one phase or the other shall or shall not pass over the line from the distant end.

The arrangements for a way-station on a short or a long line are uniformly as shown at B in Fig. 3, and in the transmission the keys merely operate to interrupt the passage of the currents conjointly emanating from the terminal stations. The instruments in circuit are always, therefore, operated by the terminal batteries.

The operation of the apparatus will be readily understood by an examination of Fig. 1, which represents the connections for one circuit in a line of ordinary length in detail. As all of the circuits in a multiplex system of this kind are identical, the explanation of one will suffice. In the figure the apparatus is connected with two main main-line contact-plates 4+ and 4−, placed at diametrically-opposite points of a circle whose periphery is for convenience of explanation laid flat or lengthwise, as shown at Fig. 1[a].

I is an induction-coil of any suitable form. *p p* represents the primary wire, and *s* the secondary.

R is a polarized relay normally resting on its back-stop.

T*r* is a transmitter, such as is used in duplex telegraphy, and is operated by the electro-magnet T*m*, key K, end battery T*b* in the usual way. The front contact *o* of the transmitter is connected by wires *wf we* to the main-line plate 4+, and the back contact *n* is connected by wire *wd* to the main-line plate 4−.

S is a switch disposed in the same manner as a circuit-closer on an ordinary Morse key and serves to bridge the contacts *o* and *n* of the transmitter by the lug *c* in connection with the wire *wd* and the arm *a* in connection with the wire *we*.

The primary wire *pp* of the induction-coil I is included in the main-line circuit, which, when the switch S is open, is traced from earth at G by brush B′, battery MB, commutator C, brush B, wire *wg*, primary *pp*, wire *we* to transmitter-spring *d*, thence (when the key K is closed and the lever T*r* depressed) by contact *o* and wires *wf we* to plate 4+, or (when the key K is open and the lever T*r* upraised) by contact *n* and wire *wd* to plate 4−; and when the switch S is closed, as shown in Fig. 1, by contact *n*, wire *wd* to 4−, or *via* lug *c*, arm *a*, and wire *we* to 4+; or by contact *o*, wires *wf we* to 4+, or *via* the arm *a*, lug *c*, and wire *wd* to 4−. The main-line brush M passes over the + series of plates concurrently with the passage of a + section of the commutator C under the brush B, and the brush M passes over the − series when a − section of the commutator C is under the brush B. This action occurs regularly and uniformly. Hence when the switch S is open, the path for the pulsations of one polarity or the other determined by the position of the transmitter will be interrupted. Thus, if the key K is depressed and the transmitter is thereby actuated, putting the spring *d* in contact with the point *o*, the circuit will be complete for the passage of the + currents when the brush M passes over a + plate, while the contact is broken at *n* and no path is afforded for the − pulsations when the brush M passes over a − plate, and if the key K is upraised, as shown in Fig. 7, and the transmitter rests with the spring d in contact with n, the circuit will be complete for the − currents, while the contact is broken at o, thereby interrupting the path of the + pulsations. The position of the key therefore determines the circulation of + or − currents in the circuit. When the switch S is closed, the + and − pulsations pass by way of the plates 4+ and 4− regularly to line.

The arrangement of the receiving-instruments is as follows: The secondary wire s of the induction-coil I is in local circuit with the polarized relay R. The plates 4^a and the brush L are the terminals of this local circuit. It is traced from 4^a by wire wb to s, thence by wire wa through R, and by wire w to L. The plates 4^a are connected together and are the accompaniment of the main-line plates 4 + and 4−. The arrangement of these plates is clearly shown in Fig. 1^a. The brushes M and L are exactly parallel and travel together. The local plates are fixed a little in advance of the main-line plates. Consequently the brush L will be on 4^a and close the local circuit (in which the secondary wire s of the induction-coil and the relay R are included) before the main-line brush M will be on the contact 4− or 4+, and L will leave 4^a and open the local circuit before M will have left 4− or 4+. This action is clearly illustrated in Fig. 3 at A B C. The consequence of this action is that the induced effect due to the introduction of the main-line current into the primary of the induction-coil will be communicated to the relay R and the induced effect due to the withdrawal of the main-line current (after L has left 4^a) will be obviated. Hence the induced currents that operate in the secondary circuit alternate in polarity in accordance with the currents that are introduced into the primary of the induction-coil I. It follows, therefore, that if the switches S in a given circuit throughout the line were closed, thus affording paths for both currents + and −, as has been explained, the main-line currents + and − alternately would be transmitted to any given polarized relay R and the lever thereof would oscillate between its back and front stops, whereas if at any station the switch S were open only the currents of one polarity dependent upon the position of the transmitter could circulate in the circuit and all of the relays simultaneously in circuit would be actuated in response to it. The interchange of signals is therefore readily and easily accomplished.

As in a multiplex system of this kind the length of time during which the main-line brushes are in contact with a given set of contact-plates at the several stations is extremely brief, it has been found desirable to effect a discharge of the line before each reversal, so as to secure the greater efficiency of the signaling-current. In systems operated by irregularly-reversed currents narrow segments connected to earth are inserted between the successive plates for this purpose. A similar arrangement is shown at Fig. 1^a. Its function is, however, somewhat different, as only currents of one polarity occur during the passage of the main-line brush over a given series of the contacts, and between each series an earth-plate E, as large as may be desired, is provided, whereby the line is effectually discharged after each + or − phase of the current has traversed it. The space occupied by the earth-plate E is also made sufficiently large when required to accommodate the contact-plates for the correcting devices of the synchronous system with which this apparatus is associated.

The object of the narrow segments placed between the contact-plates and connected with the earth-plate is to check the current in its tendency to rise when traversing several closed circuits in succession, the result of which would be to charge the line to such an extent that the brief interruption caused by the opening of any one circuit would be insufficient to produce the effect properly due to it.

The use of the transmitter Tr secures continuity of connection between the receiving-instrument and the contact-plates in the + and − divisions of the circle traversed by the main-line brush, thus obviating the partial loss of a current pulsation that could otherwise occur during the transition of an ordinary key or its equivalent between its back and front contacts.

The use of induction-coils employed in the manner indicated secures a more rapid reproduction of the transmitted signals than can be effected in the receivers when these are placed directly in circuit. I have found that in the latter case three successive impulses of the current are requisite to actuate a given relay, whereas with the induction-coil intervening a single impulse is sufficient. The explanation appears to rest in that, on the one hand, the self-induction in the relay-coils opposes the brief energizing-current to such an extent that only a very small degree of magnetism is developed by each impulse, and, on the other hand, the convolutions of the primary wire of the induction-coil are not necessarily so numerous as those of the relay. The self-induction in the primary is therefore not so great and the energizing-current has more power in it, while in the secondary circuit the self-induction, though opposed to the current induced from the primary, is in the same direction as the energizing-current in the primary, whence the effect is enhanced and prolonged, as is evidenced in the relay to which it is communicated.

In Fig. 2 the apparatus of Fig. 1 is represented in conjunction with a triple spring-jack switch SJ, the object of which is to render the signaling-instruments and circuits interchangeable. The several parts and connecting-wires are similarly lettered, so that the tracing of the circuits in both is identical.

The upper contacts X′ Z′ of the two outer spring-jacks are electrically connected with the wire *wg*, already mentioned in Fig. 1. Their lower contacts X and Z are connected, respectively, with the wires *we* and *wd*. The upper contact *y′* of the middle spring-jack is connected with wire *w* and its lower contact *y* with wire *wb*. The contact-plates on the knife F are connected with the correspondingly-lettered wires leading to the instruments, as can be readily seen.

Fig. 4 shows a line with three stations, terminals A C, and way-station B. The terminals are represented with five circuits, (any number might have been represented,) all connected with spring-jack switches. Signaling-instruments are included in the circuits 1 and 4. All of the parts are identical and lettered to correspond with those represented in Fig. 2. To avoid confusion in the drawings, the way-station B is represented with connections for only the two circuits 1 and 4, with instruments included in the circuit 1. The remainder of the circuit-contacts are represented as being in electrical connection "through." The brushes and contact-plates are duplicated, and, as shown, the signaling apparatus is put in circuit between the two sets. Ground-plates *gp* are also provided. The object of this arrangement is to afford independent communication on either side of the station at pleasure. It will readily be seen that the arrangements are exactly similar for any number of circuits. Any number of intermediate stations, like B, could be put on the line; but as the arrangements at all of them would be identical the representation of one will be sufficient for explanation.

In Fig. 4 the main-battery connections MB MB′ at the terminal stations A C, respectively, are concurrently in circuit and reversed not less than twenty-four times per second, and, as already explained, these supply the working-currents to the line. There is no main-line battery at the way-station B. The drawing represents station A sending to B and C on circuit 1, with the key closed at A, and A sending to C on circuit 4, with the key open at A. These two conditions cover the whole of what takes place in the operation, and from the explanations given in connection with Fig. 2, the parts being similarly lettered throughout, the connections can be readily traced and the operation clearly understood. The only parts unexplained in detail are the triple-spring jacks duplicated at the way-station B. In these the upper contacts *x′ z′* of the two outer spring-jacks under W, the (unplugged) ground switch-plate G*p*, and the upper contacts *x′ z′* of the two outer spring-jacks under E*a* are connected together. The remaining contacts under W are connected as follows: Lower *x* by wire *we* to plate 1+ of the west side main; lower *z* by wire *wd* to plate 1− of the west side main; upper *y′* by wire *w* to brush L of the west side local; lower *y* by wire *wb* to plate 1*a* of the west side local. The contacts under E*a* are connected as follows: Lower *x* by wire *we* to plate 1+ of the east side main; lower *z* by wire *wd* to plate 1− of the east side main; upper *y′* by wire *w* to brush L of the east side local; lower *y* by wire *wb* to plate 1*a* of the east side local. The spring-jack connections for circuit 4 are precisely the same. No instruments are in the figure introduced into this circuit. When the main brushes M W and M E*a* are on the plates 4+4−, respectively, the circuit is traced from 4+ by wire *we* to *x* under W, *x′* to *z′* through G*p* to *x′* and Z′, under E*a* Z, wire *wd*, to plate 4−. It is therefore completed through and uninterrupted. The instruments inserted in a circuit 1 are connected to the spring-jack knife in the way described in Fig. 2. The parts are correspondingly lettered.

Fig. 5 shows the arrangements for a terminal station on a long line, where it becomes necessary to obviate the effects of charge from the battery at the distant end during the interval when a given key at the transmitting-station operates to interrupt the circuit. The induction-coil, polarized relay, local contact-plates, and brushes are arranged as already described. A single series of main-line contacts, or the double series connected in diametrically-opposite pairs, is sufficient for my purpose in this case. The main-line brush M makes contact with the apparatus, as before, not less than twenty-four times per second, and the commutator C presents an equal number of reversals concurrently. Two transmitting-batteries MB MB′ are employed at each terminal station. Taking the fourth circuit for an example, in the normal condition of the apparatus with the switches S^4 on the contact *a*, the currents alternately presented to the brush B by the commutator C will pass by wire *w*, contact *a*, switch-arm S^4, by wire i^4, through the primary wires *pp* of the induction-coil I^4, wire q^4, to plate 4−, and thence to line. The plate 4− is touched by the brush M once during the existence of each succeeding phase + and − of the current. The alternate currents are therefore uniformly and regularly presented to line. The same condition obtains at the distant terminal station. The currents combine in the line and affect the receiving-instruments arranged for operation as already fully explained in the other figures. When the switch is closed, as represented at S′ in the first circuit, the connection between the commutator-brush B and the main-line plate 1− is broken. The circuit in this case depends on the position of the lever T′, which is operated by the electro-magnet T*m*, key K, and battery T*b*, and takes the place of the duplex transmitter shown in the other figures. When the key K is open and the lever T′ is on the contact *v*, as shown in the figure, the − current from the battery MB′ is presented steadily to line, the circuit being traced from MB′− by wire *wa*, contact *v*, lever T′, wire *w′*, contact *c*, switch-arm S, wire *i′*, through the primary wire pp of the inductor I' and wire q' to the plate 1, and thence to line. This bieng the case, a + pulsation presented to line at the distant terminal station will combine with the − here presented and will operate, say, to open the relays connected in circuit, whereas a − current presented at the distant end will oppose and be opposed by the − current here presented. Hence no effect will be produced in the circuit and the relays will remain open. Likewise when the key is closed and the lever is depressed, as shown in circuit 3, the + current from battery MB is presented steadily to line, the circuit being from MB+ by wire wb, contact o, lever T^3, wire w^3, contact c, switch-arm S^3, wire i^3, through the primary wire pp by wire q^3 to the plate 3, and thence to line. In this case if a + current is presented to line at the distant terminal no effect will be produced in the circuit, and the relays will remain open; but if a − current is presented at the distant end the two currents will combine in the line and will operate to close the relays. As the + and − currents are put to line at the distant terminal at least twenty-four times in a second, which is faster than any manipulation can be effected, it follows that the relays in a given circuit will promptly respond to the key at the transmitting-station, no matter how long the line may be on which this apparatus is operated.

In Fig. 6 the apparatus of Fig. 5 is also represented in combination with triple spring-jack switches for the convenient interchange of the signaling instruments and circuits. The several parts and connecting-wires are similarly lettered, so that the tracing of the circuits in both is identical. The jaws of the third jack in each instance are permanently insulated. All of their upper contacts z' z^2, &c., are connected by wire wa to the battery MB', and all of the lower zs by wire wb to the battery MB. The upper contacts x are connected by wires q' q^2, &c., to the line-plates, and the lower Xs are connected by wire w to the commutator-brush B. The upper contacts y' y^2, &c., are connected by wires d' d^2, &c., to the local contact-plates 1^a 2^a, &c., and all of the lower ys are connected by wire f with the brush L.

Having thus described my invention, I claim—

1. The combination of induction-coils with the polarized relays, the local contact-plates 1^a 2^a, &c., and brush L, for completing and interrupting the circuit embracing the relays and secondary wires of the induction-coils, whereby only one induced effect is communicated to the relays from each pulsation (+ or −) transmitted.

2. In synchronous multiplex telegraphy, the combination, with continuity-preserving duplex transmitters, of two sets of main-line contacts arranged to receive the plus and minus currents, respectively.

3. In multiplex telegraphy, commutators at both ends of the line operating to present currents to line concurrently plus at one end and minus at the other, and the reverse, alternately, in combination with an arrangement of keys and transmitters, whereby when the keys are depressed the path to line for the currents of one polarity is interrupted, while the path for the currents of opposite polarity is established and when the keys are upraised the reverse effect is produced.

4. In multiplex telegraphy, commutators and batteries at both ends of the line arranged normally to concurrently send to line from both ends alternately-reversed currents, and the arrangement of keys and transmitters, in combination therewith, operating when the keys are depressed to send a current of one polarity uniformly to line, and when the keys are upraised to send a current of opposite polarity to line, to combine with or to oppose the currents emanating under the normal condition from the distant terminal station.

5. In synchronous multiplex telegraphy, the combination at intermediate stations of duplicate contact plates and brushes and duplicate spring-jack switches and earth-plates and connections, whereby the line may be grounded in any one or more of the multiple circuits without interference with the others, and the signaling-instruments may be introduced into any circuit on either side of the ground-plate at pleasure.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

DAVID HERBERT KEELEY.

Witnesses:
F. N. GISBORNE,
J. G. JAMENT, Jr.