

March 14, 1933.

H. H. HAGLUND

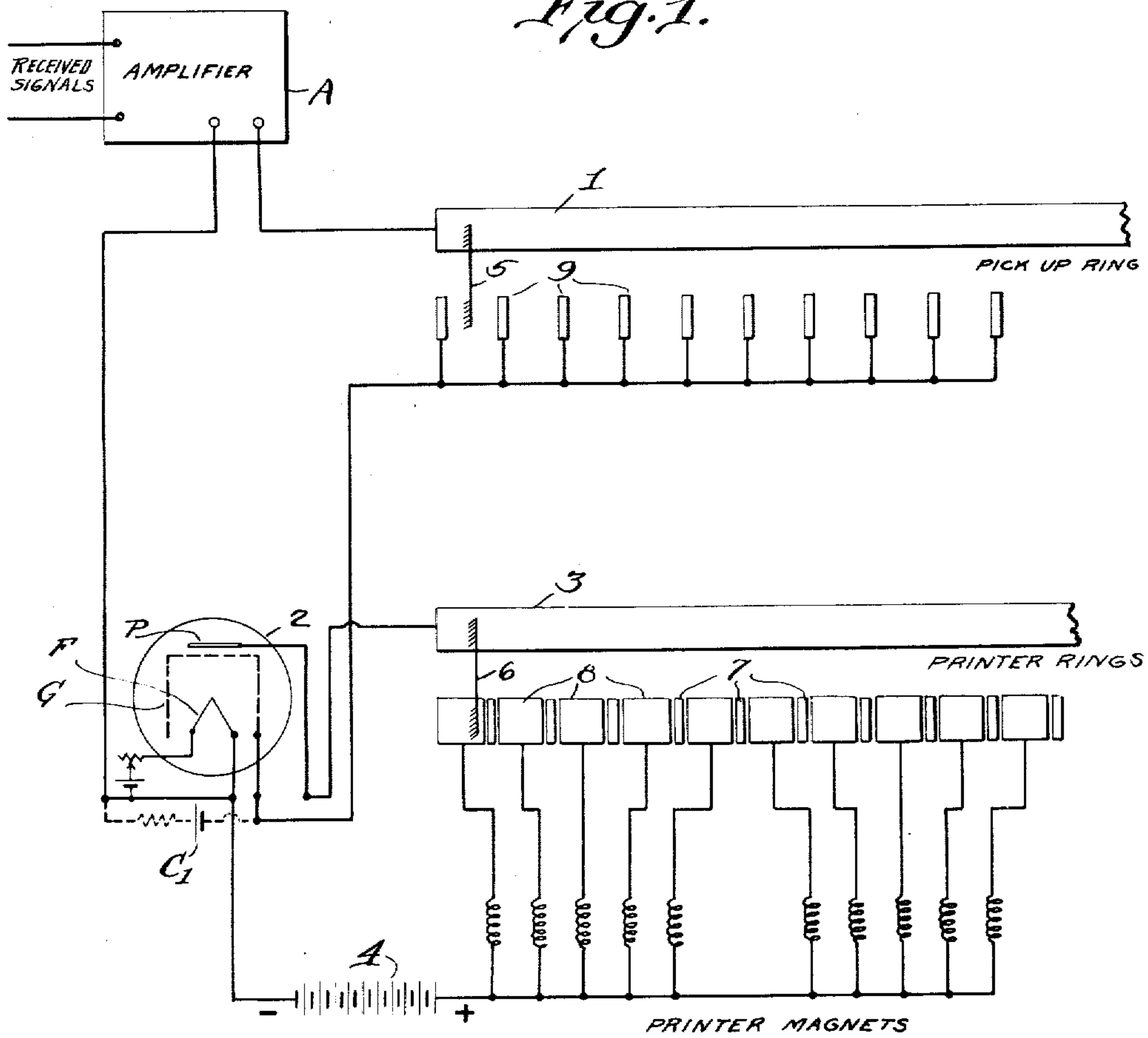
1,901,296

MULTIPLEX TELEGRAPH SYSTEM

Original Filed Feb. 27, 1929

7 Sheets-Sheet 1

Fig. 1.



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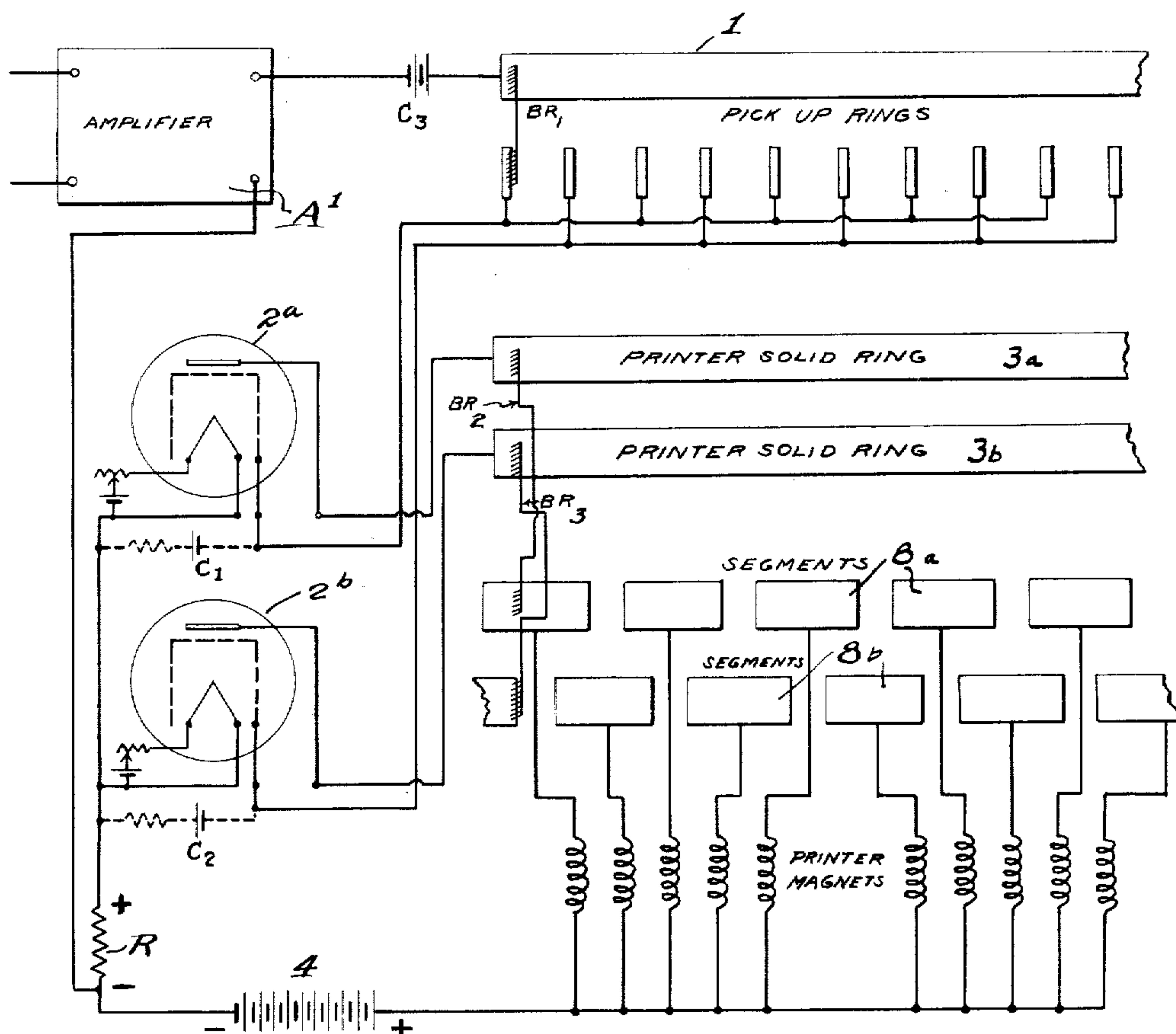
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MULTIPLEX TELEGRAPH SYSTEM

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7 Sheets-Sheet 2

Fig. 2.



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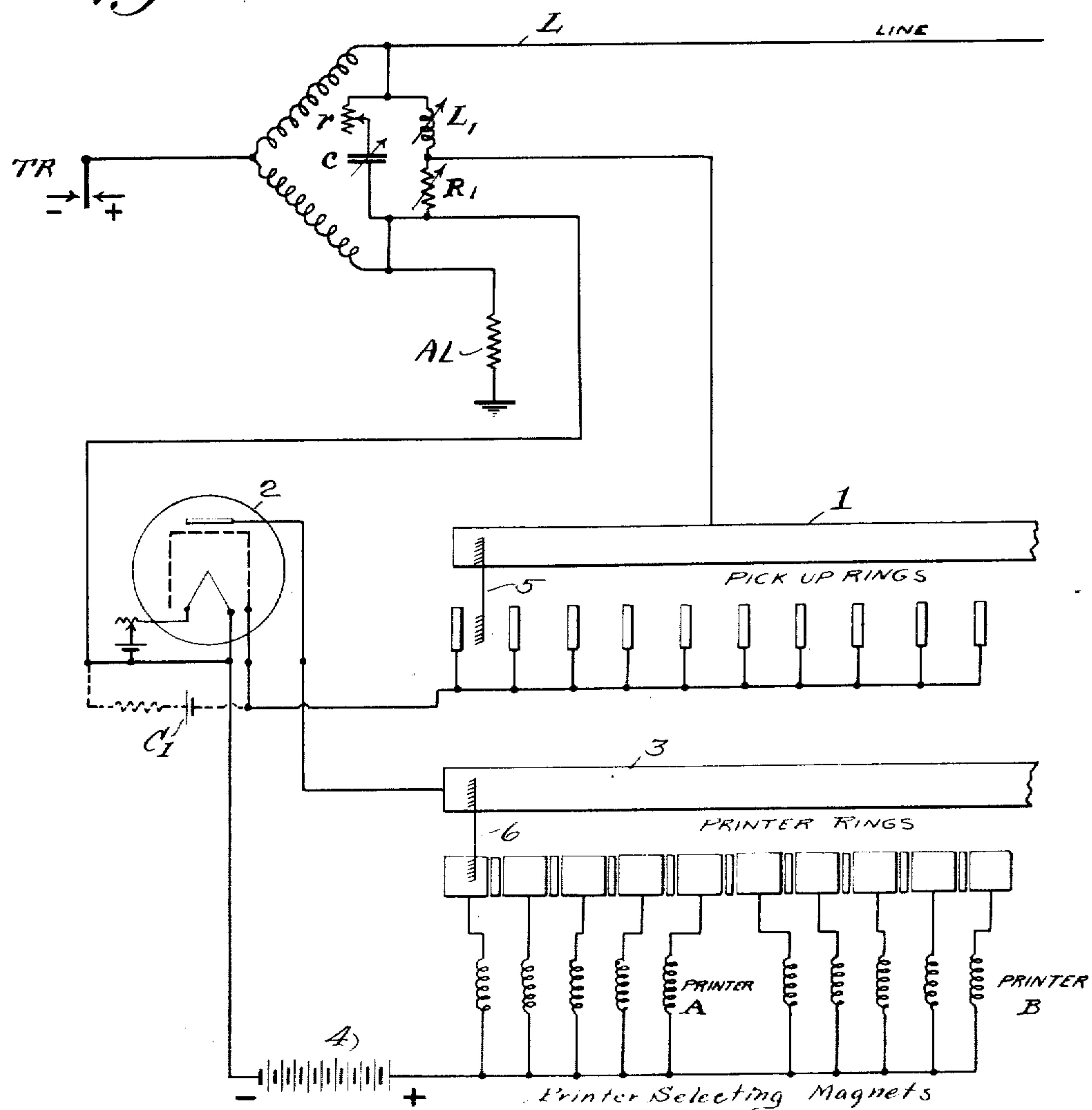
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MULTIPLEX TELEGRAPH SYSTEM

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Fig. 3



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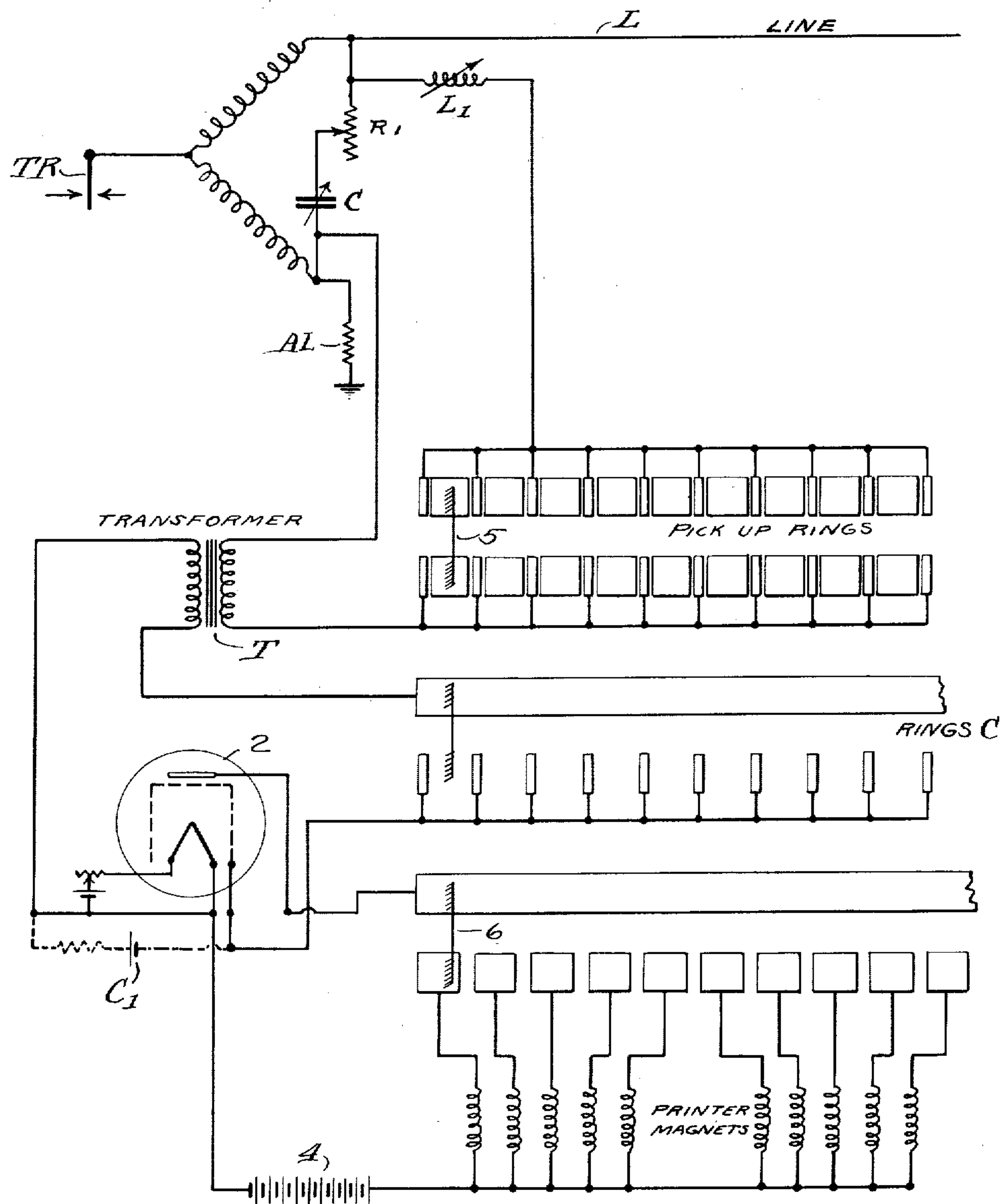
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MULTIPLEX TELEGRAPH SYSTEM

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7 Sheets-Sheet 4

Fig. 4.



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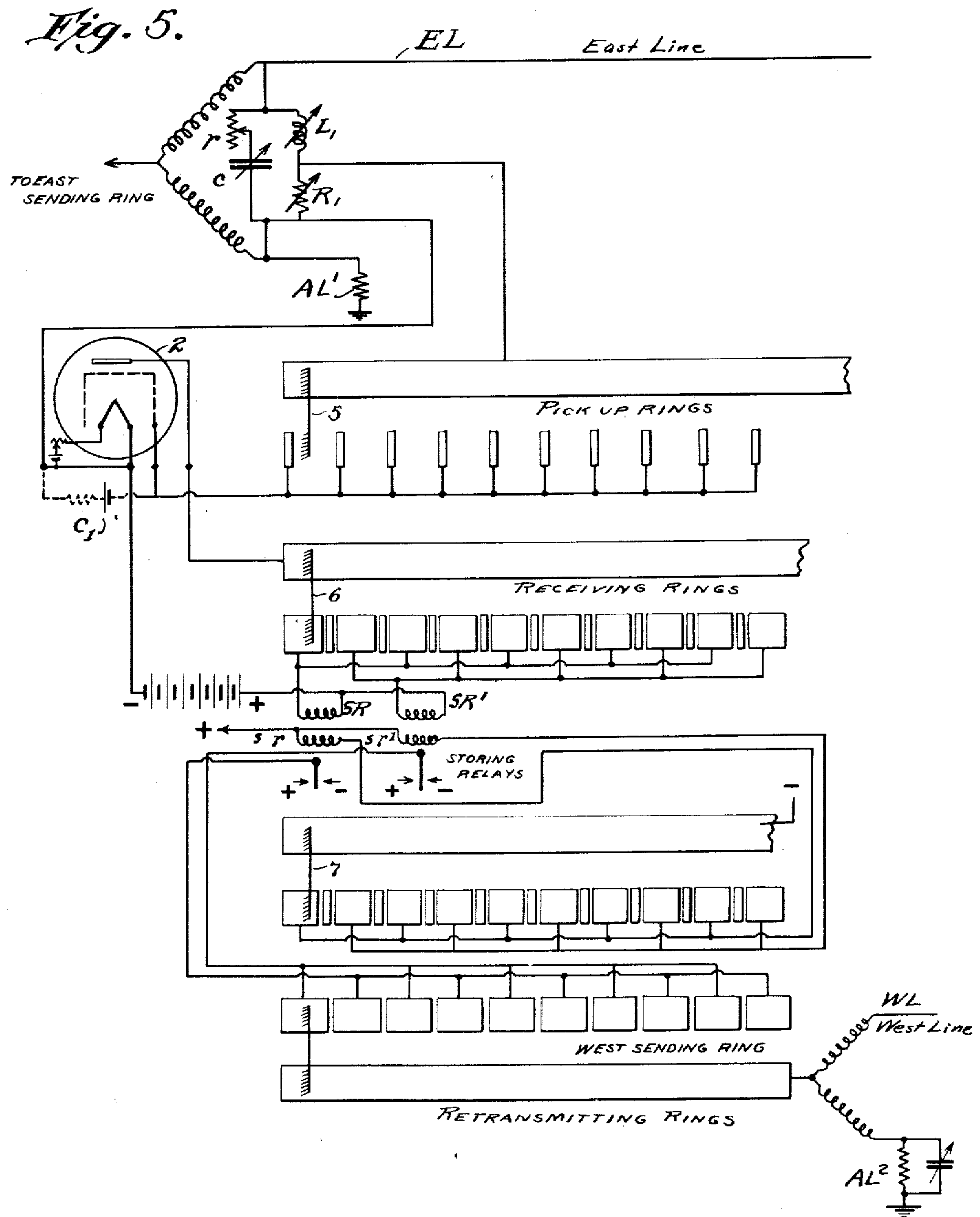
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MULTIPLEX TELEGRAPH SYSTEM

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7 Sheets-Sheet 5



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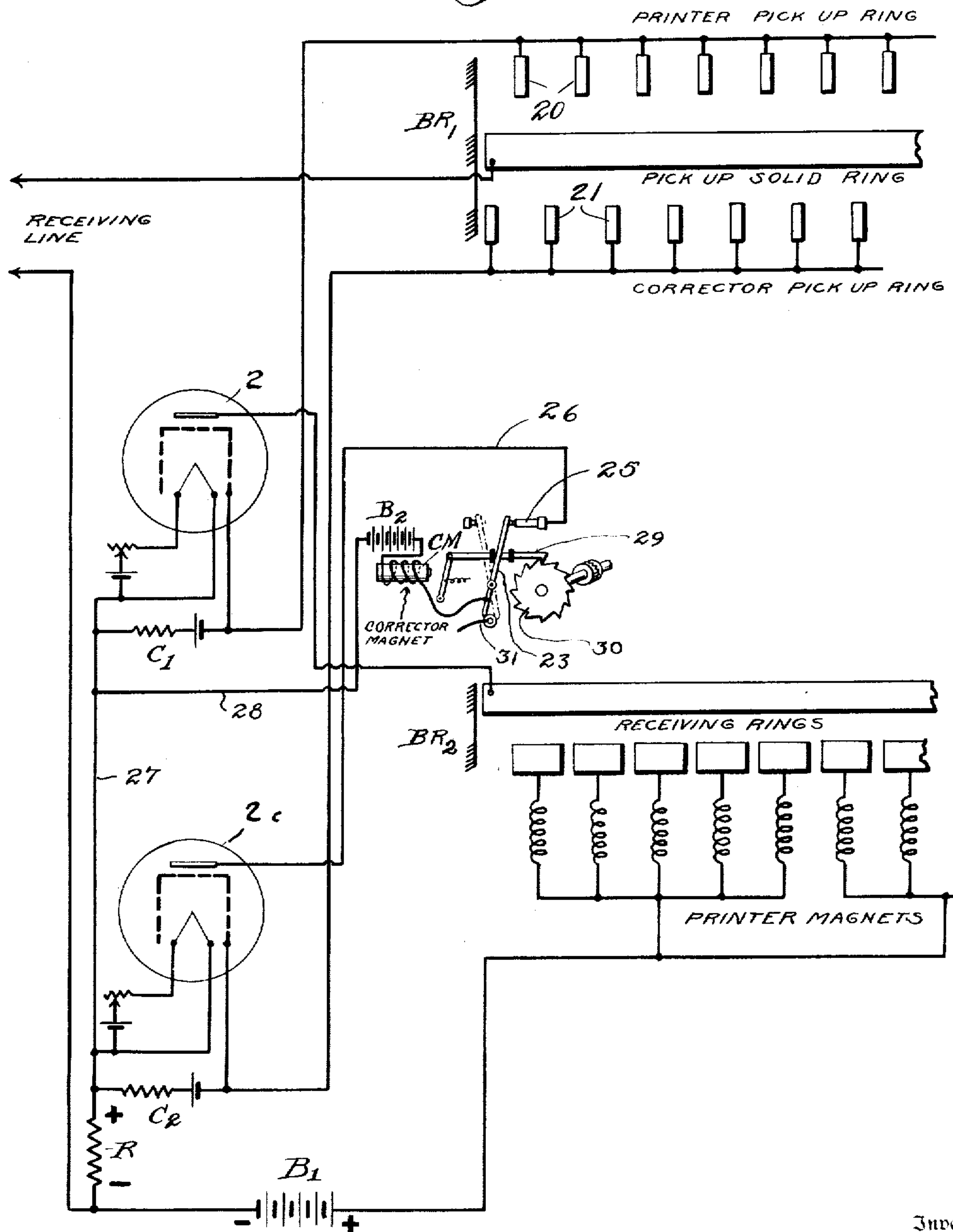
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MULTIPLEX TELEGRAPH SYSTEM

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7 Sheets-Sheet 6

Fig. 6.



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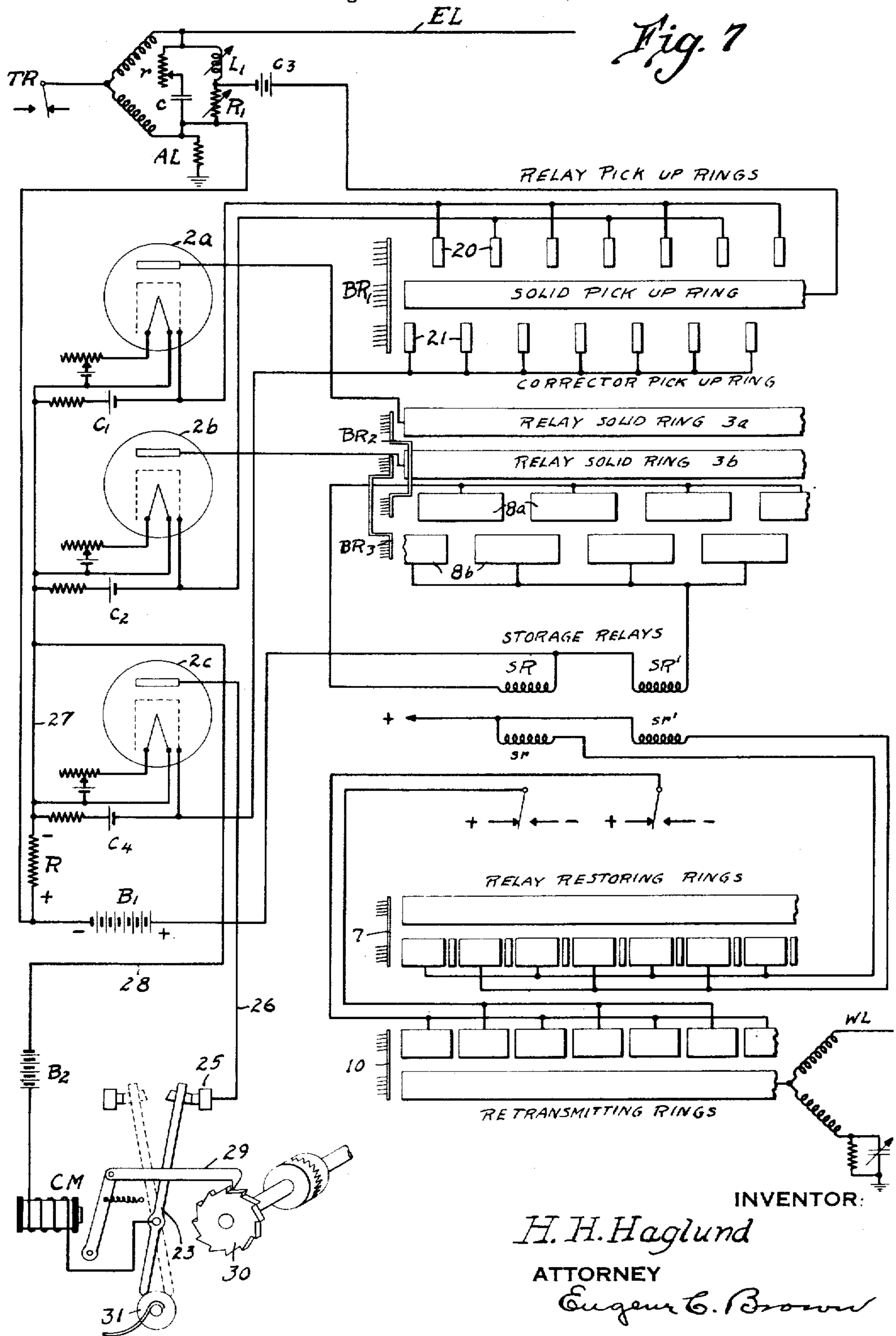
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MULTIPLEX TELEGRAPH SYSTEM

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UNITED STATES PATENT OFFICE

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MULTIPLEX TELEGRAPH SYSTEM

Application filed February 27, 1929, Serial No. 343,109. Renewed October 14, 1931.

This invention relates to telegraph systems and more particularly to a system for receiving or repeating telegraph signals without the use of electro-magnetic relays. It is shown with particular reference to the operation of telegraph printers or storing relays direct from the output of an amplifier or magnifier; and also direct from a land line or cable but is not limited thereto.

It is usual, in telegraph systems as heretofore constructed, to employ electro-magnetic relays connected directly to the line or through a signal amplifier, to respond to the received signal impulses. Appreciable time is required, however, to magnetize and demagnetize the magnets of such relays and the relay tongues have considerable inertia, which limit the rate of operation thereof. Consequently such relays are relatively slow in operation and limit the rate of transmission of signals over the line or cable. They also increase the inductance of the line, causing distortion of the signals. In cable telegraphy where the signals are highly attenuated and the received impulses build up slowly in amplitude, the relays must be highly sensitive in order to follow the signal changes. Such relays are delicate and require careful adjustment and maintenance.

One of the objects of the present invention is to overcome the above difficulties met in the use of electro-magnetic relays and to provide a telegraph system in which signals of high speed or extreme attenuation may be accurately received and recorded or repeated.

Another object is to provide receiving apparatus for such a system which will have a long life, which is rugged and reliable and which requires a minimum of maintenance and adjustment.

Another object is to eliminate the signal distortion ordinarily caused by the magnetizing and de-magnetizing effects on electro-magnetic relays.

Another object is to produce faster operation of the receiving apparatus in response to the received signals, whereby high speed signalling may be practiced.

A further object is to permit the use of

substantially inertialess relays having no moving parts.

Still further objects are to obtain full regeneration of the received signal impulses, or to prolong the same sufficiently to operate relatively slow acting devices from high speed signals and to provide a simple and reliable means of maintaining synchronism between the multiplex apparatus and the received signals.

Still another object of this invention is to devise a system for operating printers or storing relays directly from the output of an amplifier without the intervention of electro-mechanical relays.

For this purpose I employ a special inertialess electric discharge device which may be in the form of a gas-filled thermionic tube, interposed between the amplifier and the printer or storing relay.

The invention is illustrated in the accompanying drawings in which:—

Figure 1 shows the invention as applied to a multiplex printer.

Figure 2 illustrates the invention as applied to a multiplex printer system for filling in single element pulses which have been attenuated.

Figure 3 illustrates the invention as applied to a land line arranged for duplex operation.

Figure 4 is a modification of the arrangement shown in Fig. 3.

Figure 5 illustrates the invention as applied to a full regenerative repeater using only two storing relays.

Figure 6 illustrates the invention as applied to a system for correcting a rotary distributor.

Figure 7 shows a complete system embodying the features of Figures 2, 3, 5 and 6.

In accordance with the present invention I employ in place of the usual electro-magnetic relay, an electrical discharge tube of a type in which the discharge is started by a momentary application of a signal condition thereto, the discharge continuing independently of the applied signal condition until interrupted by a locally controlled

means. In one form the electrical discharge tube may comprise a gas discharge path, which is electro-statically controlled.

A convenient form of discharge tube for this apparatus may comprise a gas-filled thermionic tube of such construction that when the anode is connected to positive battery and a certain potential is applied to the grid, the tube will "start" and current will flow from the anode to the cathode. As soon as the plate current begins to flow the grid is instantly surrounded by a sheath of positive ions and has no further effect in controlling the plate circuit. This sheath, usually only a fraction of a millimeter thick, contains the whole voltage drop between the grid and the space surrounding it. Changing the grid voltage merely changes the thickness of the sheath and has no effect on the potential of the rest of the space. Hence removal of the grid potential will not stop the plate current, once it is started. However, it can readily be stopped by removing the plate voltage.

The function of the grid may therefore be likened to a trigger. The amount of power required to start the tube is exceedingly small.

An electrostatically controlled discharge tube inherently capable of operation in this matter is shown in re-issue patent to Von Lieben and Reisz, No. 13,779, re-issued July 21st, 1914 and entitled Relay for undulatory currents. This tube is more fully described in *Elektrotechnische Zeitschrift* of November 27th, 1913, pages 1359 to 63. In operating the tube shown by Von Lieben as a trigger device, it is not necessary to observe the exacting conditions described by Von Lieben for obtaining modulation, that is for preventing the discharge from arcing through the grid. Where mercury is employed, the mercury may be placed directly in the tube where it will be under the direct heating effect of the cathode, since the mercury temperature for the well defined trigger action should be above that corresponding to approximately 40 degrees C.

Another form of thermionic tube having the characteristics described is disclosed in patent to Irving Langmuir No. 1,289,823. The name "thyatron" has been applied to tubes of this general type in an article entitled "Gas-filled thermionic tubes" by A. W. Hull, published in the *Journal of the American Institute of Electrical Engineers*, November 1928, page 802, in which other forms are described and in which the characteristics of the Von Lieben tube when employed as a trigger device, are more fully set forth.

The magnitude of the discharge current is independent of the charge applied to the grid as long as the applied potential is sufficient to start the discharge. This starting potential may be positive or even negative,

depending upon the geometry of the tube, particularly the mesh of the grid and the spacing of the grid and plate, but in any case is definite for a particular tube. Where the tube is designated to start upon the application of a zero or negative potential of the control electrode, it is necessary to provide a negative bias to the grid to maintain the tube in a normally inoperated condition, otherwise the tube will be self-starting.

In the embodiment shown hereinafter the signal conditions, either directly or through an amplifier, are applied to the electrical discharge tube by a circuit interrupter operating in substantial synchronism with the received signals, whereby a small and reliable part only of each signal impulse is applied to the discharge tube and simultaneously therewith the output circuit is completed through a second distributor or make and break device. The output circuit may be maintained in a closed condition for any desired period so as to prolong the effective length of the impulses. In case a single tube is employed, the output circuit should be interrupted, of course, in time to interrupt the discharge before the succeeding signal is applied to the tube, but where two or more tubes are used, operating in succession, each discharge may be continued over a period in excess of the time required for the transmission of a single impulse.

While a preferred manner is shown for controlling the starting of the discharge through tubes of this general nature, in response to telegraph signals, it is to be understood, of course, that I do not desire to be limited to the particular means shown.

Referring to Fig. 1 the output circuit of amplifier A is connected on one side to the solid ring 1 of the pick-up rings of the rotary distributor or circuit interrupter, and on the other side to the filament F of the thermionic tube 2. The segments of the segmented pick-up ring of the distributor are connected together and to the grid G of tube 2. The plate element P of the tube is connected to the solid ring 3 of the printer rings. The active segments 8 of the segmented printer ring are connected respectively to the selecting magnets of the printer, the latter being connected to one pole of the battery 4, the opposite pole being connected to the filament or cathode of the thermionic tube. The brushes 5 and 6 of the rotary distributor are moved over the rings in synchronism with the incoming signal impulses in the usual manner by a synchronous motor, not shown. A small stabilizing battery C₁ may be connected as indicated in dotted lines to keep the grid normally negative with respect to the filament.

The operation of the arrangement shown in Fig. 1 will be readily understood. The incoming signals received by the amplifier

are amplified and impressed upon the output circuit which includes the printer pick-up rings and the filament-to-grid path of the thermionic tube 2. At the same instant that the pick-up brush 5 makes contact with a pick-up segment 9, the printer ring brush 6, connects the positive pole of battery 4 through a segment 8 to the plate of tube 2. When the brush 5 contacts with a pick-up segment 9 it completes the output circuit of amplifier A to the grid circuit of tube 2. If the output of the amplifier is positive, the grid of the tube will be made positive, thereby starting the flow of current from plus battery 4 through a printer selecting magnet, a segment 8, brush 6, solid ring 3, to the plate P of tube 2, and through the tube to the cathode F and negative pole of battery 4. This will operate the printer selecting magnet. The current will continue to flow until the brush 6 passes onto a dead segment 7, thereby opening the plate circuit.

If the output of the amplifier is negative when the pick-up brush passes over the pick-up segment, the grid of the thermionic tube will become more negative and hence no current will be permitted to flow through the tube, even though the printer ring brush 6 connects plus battery to the plate in the same manner as before.

It will thus be seen that the printer magnets will be operated whenever the output of the amplifier is positive but will not be operated when the amplifier output is negative.

For purposes of illustration I have shown the transmitting rings of the distributor connected to the selecting magnets of a printer or recorder but it is obvious that one or more storing relays may be substituted and used to repeat the signals into another line or cable. The segments 8 serve the double purpose of distributing the discharge current to the proper circuit and timing the period of operation of the tube.

Fig. 2 illustrates an arrangement for filling in single element pulses that have been attenuated to such an extent that they will not operate a relay or a thermionic tube in the normal manner. Two thermionic tubes 2a and 2b of the type described are used, and they are so arranged that they will be operated by alternate incoming signal impulses. Alternate segments of the segmented pick-up ring of the rotary distributor are connected to the grid of tube 2a, while the remaining segments are connected to the grid of tube 2b. The output circuit of amplifier A¹ is connected on one side through a battery C₃ to solid ring 1 of the pick-up rings, and on the other side to the cathodes of tubes 2a and 2b through a resistance R. The printer rings of the distributor comprise two solid rings and two segmented rings, as

shown. Solid ring 3a is connected to segmented ring 8a by a rotating brush BR₂, while solid ring 3b and segmented ring 8b are connected together by a rotating brush BR₃. All of the rotating brushes are operated in synchronism with the incoming signal impulses in the usual manner. Plate battery 4 is connected to supply plate current to tubes 2a and 2b through resistance R, and through the printer selecting magnets. Small stabilizing batteries C₁ C₂ may be connected between the filament and grid of tubes 2a and 2b, respectively, in series with suitable limiting resistances as indicated in dotted lines. These batteries are poled to maintain the grids negative with respect to the filaments when the grid circuits are open. Battery C₃ is poled in such manner that when connected in the grid circuit of either tube its effect is to overcome the effect of battery C₁ or C₂ and cause the grid to become positive.

The operation of the arrangement shown in Fig. 2 is as follows:

If at the moment the pick-up brushes BR₁ pass over a pick-up segment, the output of the amplifier A¹ is positive, a positive potential will be impressed upon the grid of the thermionic tube which will start the flow of current from the positive pole of battery 4 through the corresponding printer magnet, and its segment, the plate of the thermionic tube to the cathode, and through resistance R to the negative pole of the battery. This will operate the printer selecting magnet. If, on the other hand, the output of the amplifier is negative when the pick-up brush BR₁ passes over a pick-up segment, the grid of the tube will be made more negative and hence no current will flow through the plate circuit and therefore the corresponding selecting magnet of the printer will not be operated.

If the output of the amplifier is zero at the moment that the pick-up brush BR₁ passes over a pick-up segment connected say to thermionic tube 2^a, the potential from the battery C₃ will over-ride the potential from battery C₁ thus making the grid positive and hence starting a flow of current through tube 2^a. When the pick-up brush BR₁ passes over the next segment, which is connected to thermionic tube 2^b, the tendency of battery C₃ is to over-ride battery C₂ as before, but since at this moment because of the overlapping arrangement of the A and B segments, current is still flowing through brush BR₂ and tube 2^a, and through resistance R, and the resulting drop of the potential across this resistance, lowers the potential of the grid to such an extent that it cannot be overcome by the positive potential impressed by the battery C₃ and hence no current will flow through the plate circuit of tube 2^b. This alternating operation of tubes A and B con-

tinues as long as the output of the amplifier is zero. In this manner single impulses are "filled-in" by the action of the local circuit and "C" batteries of the thermionic tubes.

5 In Fig. 3 is shown a system for operating a printer directly from a duplex land line without the use of an amplifier. The line L is balanced for duplex operation by an artificial line AL. TR represents a transmitting relay or other transmitter. A receiving bridge including elements R1, L₁, c and r is connected between line L and artificial line AL in conjugate relation to transmitting relay TR. The grid circuit of thermionic tube 2 is connected in shunt to resistance R1 and includes the pick-up rings of the telegraph printer. The tube 2 is connected to the printer rings in the same manner as shown in Fig. 1. C₁ is a battery which may be employed to stabilize the tube by making the grid negative with respect to the cathode when the grid circuit is open. This battery is connected between the grid and the cathode in series with a suitable limiting resistance.

The operation of Figure 3 is as follows:—

Incoming signals are impressed upon the grid circuit of the tube 2 directly by the potential drop across resistance R. The tube 2 operates to transmit positive impulses only in the same manner as described above in connection with Figure 1.

The arrangement shown in Figure 4 is somewhat like that shown in Figure 3, like elements being indicated by corresponding reference characters. In this figure, however, the grid circuit of tube 2 is connected to the receiving bridge through a transformer T and an additional set of rings C is provided for opening the grid circuit of the tube in synchronism with the operation of the pick-up rings in the primary circuit of the transformer. The arrangement of the elements R1, c and L₁ in the receiving bridge is also somewhat different from that shown in Fig. 3.

In Figure 4, the operation, due to the presence of the transformer T, is such that only the front part of the signal is effective in operating tube 2. This is done so that when the signal decays from a negative signal to zero, the change of flux in the transformer which would normally cause a plus potential to be impressed upon the grid of the tube, cannot produce a current in the secondary because at this moment, the secondary of the transformer is open through rings C. The operation of Fig. 4 will otherwise be understood from a description of the operation of Fig. 1. Battery C₁ shown in dotted line may be employed for stabilizing the grid negative when the grid circuit is open.

The arrangement shown in Fig. 5, is a full regenerative repeater system using only

two storing relays. EL represents the "east" line from which signals are received, and WL represents the "west" line to which signals are to be repeated. The thermionic tube 2 is connected to the "east" line through pick-up rings in the same manner as shown and described in connection with Figure 3. Instead of printer magnets connected to the segments of the rings in the plate circuit of tube 2, alternate segments of the receiving rings are connected to the winding of one storing relay SR, while the remaining segments are connected to the winding of the other storing relay SR¹. Alternate segments of the retransmitting rings of the regenerative repeater are connected to the tongue of one storing relay, and the remaining segments are connected to the tongue of the other storing relay. The solid ring of the retransmitting rings is connected to apex of the "west" line.

At the same time that the receiving ring brush 6 passes over the segments connected to relay SR, the restoring brush 7 is passing over a segment connected to another coil sr of the same relay. The current through this coil sr is maintained at a value which is less than that flowing through brush 6. Hence if the tube 2 has been operated, due to a positive signal being received over the line EL, this current predominates and relay SR is moved to its marking contact. If a negative signal is received over the line EL, the tube will not be operated, and hence no current will flow through brush 6 to relay SR, and the current supplied through brush 7 to the restoring coil sr, will operate the relay to its spacing contact, thereby causing a spacing impulse to be transmitted into line WL.

The arrangement shown in Figure 6 illustrates a receiving system embodying a thermionic tube for recording signal impulses received over a line or cable and which also includes a correcting circuit including a thermionic tube for controlling a correcting device for correcting the phase position of the brushes of the rotary distributor. The input or starting circuit of tube 2 is connected to the incoming line through a resistance R and the printer pick-up ring. The input or starting circuit of tube 2c is also connected to the incoming line through resistance R and a correcting circuit including the brush-positioning magnet. The plate circuit of tube 2 includes the printer receiving rings, the printer selecting magnets, battery B₁ and resistance R. The plate circuit of tube B includes the corrector magnet CM, and battery B₂. C₁ and C₂ are stabilizing batteries for supplying a negative potential to the grids when the grid circuits are open.

The operation of Figure 6 is as follows:

The circuit is so arranged that the printer

receiving elements operate on a plus signal from the line, and the corrector mechanism operates on a reversal from minus to plus, if a phase correction of the brushes is necessary. The possibility of operating the corrector at any other point than at the beginning of a plus signal from the line is eliminated by causing a negative potential to be placed on the tubes after a positive signal has been picked up by the receiving brushes. The printer pick-up segments normally pick up in the middle of a receiving signal. A plus impulse would operate receiving tube 2, the plate circuit of which is completed through the receiving rings, printer magnets, battery B_1 and resistance R . When current is still flowing through resistance R and the pick-up brushes move onto a corrector pick-up segment, the drop of potential across the resistance R produces a negative potential at the grid of the tube $2c$ which is greater than the potential of the line signal and therefore prevents the operation of the corrector tube $2c$ at the end of a positive impulse. It is evident therefore that the tube $2c$ can only be operated at the beginning of a positive impulse and at no other time.

It will be observed that the corrector pick-up segments are positioned midway between the printer pick-up segments 20. The brushes BR_1 and BR_2 of the rotary distributor are operated in synchronism with the received signal impulses in the well known manner. The brushes are phased so that the brush BR_1 passes over a segment 20 just as an incoming signal impulse is at full strength in the middle of the signal. If a positive impulse is received at this instant, a positive potential is impressed upon the grid of tube 2 and current will therefore flow from battery B_1 , through the corresponding printer selecting magnet, through brush BR_2 , plate and filament of tube 2 and through resistance R back to battery B_1 . While the current is still flowing in said circuit through tube 2 and the printer magnet, the pick-up brush BR_1 will contact with the next segment 21 of the corrector pick-up ring and since the positive impulse being received still persists, it will not make the grid of tube $2c$ positive because the current still flowing through resistance R produces a drop of potential which assists the battery C_2 in maintaining the grid of tube $2c$ sufficiently negative to prevent its operation.

If, however, the brushes are displaced in phase with relation to the incoming signals, so that the positive signal is received just as the brush BR_1 engages a corrector segment 21, thereby causing the grid of tube $2c$ to become positive, a current will flow from the corrector battery B_2 , through corrector magnet CM , pivoted lever 23, contact 25, conductor 26, plate and cathode of tube $2c$,

conductors 27 and 28 to battery B_2 . The magnet CM attracts its armature and causes the dog 29 to move the ratchet 30 the distance of one tooth. The ratchet is connected by a clutch or in some other suitable manner to the shaft carrying the brushes. In order that the lever 23 and contact 25 shall remain in contact until the magnet CM has caused a complete stroke of the dog 29, the lever 23 is not engaged by a stop on the dog until the armature has nearly completed its stroke, the lever being yieldingly held in either extreme position by a spring jockey 31. This method of correcting the phase position of the brushes by stepping the shaft carrying the brushes either forwardly or backwardly has long been known to telegraph engineers.

In Figure 7, I have shown a complete receiving system embodying the features disclosed in Figures 2, 3, 5 and 6. The incoming line EL is balanced for duplex operation by the artificial line AL , the receiving bridge which includes the elements R_1 , L_1 , c and r , being connected between the line EL and the artificial line AL in conjugate relation to the transmitting relay TR . The incoming signals are impressed alternately upon the grid circuits of the tubes $2a$ and $2b$ by the pick-up rings 20, as described in connection with Figure 2. The cathodes of the tubes $2a$ and $2b$ are connected through a resistance R to the artificial line AL so that the tubes operate by the potential drop occurring across the resistance R_1 .

A biasing battery C_3 is connected in series with the solid pick-up ring and is poled so as to apply a bias to the grids of tubes $2a$ and $2b$ which will overcome the negative bias applied by batteries C_1 and C_2 . Due to the combined effect of the batteries C_1 , C_2 and C_3 , and drop in potential across to resistance R , a filling in of signals is obtained when the received signals are attenuated, as described in connection with Figure 2.

The plate circuits of tubes $2a$ and $2b$ include the solid rings $3a$ and $3b$, brushes BR_2 and BR_3 , segments $8a$ and $8b$, and storing relays SR and SR' , respectively. The relays SR and SR' have their contact tongues connected, respectively, to the alternate segments of the retransmitting rings for repeating the signals in re-generated form over the outgoing line WL . The relays are biased to their marking sides by the local restoring rings through the windings sr and sr' .

The corrector pick-up rings 21 are connected to the grid of a corrector tube $2c$ having in its plate circuit the corrector magnet CM , the circuit therefor being traced from the plate over conductor 26, contact 25, lever 23, corrector magnet CM , battery B_2 and conductors 28 and 27 to the

cathode of the tube. The resistance R is connected in the plate circuits of the tubes 2a and 2b and in the grid circuit of the tube 2c, so that the discharge through the corrector tube is blocked whenever a discharge occurs in either of the tubes 2a or 2b. Consequently, the tube 2c will start only when the distributor is out of phase following a spacing signal, as described in connection with Figure 6. The discharge in the tube 2c, however, does not effect the starting of a discharge through the other tubes.

It will be noted, therefore, that in the system of Figure 7, the receiver responds to signals received over the duplexed line, alternate signals being distributed to the tubes 2a and 2b and the resultant discharges in these tubes being prolonged by the elongated segments 8a and 8b for a period greater than the normal signal period, the signals being retransmitted in regenerated form by the relays SR and SR1 to the outgoing duplexed line. Attenuated or weak signals are filled in without the use of vibrating relays or similar expedients and the distributors are maintained in synchronism with the incoming signals by the corrector mechanism.

I wish it to be understood that the illustrative diagrams are merely for the purpose of clearly disclosing my invention and that various changes in the circuits will be obvious to engineers without departing in any manner from the invention.

I claim:

1. In a multiplex telegraph system, the combination of a source of periodic telegraph signals, a distributor equipment including pick-up rings and storage rings, telegraph storage elements connected to said storage rings, a thermionic device of the type described having input and output circuits, said thermionic device being characterized by continued operation unaffected by grid potential after starting, said source of signals and said pick-up rings being included in said input circuit, and said storage rings, said telegraph storage elements and a source of current being included in said output circuit.

2. A telegraph system comprising a source of telegraph signals, an amplifier for amplifying said signals, a thermionic device of the type described including input and output circuits, said thermionic device being characterized by continued operation unaffected by grid potential after starting, a distributor equipment including solid and segmented rings and a brush movable thereover in synchronism with the received signals, said distributor element being connected in said input circuit and included in the output circuit of said amplifier, a second distributor element comprising transmitting rings and a brush movable thereover in

synchronism with said first distributor equipment, signal storage elements connected to the segments of said transmitting distributor, said second distributor element, said signal storage elements and a source of current being included in the output circuit of said thermionic device.

3. A telegraph system comprising a source of telegraph signals, a distributor equipment including transmitting rings and a brush movable thereover in synchronism with the received signals, a transmitting circuit connected to the solid and segmented elements of said transmitting rings and including a source of current and a thermionic device characterized by anode, cathode and starting electrode elements so constructed and arranged that current continues to flow in the anode-cathode circuit unaffected by the potential of the starting electrode after being started, and means controlled by the movable member of said distributor for impressing signals from said source upon the starting electrode of said thermionic device synchronously with the signal impulses.

4. A telegraph system comprising a source of telegraph signals, a thermionic device of the type described having input and output circuits, said thermionic device being characterized by continued operation unaffected by grid potential after starting, said source of signals being connected in said input circuit, a distributor ring included in said input circuit, and means for operating said distributor in synchronism with the incoming signals.

5. In a telegraph system the combination of a thermionic device of the type described having input and output circuits, said thermionic device being characterized by continued operation unaffected by grid potential after starting, a source of telegraph signals connected in said input circuit, means included in said input circuit for interrupting said circuit in synchronism with said signals, and means for maintaining the grid of said thermionic device negative with respect to the cathode when said input circuit is open.

6. In a telegraph system, two thermionic devices of the type described including input and output circuits, a distributor equipment including a solid ring, a segmented ring and a rotating brush, alternate segments of said segmented ring being connected to the grid element of one of said devices, and the remaining segments of said segmented ring being connected to the grid element of said second device, a source of telegraph signals connected between the cathodes of said devices and the solid ring of said distributor, distributor elements included in the output circuits of each of said devices, signal responsive devices controlled by each of said last mentioned distributors, and means for

rotating the brushes of all said distributors in synchronism with the telegraph signals.

7. In a telegraph system the combination of two thermionic devices of the type described including input and output circuits, a distributor element including a solid ring and a segmented ring alternate elements of which are connected to the grid of one of said devices and the remaining elements connected to the grid of the second device, a source of telegraph signals connected between the cathodes of said devices and the solid ring of said distributor, a source of current connected between the cathode and grid of each device for making the grid negative with respect to the cathode when the grid circuit is open, and a source of current included in a common path of said grid circuits for making the grid positive when the grid circuit is closed by said distributor and the amplitude of the line signal is not sufficient to determine the grid potential.

8. In a telegraph system the combination of two gaseous thermionic devices of the type described including input and output circuits, a distributor element including a solid ring and a segmented ring alternate elements of which are connected to the grid of one of said devices and the remaining elements connected to the grid of the second device, a source of telegraph signals connected between the cathodes of said devices and the solid ring of said distributor, a source of current connected between the cathode and grid of each device for maintaining the grid negative with respect to the cathode when the grid circuit is open, a source of current included in a common path of said grid circuits for making the grid positive when the grid circuit is closed by said distributor and the amplitude of the line signal is not sufficient to determine the grid potential, and a resistance included in a common path for the grid circuits and plate circuits of both said devices whereby when plate current flows in one device the grid of the other device is maintained negative with respect to its cathode when the grid circuit is completed by said distributor.

9. In a signaling system, a signal responsive means comprising a thermionic tube of the type described wherein the grid, anode and cathode elements are so constructed and arranged that, when started, the current flowing between anode and cathode is unaffected by the grid potential, a source of current, means for connecting said source in circuit with the anode and cathode for predetermined intervals in synchronism with the signals, and means for impressing a starting voltage upon the grid in synchronism with the signals.

10. The method of repeating signal impulses, which consists in establishing recurrent potentials in synchronism with the re-

ceived impulses, causing said potentials to establish a field in an arc path in a circuit connected to a source of power which first starts the flow of current from said source across the arc and then automatically nullifies the effect of said field upon the continued flow of current, interrupting the current flow after a predetermined interval and transmitting the recurrent periods of current flow from said source.

11. In a communication system, apparatus for repeating and regenerating the received intelligence signals, comprising a receiving three-element tube relay characterized by the anode, cathode and starting electrode elements so constructed and arranged that current continues to flow in the anode-cathode circuit irrespective of the starting electrode potential after being started by a predetermined potential applied to the starting electrode, means for impressing the received signal impulses upon the starting electrode, a source of current and a distributor operating to complete the connection of said source to the anode and cathode and to a transmitting circuit synchronously with the received intelligence signals for predetermined intervals.

12. In a signaling system, receiving means responsive to impulses of short duration, electrostatically controlled gas discharge tubes responsive to said short impulses, operating irrespective of grid potential after being started by said impulses, and impulse transmitting means determining the duration of operation of said tubes.

13. In a signaling system, apparatus for receiving from a line or cable impulses of short duration recurring in rapid succession, electromagnetic translating devices, electrostatically controlled gas discharge tubes, having an input circuit including a grid element connected to receive said impulses of short duration and an output circuit including anode and cathode elements connected to said translating devices, said grid, anode and cathode elements being so constructed and arranged that the output circuit is unaffected by the grid potential after being started, and means for determining the duration of the operation of the output circuit.

14. In a signaling system, a signal responsive means comprising a thermionic tube of the type described wherein the grid, anode and cathode elements are so constructed and arranged that when started the current flows between anode and cathode unaffected by the grid potential, a source of current, means for connecting said source in circuit with the anode and cathode for predetermined intervals in synchronism with the signals, and means for impressing a starting voltage upon the grid in synchronism with the signals.

15. A communication system, comprising a signal receiving apparatus responsive to intelligence signals of varying polarity including a thermionic tube relay characterized by anode, cathode and starting electrode elements so constructed and arranged that current continues to flow in the anode-cathode circuit unaffected by the potential of the starting electrode after being started by a positive starting potential applied to the starting electrode.

16. In a communication system as set forth in claim 15, means for impressing the received intelligence signals upon the starting electrode, a transmitting circuit including a source of current, and means for connecting said transmitting circuit to the anode and cathode synchronously with the received signals.

17. In a signaling system, an electric discharge device having a controlling circuit and a controlled circuit, an indicating device normally maintained in an unoperated condition, said indicating device being adapted to assume an operative condition by a current in said controlled circuit under the influence of said controlling circuit and to be maintained in said operative condition by said current independent of changes in the condition of the controlling circuit.

18. In a telegraph system, a source of signals, a gaseous conduction device having a starting condition differing from its operating condition, means for applying a starting condition to said device in accordance with said signals to initiate a discharge therethrough, and means operating independently of the energy of said discharge for limiting the operating condition, so as to interrupt the discharge.

19. In a telegraph signaling system, a source of signal impulses, a receiver comprising a gaseous conduction device having a starting element, an output circuit for said device, means for applying a signal condition to said starting element to initiate a discharge through the device whereby a current flow is produced in the output circuit, means for maintaining said discharge independently of said starting element, current responsive means in said output circuit and means independent of said current responsive means for interrupting the discharge through said device.

20. In a signaling system, a source of signal impulses, a receiver comprising an electric discharge device having a starting element, an output circuit for said device, means for momentarily applying a signal condition to the starting element to initiate a discharge through the device whereby current flow is produced in the output circuit, means for maintaining said discharge beyond the period of application of said signal condition to the starting element, and means

independent of said device for interrupting a discharge through the device.

21. In a telegraph signaling system, an electric discharge device, an output circuit therefor, means for applying a signal condition to said device to initiate a discharge therethrough whereby to produce a current flow in said output circuit, means for maintaining said discharge beyond the period of application of said signal condition to the device and means for interrupting said output circuit externally of the device to terminate the discharge.

22. In a telegraph signaling system, an electric discharge device, means for applying a signal condition to said device to initiate a discharge therethrough, means independent of energy supplied by said signal condition for maintaining the discharge and means operating independently of the energy applied to or supplied by said device for terminating the discharge.

23. In a signaling system, an electrostatically controlled gas discharge tube, responsive to short signal impulses, said tube, after a discharge has been started therethrough by a signal impulse, operating irrespective of signal impulses applied thereto and circuit interrupting means for determining the duration of operation of said tube.

24. In a signaling system, an electric discharge device, an output circuit therefor, a source of signals, means for applying said signals to said device to initiate a discharge therethrough and means in said output circuit operating in substantial synchronism with said signals for interrupting the discharge.

25. In a signaling system, an electric discharge device, an output circuit therefor, a source of signals, means for applying said signals to said device to start a discharge therethrough and means in said output circuit operating in definite timed relation to the starting of said discharge for interrupting the discharge.

26. In a signaling system, an electric discharge device, a source of signal impulses, means for applying said impulses to said device to initiate a discharge therethrough, whereby to produce current flow in said output circuit, said device being characterized in that the magnitude of the current flow therethrough is constant and independent of the amplitude of the signal impulses, means for maintaining said discharge independent of said signal impulses, and means for terminating the discharge in timed relation to the signal impulses whereby substantially square-topped signals are produced in said output circuit.

27. In a communication system, apparatus for receiving telegraph signals, comprising a three-element tube relay characterized by

the anode, cathode and starting electrode elements so constructed and arranged that current continues to flow in the anode-cathode circuit irrespective of the starting electrode potential after being started by a predetermined potential applied to the starting electrode, means for impressing the received signal impulses upon the starting electrode, a source of current and means for completing the connection of said source to the anode and cathode synchronously with the received intelligence signals for predetermined intervals.

28. In a signaling system, a signal responsive means comprising an electric discharge device wherein the anode, cathode and starting means are so constructed and arranged that when started the current flows between anode and cathode unaffected by the condition of said starting means, a source of current, means for connecting said source in circuit with the anode and cathode for predetermined intervals in synchronism with the signals, and means for impressing a starting condition upon the starting means in synchronism with the signals.

29. In a communication system, an electric discharge device, means for supplying a signal condition to said device to start a discharge therethrough, means for maintaining said discharge independent of continued application of said signal condition to the device, an output circuit for the device, and a circuit interrupter in said output circuit operating in substantial synchronism with applied signal conditions for terminating the discharge through the device.

30. In a communication system, an electric discharge device, a controlling circuit and a controlled circuit therefor, a source of signals in said controlling circuit, a circuit interrupter in said controlling circuit for determining the application of said signals to the device to time the initiation of a discharge therethrough and a circuit interrupter in said controlled circuit for timing the termination of said discharge.

31. In a communication system, an electric discharge device, an input circuit therefor, a source of signals, means for applying said signals to the input circuit to initiate a discharge through the device, an output circuit and means operating after the application of a signal impulse to the device for interrupting both the input and output circuits, said input circuit being interrupted prior to the interruption of the output circuit.

32. In a signaling system, an electric discharge device, means for applying telegraph code signal impulses to said device to produce a discharge therethrough, an output circuit for said device, a plurality of receiving elements and means for connecting said

receiving elements in succession in said output circuit.

33. In a signaling system, an electric discharge device, means for applying telegraph code signal impulses to said device to produce a discharge therethrough, the magnitude of which is independent of the amplitude of the impressed signals, an output circuit for said device, a plurality of receiving elements and means for connecting said receiving elements in succession in said output circuit.

34. In a signaling system, an electric discharge device, means for applying telegraph code signal impulses to said device to produce a discharge therethrough, an output circuit for said device, a plurality of receiving elements and a distributor in said output circuit for determining the period of operation of said device in response to each signal impulse applied thereto and for connecting said receiving elements in succession in said output circuit.

35. In a signal system, apparatus for increasing the effective length of signal impulses comprising an electric discharge device responsive to signal impulses, said device being characterized by continued operation unaffected by signal impulses after being started by a signal impulse applied thereto, an output circuit for said device and a distributor in said output circuit.

36. In a signaling system, an electric discharge device, means for applying telegraph code signal impulses to said device to produce a discharge therethrough, an output circuit for said device, a telegraph recorder having a plurality of selecting magnets and a distributor in said output circuit connecting said magnets in succession in said output circuit in synchronism with said signals.

37. In a telegraph receiving system, a source of signals, means for filling in the attenuated impulses comprising two electric discharge devices, means for applying received signal impulses to said device alternately, means for creating a discharge through one of said devices in response to signals of one polarity and means for blocking a discharge through the other tube when the following signal is attenuated to a predetermined degree.

38. In a telegraph receiving system, a source of signals, means for filling in the attenuated impulses comprising two electric discharge devices, means for applying received signal impulses to said device alternately and means for periodically creating and interrupting the discharge through one of said devices and continuously blocking the discharge through the other device when said signals are attenuated to a predetermined degree.

39. In a telegraph system, the combination of two electric discharge devices hav-

ing input and output circuit, means for applying received signal impulses to said devices alternately, means normally restricting the discharge through said devices, means for applying a starting condition to one of said devices when a signal attenuated to a predetermined degree is applied thereto, an output circuit for each device and means in the output circuit of an operating tube responsive to current flow therein for preventing a discharge in the other tubes when the following signal applied thereto is attenuated to a predetermined degree.

40. In a telegraph system, the combination of two electrostatically controlled gas discharge tubes having input and output circuits, means in the input circuit for applying received signal impulses to said tube alternately, means for applying a bias in said input circuit of a nature to prevent a discharge through said tubes, a source of potential adapted to be connected in said input circuit simultaneously with the application of received signal impulses to said tubes, said potential being in opposition to said bias and serving to apply a starting potential to the tube to which it is connected when the signal impulse is of an indeterminate polarity; said input and output circuits having a common path and means in said path operating when there is a current flow in the input circuit of one tube for preventing the starting of a discharge through another tube, when the signal applied to the last mentioned tube is of an indeterminate polarity.

41. In a telegraph system, the combination of two electrostatically controlled gas discharge tubes having input and output circuits, means in the input circuit for applying received signal impulses to said tube alternately, means for applying a bias in said input circuit of a nature to prevent a discharge through said tubes, a source of potential adapted to be connected in said input circuit simultaneously with the application of received signal impulses to said tubes, said potential being in opposition to said bias and serving to apply a starting potential to the tube to which it is connected when the signal impulse is of an indeterminate polarity, said input and output circuits having a common path and a resistance in said path arranged so that the potential drop thereacross, when there is a current flow in the output circuit of one tube, will apply a blocking potential to the input of the other tube, of such value as to prevent the starting of a discharge therethrough when the signal applied thereto is of an indeterminate polarity.

42. In a telegraph system, a source of code signal impulses of varying polarity, a pair of electric discharge devices having controlling and controlled circuits, means in said

controlling circuit for applying said signal impulses alternately to said devices to create a discharge therethrough and current responsive means in said controlled circuit.

43. In a telegraph system, a source of recurrent signal impulses, a pair of electric discharge devices having controlling and controlled circuits, means in said controlling circuit for applying said signal impulses alternately to said devices to create discharges therethrough, means for maintaining the discharge through each device independently of the signal and means for terminating the discharge through one device after the application of the succeeding signal to the other device.

44. In a telegraph system, a source of recurrent signal impulses, a plurality of electric discharge devices of the type in which a discharge once started therein continues independently of the starting condition, means for applying starting or non-starting conditions to said tubes in succession in accordance with the received marking or spacing signal impulses, respectively, and means for interrupting the discharge through each tube before the reapplication of a starting condition thereto.

45. In a telegraph system, a source of recurrent signal impulses, a plurality of electric discharge devices of the type in which a discharge once started therein continues independently of the starting condition, means for applying starting or non-starting conditions to said tubes in succession in accordance with the received marking or spacing signal impulses, respectively, and means for interrupting the discharge through each tube after the arrival of the succeeding signal impulse but before the arrival of the impulse which controls the application of a starting or non-starting condition thereto.

46. In a telegraph system, means for increasing the effective length of signal impulses comprising a pair of electrostatically controlled gas discharge devices, means for distributing received signal impulses to said devices alternately to create discharges therethrough, means for maintaining the discharge through each tube for a period longer than the normal period of the received impulses and means for interrupting the discharge therethrough before the application of a succeeding impulse thereto.

47. In a telegraph system, a source of signals, a resistance element, means for causing a current flow through said resistance in accordance with a received signal impulse, an electric discharge device and means responsive to the drop in potential across said resistance for controlling the operation of said device.

48. In a telegraph system, a source of signals, a resistance element, means for causing a current flow through said resistance

element in accordance with a received signal condition, a gaseous conduction device having a starting means, said starting means being connected to said resistance whereby the drop in potential across said resistance due to current flow therethrough, restricts the starting of said device and means for applying a potential to said starting means in accordance with another signal condition to overcome said restriction whereby to create a discharge through the device.

49. In a telegraph system, a source of signals, a plurality of electric discharge devices, means for normally applying starting conditions to said devices in succession, when no signals are received from said source and means responsive to the creation of a discharge through one device for precluding the starting of a discharge through the other thereof.

50. In a telegraph system, a source of signals, an electric discharge device and means operating in substantial synchronism with said signals for intermittently applying a starting condition to the device when no signals are received.

51. In a telegraph system, a source of signals, an electric discharge device and means operating in substantial synchronism with said signals for intermittently applying a starting condition to the device when no signals or signals of a marking character are received and means for applying a non-starting condition to the device when a signal of spacing character is received.

52. In a telegraph system, a source of telegraph signals, an electric discharge device and means for creating an intermittent discharge through said device in timed relation to every alternate signal impulse when the amplitude of said signal impulses is below a predetermined minimum.

53. In a telegraph system, means for increasing the effective length of signals comprising a plurality of electric discharge devices, means for distributing said signals in succession to said devices to create discharges therethrough, means for maintaining said discharges independent of the continued application of signals to said devices, an output circuit for each device and contact means in each output circuit for determining the period of operation of the device associated therewith, said contact means being arranged to continue the operation of one device into the period of operation of the succeeding device.

54. In a duplex telegraph system, a main line, an artificial line, a receiving net work connected between said main and artificial lines including a resistance element, an electric discharge device having input circuit connected across said resistance whereby discharges are produced therein due to the drop

in potential across said resistance occasioned by the incoming signals.

55. In a duplex telegraph system, a main line, an artificial line, a receiving net work connected between said main and artificial lines including a resistance element, an electric discharge device having input circuit and means for connecting said input circuit across said resistance in synchronism with the received signals whereby discharges are produced in the device due to the potential drop across said resistance occasioned by the incoming signals.

56. In a duplex system, a main line, an artificial line, a current conducting path for received signals between said main and artificial lines, an electric discharge device, means for starting a discharge through said device upon predetermined current flow through said path, produced by said signals, means for maintaining said discharge independent of current flow and means for terminating the discharge in definite time relation to said received signals.

57. In a duplex telegraph system, a main line, an artificial line, an electrostatically controlled gas discharge path, a controlling circuit therefor connected between said main and artificial lines and arranged for producing a discharge through said path, upon reception of predetermined signals and means independent of said signals for interrupting the discharge.

58. A duplex telegraph system, comprising a main line, an artificial line, a transformer having its primary winding connected across said main and artificial lines and an electric discharge tube having an input circuit including the secondary winding of said transformer, said device responding to direct current telegraph signals transmitted over said line and impressed on the primary of said transformer and serving to repeat the same of substantially full duration and uniform magnitude.

59. A duplex telegraph system, comprising a main line, an artificial line, a transformer having its primary winding connected across said main and artificial lines, an electric discharge tube having an input circuit including the secondary winding of said transformer and means for connecting the secondary winding of said transformer in said input circuit during the forward part only of each signal impulse.

60. In a telegraph system, a source of signals, a transformer, an electric discharge tube having an input circuit and means for applying the rising portion only of each signal impulse to said input circuit through said transformer, to create a discharge through the tube.

61. In a telegraph system, a source of signals, a transformer, an electric discharge tube having an input circuit and contact

mechanism for connecting the primary winding of the transformer to said signal source and the secondary winding in said input circuit in substantial synchronism with the signals.

62. In a telegraph system, a source of signal impulses, a transformer, signal responsive means in the secondary circuit of said transformer and means for connecting the primary winding of the transformer to said source of signals in substantial synchronism therewith.

63. In a telegraph system, a source of signal impulses, a transformer, signal responsive means in the secondary circuit of said transformer and means for connecting the primary winding of the transformer to said source of signals during the period of increase of each signal impulse and for disconnecting said winding from the source of signals during the period of decay of the impulse.

64. In a telegraph system, a source of signals, an electric discharge device, a non-conductive coupling between said source of signals and said device whereby the device is caused to respond to received signal impulses to produce a discharge therethrough and means independent of said signals for interrupting the discharge.

65. A regenerative repeater comprising an electrical discharge device, an output circuit therefor, a plurality of storage elements, means for creating discharges through said device in accordance with received signals and means for connecting said storage elements in succession in said output circuit in synchronism with said received signals.

66. A regenerative repeater comprising an electric discharge device, an output circuit therefor, a plurality of storage elements, means for creating discharges through said device in accordance with received signals, means for connecting said storage elements in succession in said output circuit in synchronism with said received signals, an outgoing line and a transmitter associated with said storage elements for repeating the received signals to said outgoing line.

67. A regenerative repeater comprising an electric discharge device, an output circuit therefor, a plurality of storage elements, means for creating discharges through said device in accordance with received signals, means for connecting said storage elements in succession in said output circuit in synchronism with said received signals, an outgoing line, one of said storage elements serving to repeat a received signal impulse over the outgoing line during the time of connection of the succeeding storage element in the output circuit.

68. A regenerative repeater comprising an electrostatically controlled arc discharge tube, input and output circuits therefor, a

source of signals, means for connecting said source of signals in the input circuits in synchronism with the signals to start discharges through said tube, means independent of the signals for interrupting said discharges, a plurality of storage elements and means for connecting said storage elements in succession in the output circuit during such discharge periods.

69. A regenerative repeater for a telegraph system comprising an electrostatically controlled arc discharge tube, means for applying received signals of attenuated or distorted form to said tube to initiate a discharge therein, the magnitude of which is constant and independent of the amplitude of the received signals, means for prolonging said discharge for a full signal period and means for utilizing said discharge for re-transmitting the signals in regenerated form.

70. A telegraph system comprising a source of signals, a circuit interrupting device operating in substantial synchronism with said signals, a corrector mechanism for said device, an electric discharge tube responsive to received signal impulses, and a second electric discharge tube, normally non-responsive to signal impulses, but responding to said signals when an out of phase condition of said device occurs, said second discharge device, upon operation thereof, actuating said corrector mechanism to restore the phase relation of said device, relative to the signals.

71. A telegraph system comprising a source of signals, two electric discharge tubes, means for distributing a different part of each signal impulse to each of said tubes, an output circuit for each tube, a signal receiving device in the output circuit of one tube and a control mechanism in the output circuit of the other tube.

72. A telegraph system comprising a source of signal impulses, a plurality of electric discharge tubes, and means for distributing a single signal impulse to said tubes in succession to initiate discharges therein, said discharges being maintained independently of the continued application of the signal impulse to said devices.

73. A telegraph system comprising a source of signals, two electric discharge tubes, a distributor operable in synchronism with said signals, for distributing different parts of each signal impulse to each of said tubes, an output circuit for each of said tubes, a signal receiving device in the output of one of said tubes and a control mechanism for said distributor in the output circuit of the other tube.

74. A signal squaring and lengthening device comprising an electric discharge tube of the type in which the discharge may be started by momentary application of a sig-

nal condition thereto and continued at a uniform magnitude independently of signal conditions, and a timing device for interrupting the discharge.

- 5 75. In a communication system, a source of signals, a plurality of electric discharge tubes having input and output circuits, means for selectively connecting the input circuit to said source of signals to create dis-
10 charges in said tubes selectively, and means in the output circuit of said tubes for interrupting the discharges therethrough.

In testimony whereof I affix my signature.

HAKON H. HAGLUND.

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DISCLAIMER

1,901,296.—*Hakon H. Haglund*, Flushing, N. Y. MULTIPLEX TELEGRAPH SYSTEM.
Patent dated March 14, 1933. Disclaimer filed June 1, 1935, by the
20 patentee, the assignee, *The Western Union Telegraph Company*, assenting.

Hereby disclaims the system defined in claim 47 of said patent, No. 1,901,296, except when limited to read upon the disclosure of said patent and wherein "said resistance element" is arranged to be connected in both the input and output circuits of the electric discharge device.

25 [Official Gazette June 18, 1935.]

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