Oct. 11, 1932. A. E. FROST 1,881,458

TELEGRAPH RECEIVING OR REPEATING CIRCUIT

Filed April 10, 1930 4 Sheets-Sheet 1

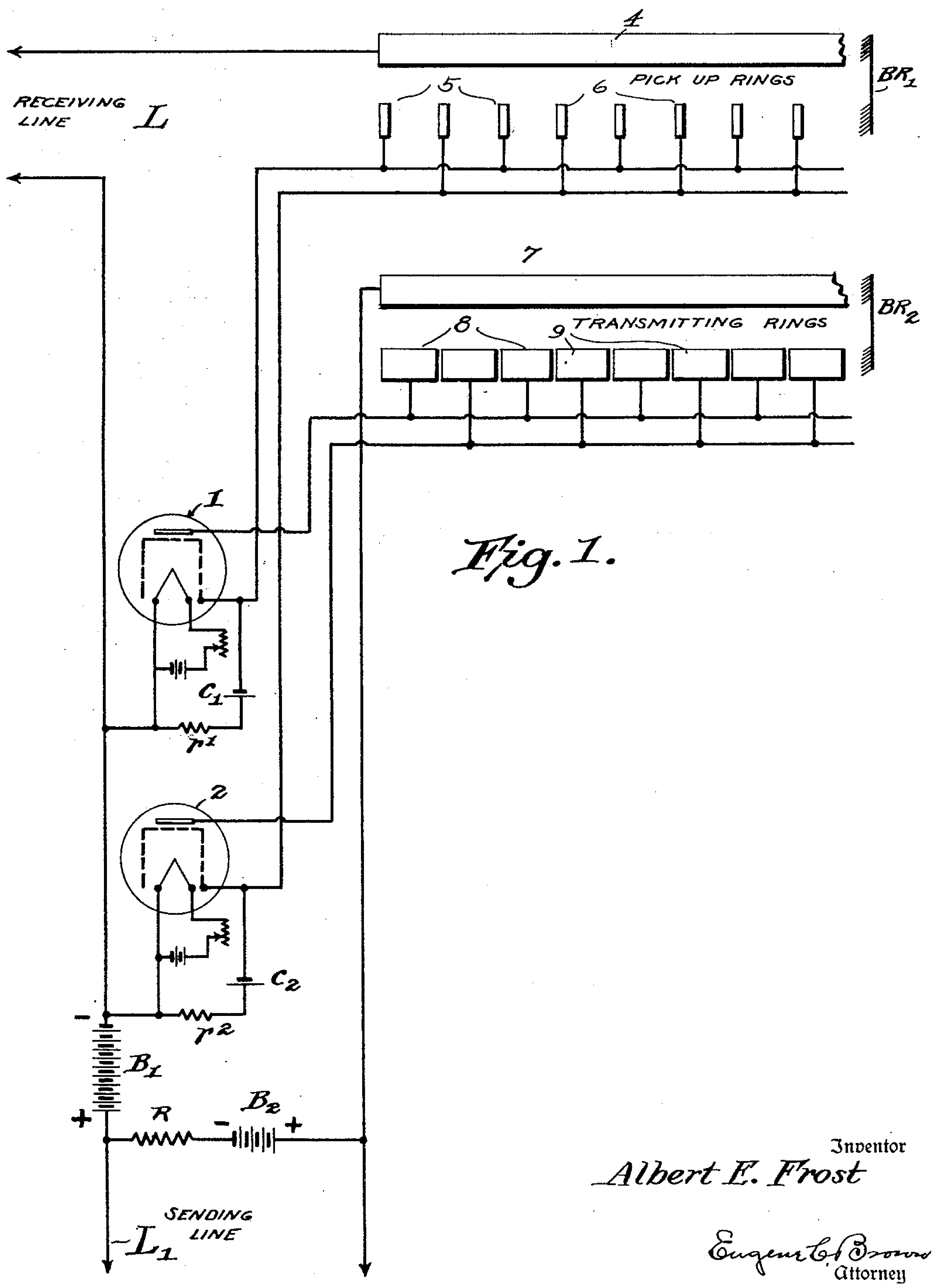

Fig. 1.

Inventor

Albert E. Frost

Eugene C. Brown

Attorney

Oct. 11, 1932.

A. E. FROST

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4 Sheets-Sheet 2

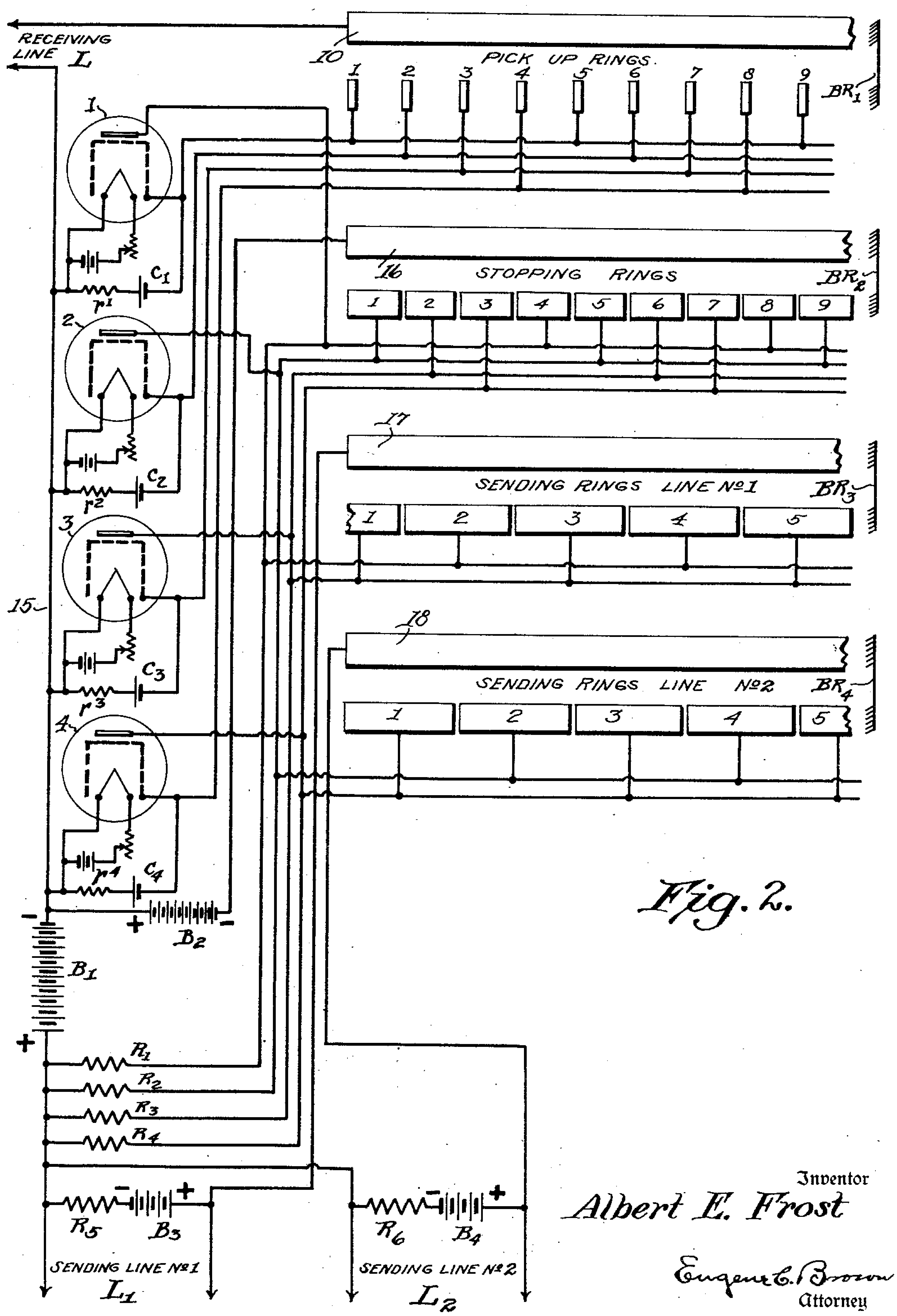

Fig. 2.

Inventor

Albert E. Frost

Eugene C. Brown

Attorney

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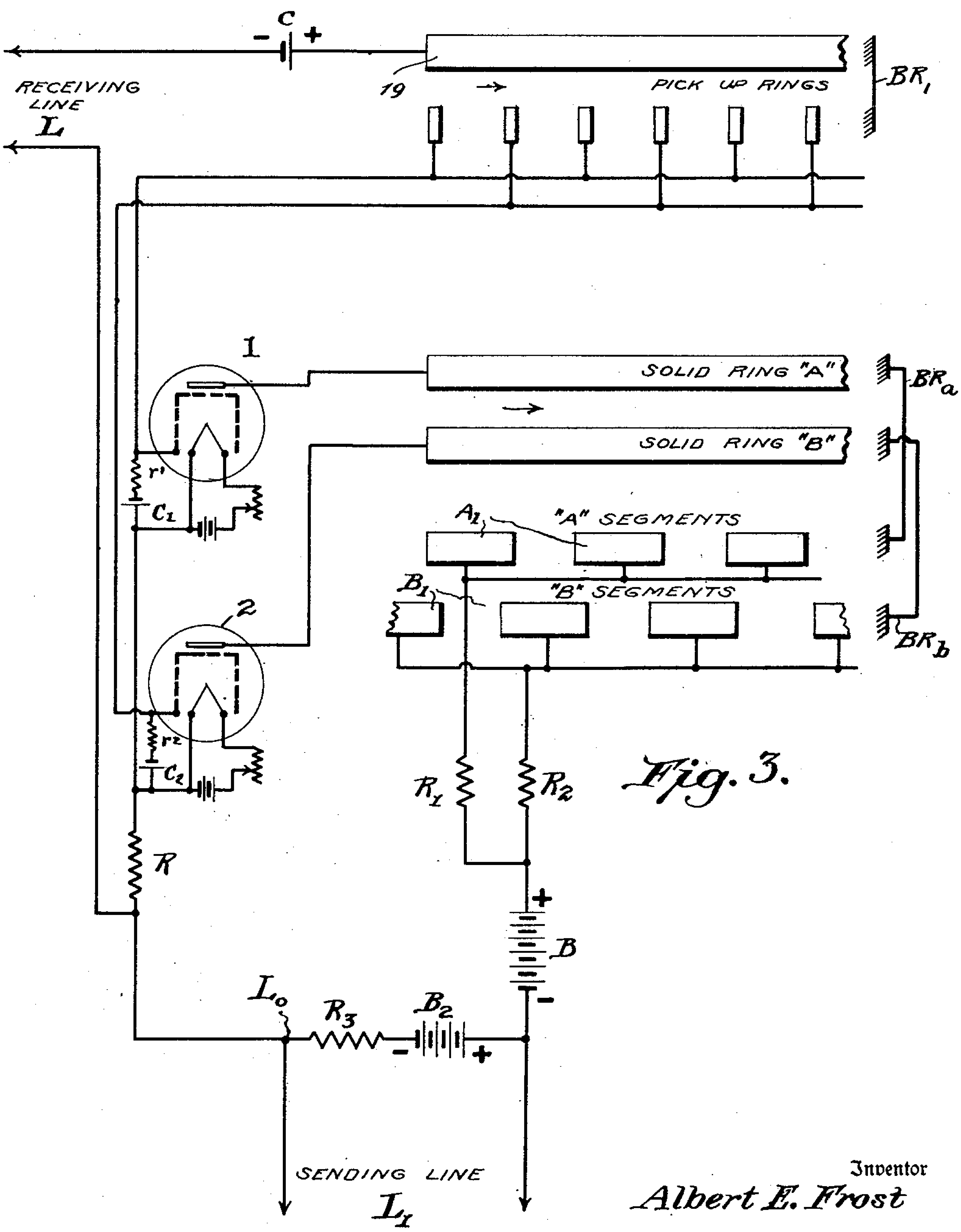

Fig. 3.

Inventor
Albert E. Frost

Eugene C. Brown
Attorney

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Fig. 4.

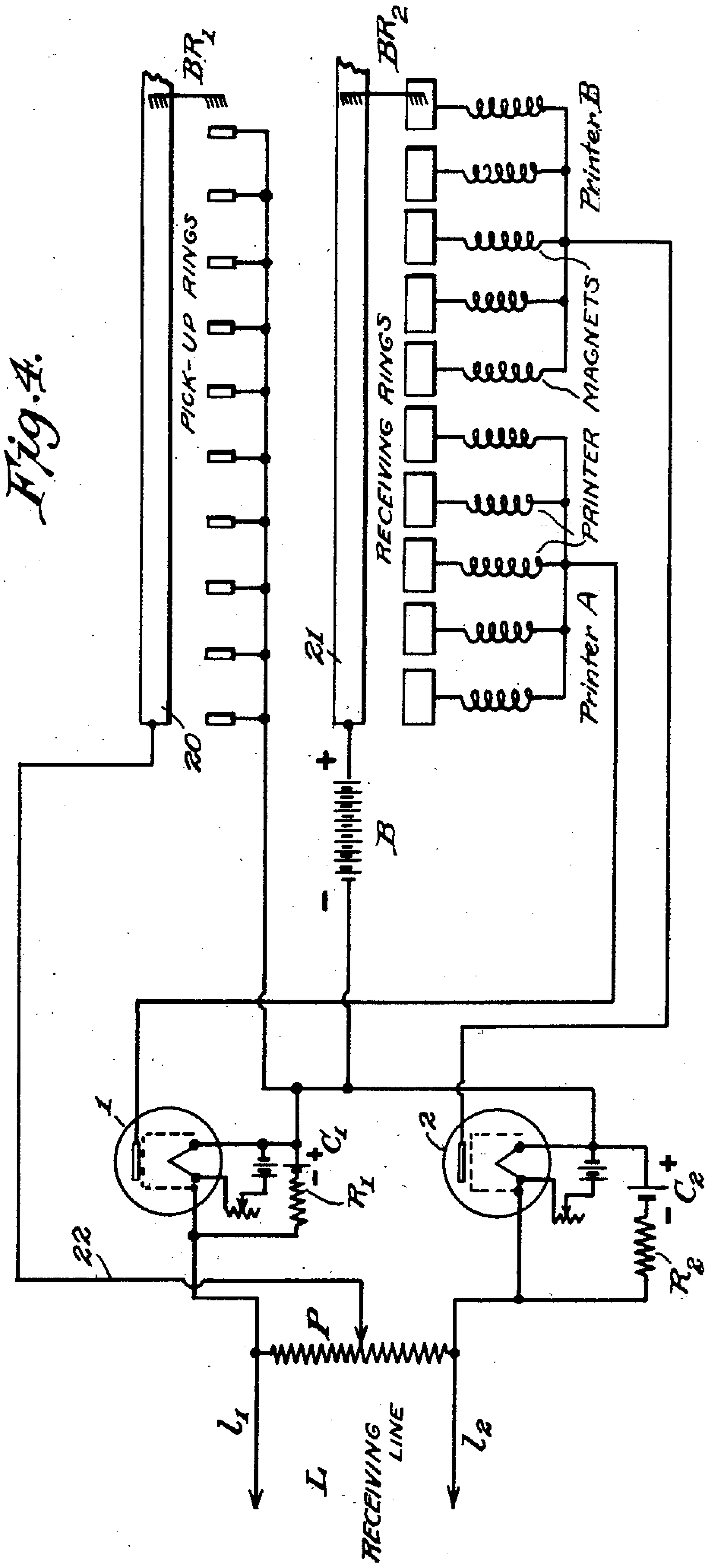
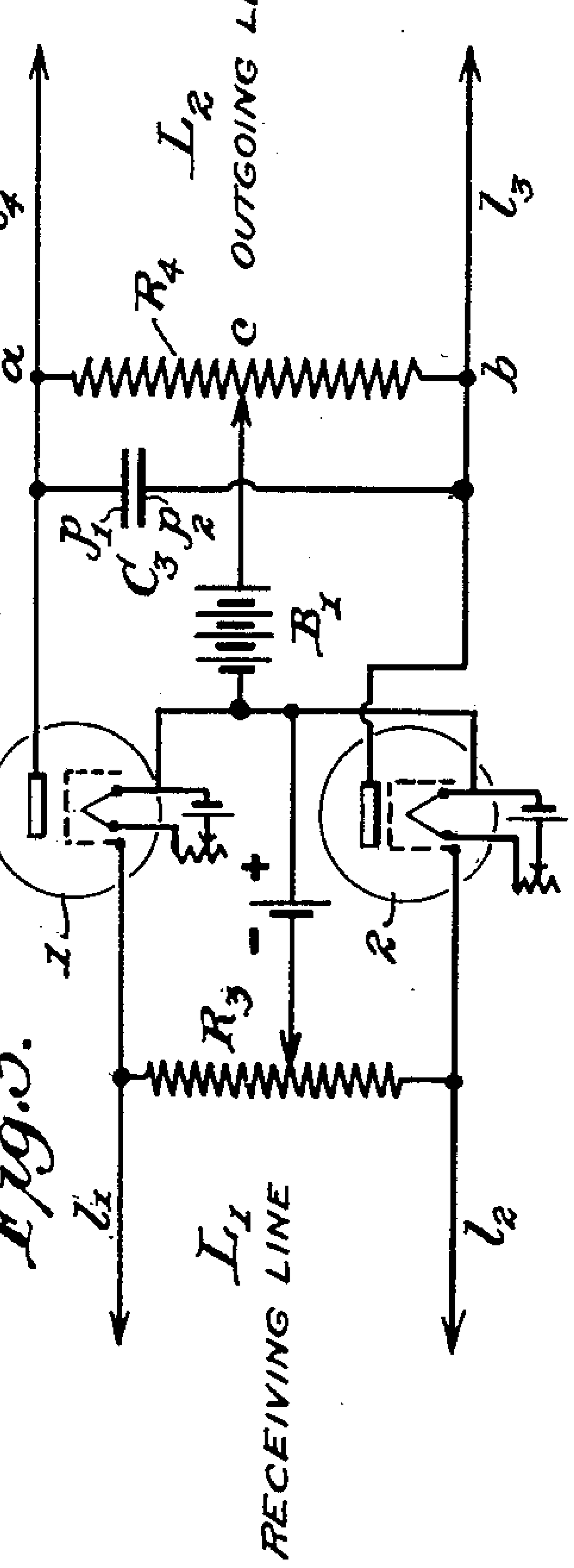


Fig. 5.



Inventor
Albert E. Frost

Eugene E. Brown
Attorney

Patented Oct. 11, 1932

1,881,458

UNITED STATES PATENT OFFICE

ALBERT E. FROST, OF BROOKLYN, NEW YORK, ASSIGNOR TO THE WESTERN UNION TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

TELEGRAPH RECEIVING OR REPEATING CIRCUIT

Application filed April 10, 1930. Serial No. 443,212.

This invention relates to telegraph receiving or repeating circuits, and in particular to circuits employing relay devices of the thermionic type hereinafter described, wherein the grid serves only to start the tube into operation.

An object of this invention is to devise circuit arrangements for employing thermionic tubes for repeating telegraph signals into a printer or other recorder or from one line to another.

A further object of the invention is to devise circuit arrangements whereby a thermionic tube device may be utilized for controlling the retransmission of both positive and negative signal impulses.

A further object is to devise a telegraph repeating relay for filling in attenuated signal impulses.

Still another object is to devise a telegraph repeating system in which the signals from one line are stored up and retransmitted over a plurality of lines.

My invention is illustrated in the accompanying drawings in which:

Figure 1 illustrates a simple repeating arrangement employing two thermionic tubes for repeating telegraph signals from one line to another.

Figure 2 illustrates a repeater employing four thermionic tubes for storing up the signals from a receiving line and retransmitting the signals to two sending lines.

Figure 3 illustrates a repeater system for filling in impulses which have been attenuated.

Figure 4 shows a relay system employing two thermionic tubes, one of which operates on positive impulses and the other operates on negative impulses.

Figure 5 shows a repeating arrangement employing two thermionic tubes in "push-pull" relation for repeating telegraph signals from one line to another, statically, without any moving parts and without employing a magnetic circuit.

The special device, or thermionic tube, employed in my invention comprises gas-filled thermionic tubes 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 current. 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 the grid is powerless to stop the plate current, once it is started. It can only be stopped by removing the plate voltage. The tube may be unstable with a free grid and hence a small negative potential is normally applied to the grid to keep the tube from starting.

The function of the grid may therefore be likened to a trigger. The amount of power required to start the tube is exceedingly small. A thermionic tube having the characteristics described is disclosed in patent to Irving Langmuir No. 1,289,823. The name "thyratron" has been applied to tubes of this 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 suitable forms are described.

Referring to Figure 1, L represents a receiving line, and L_1 a sending line. Numerals 1 and 2 indicate gaseous thermionic tubes of the type described above. One side of the incoming or receiving line L is connected to the solid ring 4 of the pick-up rings of the distributor equipment, which is provided with rotating brushes BR_1 and BR_2 operated in synchronism with the incoming signals. Alternate segments 5 of the segmented pick-up ring are connected to the grid of tube 1, and the remaining segments 6 are connected to the grid of tube 2. The other side of the receiving line L is connected to the cathodes of tubes 1 and 2. One side of the sending line L_1 is connected to the cathodes of vacuum tubes 1 and 2 through a battery B_1. The other side of the sending line is connected to the solid ring 7 of the transmitting rings. Alternate segments 8 of the segmented transmitting ring are connected to the plate of tube 1, and the remaining segments 9 of this ring are connected to the plate of tube 2. A battery B_2 and a resistance R are connected in series across the terminals of sending line L_1, batteries B_1 and B_2 being properly poled to supply plate current to tubes 1 and 2 through the transmitting rings. C_1 indicates a battery connected between the cathode and grid of tube 1 through a limiting resistance r' for maintaining the grid negative when the input circuit is disconnected from the grid circuit, and a battery C_2 and resistance r^2 are provided in connection with tube 2 for the same purpose.

The operation of Figure 1 is as follows:

Brushes BR_1 and BR_2 of the pick-up transmitting rings respectively, are rotated in synchronism with the incoming signals. Normally battery B_2 transmits negative current to the left hand side of the sending line L_1, that is when both tubes are deenergized. Tubes 1 and 2 are operated only by positive impulses received from the incoming line, and when a positive pulse is received, one or the other tube will be operated, thereby causing a current to flow in the plate circuit. The constants of the plate circuits are so adjusted that when either tube is energized, and current is flowing in the plate circuit, the positive polarity of battery B_1 overcomes the negative polarity of battery B_2 in the line L_1 and positive current is therefore transmitted to the left side L_1 of the sending line. Hence as long as positive impulses are received in succession on the receiving line, positive current is transmitted to the sending line. When a negative impulse is received over the line L, neither tube is started and no current flows in the tube circuits and the circuit of battery B_1 is open. Accordingly battery B_2 transmits negative current to the sending line L_1.

In Fig. 2 there is shown a system for receiving and storing signals from one line and retransmitting the signals alternately into each of two other lines. Four thermionic tubes 1 to 4 are employed, the cathodes of which are connected to one side of receiving line L. The other side of the receiving line is connected to the solid ring 10 of the pick-up rings. The rotary distributor equipment includes pairs of pick-up rings, stopping rings, sending rings for line No. 1, and sending rings for line No. 2, with corresponding rotating brushes BR_1, BR_2, BR_3 and BR_4 operating in synchronism with the incoming signal impulses. Segments 1, 5, 9 etc. are connected to the grid of tube 1. Segments 2, 6, 10 etc. are connected to the grid of tube 2; segments 3, 7, 11 etc. are connected to the grid of tube 3 and segments 4, 8, 12 etc. are connected to the grid of tube 4. The left hand sides of sending lines No. 1 and No. 2 are connected to the cathodes of tubes 1 to 4 through a battery B_1. The plate elements of tubes 1 to 4 are connected to the common cathode terminal conductor 15, through battery B_1 and resistances R_1 to R_4, respectively. The plate element of tube 1 is also connected to segments 4, 8, 12 etc. of the segmented stopping ring; the plate element of tube 2 is also connected to segments 2, 6, 10 etc. of said ring; and the plate of tube 4 is connected to segments 3, 7, 11 etc. of said ring. The solid stopping ring 16 is connected to the common cathode terminal 15 through a battery B_2 with the negative terminal of the battery connected to the ring. Alternate segments of the sending rings for line No. 1 are connected to the plate of tube No. 1, and the remaining segments for line No. 1 are connected to the plate of tube No. 3. In like manner, alternate segments of line No. 2 sending rings are connected to the plate element of tube 2, and the remaining segments are connected to the plate of tube No. 4. The solid rings 17 and 18 of the two sending rings, are connected respectively to the right hand sides of lines L_1 and L_2. Battery B_3 is connected in series with a resistance R_5 across the terminals of sending line L_1, and Battery B_4 is connected in series with a resistance R_6 across the terminals of line L_2. Batteries B_1 and B_3 are properly poled to supply plate current to tubes 1 and 3 through the sending rings for line No. 1, and batteries B_1 to B_4 are properly poled to supply plate current to tubes 2 and 4 through the sending rings for line No. 2.

The operation of Figure 2 is as follows:

It is understood that brushes BR_1 to BR_4 are rotated in synchronism with the incoming signal impulses. Each tube picks up every fourth pulse from the receiving line. Since the plate circuits for the tubes remain closed at all times through resistances R_1 to R_4 respectively, each tube will remain energized after it is once started until it is stopped by operation of the stopping rings. Positive impulses picked up by tubes 1 and 3 are therefore stored up and retransmitted to sending line No. 1 through sending rings for line No. 1. Positive impulses picked up by tubes 2 and 4 are stored up and retransmitted to sending line No. 2 by sending rings for line No. 2. After a tube has been operated and its signal has been transmitted to the corresponding sending line, some means must be provided for removing the operating potential from the plate of the tube. Battery B_2 connected to the stopping rings is provided for this purpose, and is so poled that when the brush BR_2 of the stopping rings connects negative pole of battery B_2 to the plate circuit of the tube which has been operated, the effect of negative polarity of

B_2 battery overcomes the positive polarity battery B_1, thereby applying a negative potential to plate of the tube, and thus stopping the plate current.

The tubes operate only on positive pulses and can therefore transmit only signals of positive polarity. In order to transmit signals of negative polarity, batteries B_3 and B_4 are permanently connected to sending lines L_1 and L_2 respectively. These batteries normally transmit negative current to the left side of each sending line when no positive signal comes in on the receiving line L. When a tube is operated by an incoming positive impulse, the circuit constants are such that a positive signal is transmitted to the line. This is brought about by the effect of the stronger positive potential of the battery B_1 overcoming the negative potential of the smaller battery B_3 or B_4 as previously explained in describing Fig. 1.

In Figure 3, I have shown a repeater system for filling in signal impulses that have been attenuated to such an extent that they cannot be received. Two thermionic gaseous repeaters 1 and 2 are employed, the cathodes of which are connected together and to one side of receiving line L through a resistance R. The other side of receiving line L is connected through a battery C to the solid pick-up ring 19. The distributor equipment includes the solid and segmented pick-up rings, solid transmitting rings A and B, and segmented transmitting rings A_1 and B_1. The pick-up brush BR_1 and the transmitting brushes BR_a and BR_b are rotated in synchronism with the incoming signals in the well known manner. Alternate segments of the segmented pick-up ring are connected to the grid of tube 1, and the remaining segments are connected to the grid of tube 2. The plate element of tube 1 is connected to solid transmitting ring A, and the plate of tube 2 is connected to the solid transmitting ring B. The left hand side of sending line L_1 is connected to the cathodes of tubes 1 and 2 through resistance R. The right hand side of transmitting line L_1 is connected through a battery B_1 to segmented transmitting ring A through a resistance R_1 and to segmented transmitting ring B through a resistance R_2. A battery B_2 is connected in series with a resistance R_3 across the terminals of sending line L_1.

The operation of Figure 3 is as follows:

With neither tube operating, battery B_2 transmits negative current to the left hand side of sending line L_1. Tubes 1 and 2 operate only on positive pulses and can, therefore, transmit only signals of positive polarity. When a tube is operated by an incoming positive pulse, the circuit constants are such that the effect of battery B_1 overcomes that of battery B_2 and positive current is transmitted to the left hand side of line L_1. This is because the drop of potential across the resistance R produces a positive potential at the intersection L_0 which overcomes the negative potential produced at this point by the battery B_2.

If the incoming signal is so attenuated that its effect is zero at the moment that pick-up brush BR_1 passes over a pick-up segment connected to, say tube 1, the potential from battery C will operate this tube. When the pick-up brush BR_1 passes over the next succeeding pick-up segment, which is connected to tube 2, the tendency of battery C is to cause the operation of tube 2, but since at this moment, due to the fact that current is flowing through resistance R, the potential of the grid of tube 2 has been still further lowered, owing to the drop of potential in resistance R, and is sufficiently negative to prevent its operation. No current will, therefore, be passed through the plate circuit of tube 2. Accordingly a negative potential is transmitted to the left hand conductor of the sending line L_1 by the battery B_2. This alternating operation of tubes 1 and 2 continues as long as the output of the amplifier is zero. In this manner single impulses which are not received, are "filled-in" by the action of the local circuit and battery C.

In Figure 4, I have shown a system for operating printer magnets on either plus or minus line signals. A potentiometer resistance P is connected across the terminals of receiving line L. The mid-point of this resistance is connected to the solid pick-up ring 20 through conductor 22. The upper side or conductor 1_1 of receiving line L is connected to the grid of thermionic tube 1, and the lower side 1_2 is connected to the grid of thermionic tube 2. The segmented pick-up ring is connected to the cathodes of both tubes. The grids are connected to the cathodes through batteries C_1 and C_2 and limiting resistances R_1 and R_2 to maintain the grids of the tubes negative with respect to the cathodes when the circuits are open. The solid receiving ring 21 is connected to the cathodes of the tubes through a battery B which supplies "space" current to the tubes through the receiving rings. One-half of the segments on the receiving rings are connected to the selecting magnets for printer A, and these magnets are connected to the plate of tube 1. The other half of the segments on the segmented receiving ring are connected to the selecting magnets of printer B and these magnets are connected to the plate of tube 2.

The operation of Figure 4 is as follows:

Due to the manner of connecting tubes 1 and 2 to the receiving line L, tube 1 operates in response to a plus signal, and tube 2 operates in response to a minus signal received over line wire 1_1. When a negative signal impulse is received over the line wire 1_1, the return wire 1_2 is of course of opposite polarity or positive and this causes tube 2 to operate. Hence the tube 2 is operated by the positive polarity of the return wire 1_2 when a negative impulse is transmitted from the distant station and received over the main line wire 1_1. The plate circuit of tube 1 is connected to receiving devices which are intended to operate on positive line signals, that is, in this case to the selecting magnets of printer A. In a like manner, the plate of tube 2 is connected to receiving devices which are intended to operate on negative signals received over line wire 1_1, that is, to selecting magnets of printer B.

In Figure 5, I have shown a repeating arrangement employing two thermionic tubes in "push-pull" relation for repeating telegraph signals from one line to another, statically, without any moving parts and without employing a magnetic circuit.

When a positive impulse is received from the receiving line conductor 1_1, tube 1 is started. Current then flows from battery B_1, through portion *ac* of the output impedance R_4, and tube 1. Current also flows from battery B_1, through portion *bc* of the output impedance R_4, conductor 1_3, the distant end impedance (not shown in diagram) of the outgoing line L_2, conductor 1_4, and tube 1. A positive impulse is thereby transmitted to conductor 1_3 of the outgoing line L_2. It is assumed that the impedance of the outgoing line plus the distant end impedance is greater than the output impedance R_4. The current flowing from *c* to *a* is greater than the current flowing from *c* to *b*. Assuming the resistance of *ac* to be equal to the resistance of *bc* the voltage drop across *ac* is greater than the voltage drop across *bc*. There is a potential difference across *ab* equal to the difference of the voltage drops across *ac* and *bc*. Condenser C_3 becomes charged to the potential difference across *ab*. The top plate p_1 of the condenser becomes negatively charged with respect to the bottom plate p_2. The potential charge on condenser C_3 may also be expressed as the voltage of battery B_1 minus the sum of the voltage drops across tube 1 and the portion *bc* of resistance R_4. Now, when conductor 1_1 of the receiving line becomes negative, conductor 1_2 becomes positive and tube 2 "starts". When tube 2 "starts" the potential of plate p_2 of condenser C_3 falls to a value equal to the voltage drop across tube 2. Plate p_1 which is connected to the anode of tube 1 must suffer instantaneously an equal fall of potential. This brings out the anode potential of tube 1 less than zero or negative with respect to the cathode and tube 1 stops. Current then flows from battery B_1, through portion *bc* of the output impedance R_4, and tube 2. Current also flows from battery B_1, through portion *ac* of the output impedance R_4, conductor 1_4, the distant end impedance of the outgoing line L_2, conductor 1_3, and tube 2. A negative impulse is thereby transmitted to conductor 1_3 of the outgoing line L_2.

When a plurality of tubes are used which are operated by signals from the same line, a battery may be placed in the immediate grid circuit of each tube to compensate for nonuniformity of the operating characteristics of the different tubes.

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 for carrying out this invention will be obvious to engineers without departing in any manner from the invention.

This application is a continuation in part of my prior application Serial No. 344,438 filed March 5, 1929.

I claim:

1. In a telegraph system, an incoming line, an outgoing line, means for normally transmitting negative current over said outgoing line, a thermionic relay device responsive to positive impulses from said incoming line to transmit positive impulses over the outgoing line, said thermionic device being 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 critical starting potential applied to the starting electrode.

2. In a telegraph system, an incoming line, an outgoing line, a plurality of thermionic devices responsive only to impulses of positive potential, the current continuing to flow in the anode-cathode circuit unaffected by variations in said potentials on the starting electrode, a rotary distributor for connecting said incoming line to the input terminals of said devices in synchronism with the incoming signals and means for connecting the output terminals of said devices in succession to the outgoing line.

3. In a telegraph system, a thermionic device responsive only to impulses of positive potential, the current continuing to flow in the anode-cathode circuit unaffected by variations in said potentials on the starting electrode, an incoming line connected to said input circuit, an outgoing line connected to said output circuit, and means to interrupt said output circuit in synchronism with the signals received on said incoming line.

4. In a telegraph system, a thermionic device having input and output circuits, said thermionic device being 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 critical

starting potential applied to the starting electrode, a resistance and a source of plate current included in said output circuit, a telegraph line connected to said output circuit to include said resistance and a portion of said source of current whereby current of one polarity is normally transmitted over said line, the constants of said output circuit being such that when "space" current is established in said device the current transmitted over said line is reversed in polarity.

5. In a telegraph system, an incoming line, an outgoing line, two thermionic repeaters, each having input and output terminals, said thermionic repeaters being 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 critical starting potential applied to the starting electrode and a rotary distributor for connecting said lines to said repeaters in alternate succession in synchronism with the incoming signals.

6. In a telegraph system, an incoming line, a plurality of outgoing lines, a plurality of thermionic devices, said thermionic devices being 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 critical starting potential applied to the starting electrode, means operated in synchronism with the incoming signals for supplying the successive signals to said devices in rotation, means to interrupt the output circuits of said devices in synchronism with the signals received on said incoming line, and means including said devices for transmitting signals received by certain of said devices to a plurality of outgoing lines.

7. In a telegraph system, a receiving line, a terminal impedance connected to said line, a pair of thermionic tubes, said thermionic tubes being 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 critical starting potential applied to the starting electrode, the input circuits of said tubes being connected to said terminal impedance in push-pull relation, distributor equipment including pick-up rings connected in the grid circuits of said tubes and receiving rings, signal responsive elements connected to certain of the segments of the receiving rings and to the plate of one of said tubes, and signal responsive elements connected to the remaining segments of the receiving ring and to the plate element of the other tube, whereby said two sets of signal elements are operated by signal currents of opposite polarity.

In testimony whereof I affix my signature.

ALBERT E. FROST.