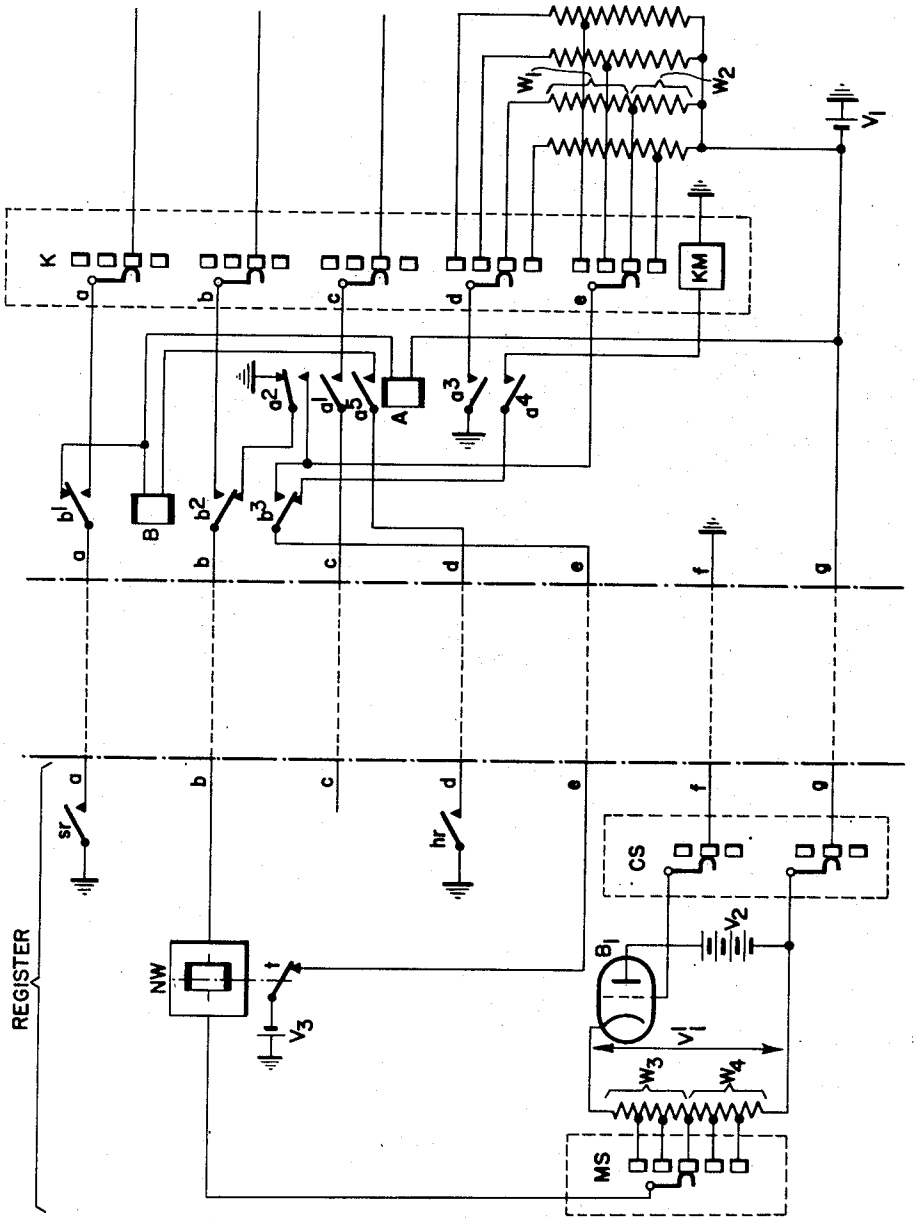
Aug. 4, 1953 R. M. M. OBERMAN 2,648,057

CIRCUIT FOR OBTAINING ELECTRIC BRIDGE EQUILIBRIUM

Filed Nov. 4, 1950 2 Sheets-Sheet 1

FIG. 1



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FIG. 2

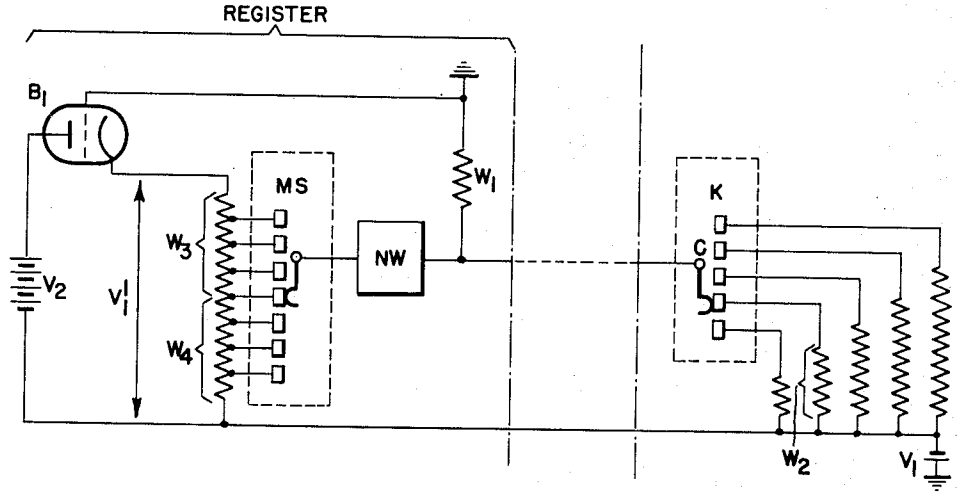
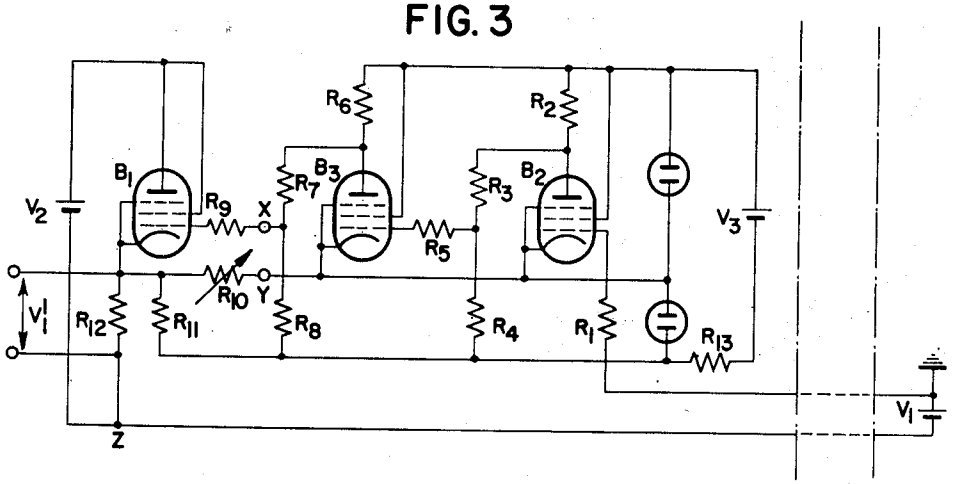


FIG. 3



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2,648,057

CIRCUIT FOR OBTAINING ELECTRIC BRIDGE EQUILIBRIUM

Roelof M. M. Oberman, The Hague, Netherlands

Application November 4, 1950, Serial No. 194,103
In the Netherlands July 16, 1946

7 Claims. (Cl. 340—172)

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The present invention relates to a circuit for telecommunication systems, and more particularly to a circuit including a rotary switch to be positioned by a register.

The present invention is a continuation-in-part of my copending application Serial No. 765,358, filed August 1, 1947, now abandoned, for "Circuit for Obtaining Equilibrium of a Direct Current Wheatstone Bridge, etc."

It is an object of the present invention to provide a remote control of a switch capable of taking a plurality of positions.

It is another object of the present invention to provide a circuit for a remote measuring of resistances.

It is a further object of the present invention to provide a Wheatstone bridge circuit which has branches arranged remote from each other.

A circuit according to the present invention comprises in combination, a rotary switch, a wiper forming part of the switch, a contact bank forming part of the switch and cooperating with the wiper, a first D. C. voltage source and a resistance connected in series to a contact of the contact bank, a zero switch arranged remote from the rotary switch, means for connecting one side of the zero switch to the wiper, means for supplying a number of marking voltages to the other side of the zero switch, the supplying means including a voltage follower including in series connection a second D. C. voltage source, an electron tube, and output resistances, and a wire pair connected to the first D. C. voltage source, one wire of the pair being connected to the grid of the tube and the other wire of the pair being connected to a point of the follower outside the tube.

A preferred embodiment of the present invention which is used in connection with a rotary switch to be positioned comprises in combination, an exchange, a switch to be positioned in the exchange, a control wiper forming part of the switch, a contact bank forming part of the switch and cooperating with the control wiper, a first D. C. voltage source in the exchange adapted to supply a number of control voltages to the contact bank, a register arranged remote from the exchange, a zero switch arranged in the register, means for connecting one side of the zero switch to the control wiper, means for supplying a number of marking voltages to the other side of the zero switch, the supplying means including a voltage follower in the register including in series connection a second D. C. voltage source, an electron tube, and output resistances, a wire pair con-

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nected to the first D. C. voltage source, one wire of the pair being connected to the grid of the tube and the other wire of the pair being connected to a point of the follower outside the tube, and means for stopping the switch by the zero switch when the control wiper touches one of the contacts of the bank having substantially the same potential as that applied by the voltage follower to the other side of the zero switch. Preferably the switch to be positioned is a rotary selector or a rotary finder.

A preferred embodiment of the present invention for the long distance evaluation of one of a plurality of resistances comprises in combination, a first D. C. voltage source, a plurality of resistances having one end thereof commoned to one terminal of the first D. C. voltage source; a switch including a wiper and a contact bank, the contacts of the bank being, respectively, connected to the other ends of the resistances, a register, the resistances and the switch being located at a long distance from the register, a wire connecting the wiper and the register, a fixed resistance in the register connected to the wire and the other terminal of the first D. C. voltage source, the fixed resistance and one resistance of the plurality of resistances forming one branch of the bridge, resistances in the register connected in series and forming the other branch of the bridge, a marking switch in the register including a wiper and a contact bank, the contacts of the bank being connected, respectively, to junctions of the resistances in the register, a voltage follower including in series connection a second D. C. voltage source, an electron tube, and some of the resistances in the register, a pair of wires connecting, respectively, the grid of the electron tube and a point of the follower outside the electron tube to the terminal of the first D. C. voltage source, and a zero switch in the register arranged between the wipers of the switches and adapted to stop the marking switch when substantial equality of potentials between the wipers is attained.

Preferably the switch is designed either as a selector or as a finder.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a diagram according to the present

invention showing a selecting stage to be positioned and the circuits of the bridge arrangement in the register.

Fig. 2 is a diagram according to the present invention showing the principle of telemeasuring a resistance.

Fig. 3 is a diagram according to the present invention showing another embodiment of a voltage reproduction device.

Referring first to Fig. 1, in the left hand part a register is shown which may be located for instance in an automatic telephone main exchange, while in the right hand part a selector circuit is shown which may be located in a minor or auxiliary telephone exchange which is arranged remote from the main exchange. As appears from Fig. 1 the minor exchange is not provided with registering means, the selection being obtained under the control of the register located in the main exchange. Both the register, the selector, and the interconnecting circuit thereof are shown only so far as it is necessary for a clear understanding of the invention.

Both the main and the minor exchanges are interconnected by a plurality of wires, denominated *a* to *g*, inclusive.

The brushes of the selecting switch K arranged in the minor exchange are capable of taking a plurality of different positions, four of which are indicated in Fig. 1. The contacts of the contact bank of the *e*-section of said selecting switch K are marked by different potentials derived from potentiometers such as those formed by resistances W1 and W2. The *d*-section of selecting switch K may either connect one terminal of the potentiometers to ground (or plus battery V1) or may be omitted, in which case all the corresponding terminals of the potentiometers are grounded.

The contacts of the contact banks of sections *a*, *b* and *c* of selecting switch K are connected either with brushes of a successive selecting stage, or directly to the lines to different subscribers. In the last mentioned case the shown selecting stage is final.

The positioning of the selector K by the register of the main exchange shown at the left-hand side of Fig. 1 is initiated by connecting the *a*-wire over the contact *sr* to ground, owing to which the relay A operates in a circuit: ground in register; make contact *sr*; *a*-wire; back-contact b^1; winding of relay A; minus battery V1. The *e*-wire is connected to minus battery V3, so that by the closure of contact a^4 the driving magnet KM of the selector K in the minor exchange operates in its circuit: ground in register; battery V3; break-contact *t*; *e*-wire; back-contact b^3; make contact a^4; driving magnet KM; ground. Consequently the brushes *a* to *e* start moving. The *e*-brush of the *e*-section of the selecting switch K to be positioned, touches the contacts thereof marked by the various voltages supplied by the successive potentiometers such as W1, W2, the components of which are connected with one terminal to minus-battery V1, whereas the other terminal is grounded over section *d* of switch K and make contact a^3, so that only touched contacts in the *e*-section obtain a characterizing voltage. The characterizing voltages are conducted over brush *e*, make contact a^2; back-contact b^2 and *b*-wire to the zero voltage identification device NW, to be called hereafter zero switch, in the register arranged remote from the auxiliary exchange. Such a zero switch is more fully disclosed in U. S. Patent No. 2,556,975 and the copending application, Serial No. 25,108, filed May 5, 1948. A marking MS switch is provided in the register which is previously positioned by a calling subscriber connected to the main exchange. Each of the contacts of the marking switch MS indicates a different marking voltage for the positioning of the selector K of the minor exchange when selection is started. If this marking voltage were derived directly from the battery V2 in the main exchange, as a rule a sufficient equality of the control voltages would not be obtainable. The marking voltages for the register in the main exchange are derived from a device which will be called voltage reproduction device or voltage follower hereinafter and comprises a tube B1.

When a circuit to an auxiliary exchange is made busy, the register is connected over a rotary switch CS to the double wire *f*—*g* of the relevant auxiliary exchange. These two wires connect ground or the positive of the battery V1 and the negative voltage of the battery V1 (termed hereinafter the first D. C. voltage source) respectively, to the voltage reproduction device in the register of the main exchange. The wires *f*—*g* are required only once for each auxiliary exchange though a greater number of sets of wires *a* to *e*, inclusive, may be provided for each minor exchange to enable more than one telephone connection at a time to be established. One position (for instance the position shown) of switch CS corresponds with one minor exchange being connected. The selectors or finders which through-connect the wires *a* to *e*, inclusive, from the register to that minor exchange, have been omitted in Fig. 1 as they operate in the same manner as switch CS.

The voltage reproduction device or voltage follower includes a pentode (Fig. 3) or a triode (Fig. 1), which reproduces the voltage applied to the control grid, for instance, as virtual standard voltage source V_1^1.

A battery V2 is connected in the anode circuit of tube B1 in the manner shown in Fig. 1.

The wire connecting the brush of marking switch CS to the zero switch MS does not carry current since the internal resistance of the zero-switch is very high.

It appears from Fig. 1, that the anode voltage *Va* of tube B1, when an anode current *Ia* flows, will amount to

$$Va=V2-V_1^1=V2-(W3+W4)Ia$$

since

$$V_1^1=(W3+W4)Ia$$

From the first formula it appears that a variation of the anode current δIa causes a variation of the anode voltage δVa given by

$$\delta Ia=\frac{-\delta Va}{W3+W4}$$

The grid voltage *Vg* of tube B1 appears to be:

$$Vg=V_1-V_1^1$$

An undesired variation in virtual standard voltage $\delta V_1^1=-\delta Vg$, as V_1 is considered constant.

Now a well-known formula for tubes is:

$$\delta Va=ra.\delta Ia-\mu.\delta Vg$$

with *ra*=differential resistance of tube B1 and

μ=amplification factor. Substituting in this formula the value of δIa results in:

$$\mu.\ \delta Vg = -\delta Va.\left[\frac{ra+W3+W4}{W3+W4}\right]$$

As μ and

$$\frac{ra+W3+W4}{W3+W4}$$

are both positive terms it appears that a variation of grid voltage results in an opposed variation of plate voltage or applying formula

$$\delta V_1{}^1 = \delta Vg : +\delta V_1{}^1$$

results in $+\delta Va$.

As appears from the firstly mentioned formula, $V_1{}^1 = V2 - Va$, so that a positive increase in voltage δVa opposes its own increase. So the circuit is stabilized against variations of virtual standard voltage $V_1{}^1$.

Should the master voltage V_1 vary by δV_1, then appears from the formula $Vg = V_1 - V_1{}^1$, that $\delta V_1 = \delta Vg$, so that, after considering the same formula it appears that a negative variation $-\delta Va$ results, which however causes a positive variation $\delta V_1{}^1$ of virtual voltage $V_1{}^1$.

The virtual voltage $V_1{}^1$ accordingly follows the variations of the master voltage V_1. That is why the name voltage follower has been chosen.

The operation of the devices shown in Figs. 1 and 2 is as follows:

The two branches of the bridge arrangement W1/W2 and W3/W4 (Figs. 1 and 2) form together a Wheatstone bridge. The contact *t* interrupts the energization circuit of the driving magnet KM thus stopping the selector K when the zero switch NW determines that the control wiper *e* of the selector K brushes a contact with a control voltage, which sufficiently approaches the voltage indicated by the marking switch MS.

The positioning of various selectors in the same auxiliary exchange by various registers can be effected without influencing one another as the voltage reproduction device does not require any control current, but only a control voltage. It is possible, dependent on the number of registers and the number of auxiliary exchanges, to equip each register with a voltage reproduction device, which, if necessary, is connected by means of the wires *f* and *g* to the relevant auxiliary exchange. A main exchange may be provided with a number of similar devices equal to the number of auxiliary exchanges, the relevant marking switches, if necessary, being connected to the desired voltage reproduction device.

It is remarked that the *c*-wire shown in Fig. 1 is not necessary for the positioning of the selectors. Over this wire special marks of a subscriber's line circuit can be transmitted to the register in the main exchange. Special characteristics can be given to the subscribers by means of resistances of different values which are connected on one side to an individual contact of the selector contact bank or finder contact bank, and on the other side to a terminal of a battery.

In Fig. 2 a final selector K in an auxiliary exchange is represented by the one section *c*, which connects the resistance W2 associated with any subscriber to a zero switch NW in the register of the main exchange. The other side of the zero switch NW is connected to a marking switch MS, which successively applies a number of voltages of a voltage reproduction device, including a tube B_1 and a plurality of resistances either forming in pairs potentiometers individual to each contact of the marking switch MS or being connected in series to form one potentiometer having a plurality of tappings connected, respectively, to the contacts of the marking switch MS, as shown in Fig. 2. The resultant resistances are denoted by W3 and W4. In order to be able to find the magnitude of the resistance W2, as if the latter were inserted in a normal Wheatstone bridge, one terminal of the battery V_1 in the auxiliary exchange is connected to the reproduction device.

The virtual standard voltage $V_1{}^1$ across the resistances W3 and W4 is automatically kept equal to the voltage of battery V_1 of the auxiliary exchange in the manner described before so that it need not be described in detail.

A special wire connecting plus-battery V_1 with the grid of tube B_1 has not been shown since differences in earth potential are as a rule too slight to affect the voltage reproduction device.

There is, however, no difficulty in inserting such a wire if disturbing effects occur causing too great a deviation of the virtual standard voltage $V_1{}^1$.

The marking switch MS is previously adjusted in any conventional manner (for instance by a calling subscriber connected to the main exchange). The thus formed junction of resistances W3 and W4 divides the virtual standard voltage $V_1{}^1$.

The selecting switch K moves and connects the successive resistances (W2) to the zero switch NW.

A stepping magnet as shown in Fig. 1 may be provided in order to stop the selecting switch K when a resistance W2 is switched in, bearing the same relation to the resistance W1 as the resistance W4 does to the resistance W3.

It makes no difference for the invention if the switch K is pre-set by a subscriber connected to the minor exchange.

In that case a contact from the zero switch (contact *t* of Fig. 1) should not interrupt the stepping magnet circuit of selecting switch K, but a similar circuit of a stepping magnet which controls switch MS in the register.

Fig. 3 shows an arrangement of a more perfect voltage reproducing device in which, moreover, two tubes amplifier B2, B3 are inserted between the standard source V_1 and the voltage reproduction tube B_1, which shift the phase through 360°.

The tube arrangement is placed in an exchange where it is desired to produce a virtual voltage source $V_1{}^1$ equal to a source V_1 at a remote exchange. Ground (plus battery) of the remote exchange is now applied at the control grid of the first amplifier tube B2 via resistance R1. Over a resistance coupling, including resistances R3, R4 and R5 the voltage is applied to the control grid of the second amplifier tube B_3. Via resistance coupling (R7, R8, R9) the control grid of the voltage following tube B1 is controlled.

The negative terminal of battery V1 is connected via a resistance R12 to the cathode of tube B1.

Across this resistance R12 the virtual voltage $V_1{}^1$ is found. Resistance R12 corresponds to the series connection of resistances W3 and W4 in Figs. 1 and 2, as will appear directly.

The amplifier comprising tubes B2 and B3 is, as will appear to those skilled in the art, a direct current amplifier. It renders the voltage reproducing device much more sensitive and better regulating than the application of one tube B1 only as described hereinbefore.

It will be understood that each of the elements

described above, or two or more together, may also find a useful application in other types of a circuit for telecommunication systems differing from the types described above.

While I have illustrated and described the invention as embodied in a circuit including a rotary switch, I do not intend to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of my invention.

Without further analysis, the foregoing will so fully reveal the gist of my invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What I claim as new and desire to secure by Letters Patent is:

1. A circuit for telecommunication systems comprising in combination, a rotary switch; a wiper forming part of said switch; a contact bank forming part of said switch and cooperating with said wiper; a first D. C. voltage source and a resistance connected in series to said contact bank; a zero switch arranged remote from said rotary switch; means for connecting one side of said zero switch to said wiper; means for supplying a number of marking voltages to the other side of said zero switch; said supplying means including a voltage follower including in series connection a second D. C. voltage source, an electron tube, and output resistances; and a wire pair connected to said first D. C. voltage source, one wire of said pair being connected to the grid of said tube and the other wire of said pair being connected to a point of said follower outside said tube.

2. A circuit for telecommunication systems in which a rotary switch is positioned by means of a D. C. Wheatstone bridge equilibrium, comprising in combination: an exchange; a switch to be positioned in said exchange; a control wiper forming part of said switch; a contact bank forming part of said switch and cooperating with said control wiper; a first D. C. voltage source in said exchange adapted to supply a number of control voltages to said contact bank; a register arranged remote from said exchange; a zero switch arranged in said register; means for connecting one side of said zero switch to said control wiper; means for supplying a number of marking voltages to the other side of said zero switch, said supplying means including a voltage follower in said register including in series connection a second D. C. voltage source, an electron tube, and output resistances; a wire pair connected to said first D. C. voltage source; one wire of said pair being connected to the grid of said tube and the other wire of said pair being connected to a point of said follower outside said tube; and means for stopping said switch by said zero switch when said control wiper moves over one of said contacts of said bank having substantially the same potential as that applied by said voltage follower to the other side of said zero switch.

3. A circuit for telecommunication systems in which a rotary selector is positioned by means of a D. C. Wheatstone bridge equilibrium comprising in combination: an exchange; a selector to be positioned in said exchange; a control wiper forming part of said selector; a contact bank forming part of said selector and cooperating with said control wiper; a first D. C. voltage source in said exchange adapted to supply a number of control voltages to said contact bank; a register arranged remote from said exchange; a zero switch arranged in said register; means for connecting one side of said zero switch to said control wiper; means for supplying a number of marking voltages to the other side of said zero switch, said supplying means including a voltage follower in said register including in series connection a second D. C. voltage source, an electron tube, and output resistances; a wire pair connected to said first D. C. voltage source; one wire of said pair being connected to the grid of said tube and the other wire of said pair being connected to a point of said follower outside said tube; and means for stopping said selector by said zero switch when said control wiper moves over one of said contacts of said bank having substantially the same potential as that applied by said voltage follower to the other side of said zero switch.

4. A circuit for telecommunication systems in which a rotary finder is positioned by means of a D. C. Wheatstone bridge equilibrium comprising in combination: an exchange; a finder to be positioned in said exchange; a control wiper forming part of said finder; a contact bank forming part of said finder and cooperating with said control wiper; a first D. C. voltage source in said exchange adapted to supply a number of control voltages to said contact bank; a register arranged remote from said exchange; a zero switch arranged in said register; means for connecting one side of said zero switch to said control wiper; means for supplying a number of marking voltages to the other side of said zero switch; said supplying means including a voltage follower in said register comprising in series connection a second D. C. voltage source, an electron tube, and output resistances; a wire pair connected to said first mentioned D. C. voltage source; one wire of said pair being connected to the grid of said tube and the other wire of said pair being connected to a point of said follower outside said tube; and means for stopping said finder by said zero switch when said control wiper moves over one of said contacts of said bank having substantially the same potential as that applied by said voltage follower to the other side of said zero switch.

5. A circuit for the long distance evaluation of one of a plurality of resistances by means of a D. C. Wheatstone bridge equilibrium comprising in combination: a first D. C. voltage source; a plurality of resistances having one end thereof commoned to one terminal of said first D. C. voltage source; a switch including a wiper and a contact bank; the contacts of said bank being, respectively, connected to the other ends of said resistances; a register, said resistances and said switch being located at a long distance from said register; a wire connecting said wiper and said register; a fixed resistance in said register connected to said wire and the other terminal of said first D. C. voltage source, said fixed resistance and one resistance of said plurality of resistances forming one branch of the bridge; resistances in said register connected in series and forming the other branch of the bridge; a marking switch in said register including a wiper and a contact bank, the contacts of said bank being connected, respectively, to junctions of said resistances in said register; a voltage follower including in series con-

nection a second D. C. voltage source, an electron tube, and some of said resistances in said register; a pair of wires connecting, respectively, the grid of said electron tube and a point of said follower outside said electron tube to the terminal of said first D. C. voltage source; and a zero switch in said register arranged between the wipers of said switches and adapted to stop said marking switch when substantial equality of potentials between said wipers is attained.

6. A circuit for the long distance evaluation of one of a plurality of resistances by means of a D. C. Wheatstone bridge equilibrium comprising in combination: a first D. C. voltage source; a plurality of resistances having one end thereof commoned to one terminal of said first D. C. voltage source; a selector including a wiper and a contact bank, the contacts of said bank being, respectively, connected to the other ends of said resistances; a register, said resistances and said selector being located at a long distance from said register; a wire connecting said wiper and said register; a fixed resistance in said register connected to said wire and the other terminal of said first D. C. voltage source, said fixed resistance and one resistance of said plurality of resistances forming one branch of the bridge; resistances in said register connected in series and forming the other branch of the bridge; a marking switch in said register including a wiper and a contact bank, the contacts of said bank being connected, respectively, to junctions of said resistances in said register; a voltage follower including in series connection a second D. C. voltage source, an electron tube, and some of said resistances in said register; a pair of wires connecting, respectively, the grid of said electron tube and a point of said follower outside said electron tube to the terminals of said first D. C. voltage source; and a zero switch in said register arranged between the wipers of said selector and said marking switch and adapted to stop said marking switch when substantial equality of potentials between said wipers is attained.

7. A circuit for the long distance evaluation of one of a plurality of resistances by means of a D. C. Wheatstone bridge equilibrium comprising in combination: a first D. C. voltage source; a plurality of resistances having one end thereof commoned to one terminal of said first D. C. voltage source; a finder including a wiper and a contact bank, the contacts of said bank being, respectively, connected to the other ends of said resistances; a register, said resistances and said finder being located at a long distance from said register; a wire connecting said wiper and said register; a fixed resistance in said register connected to said wire and the other terminal of said first D. C. voltage source, said fixed resistance and one resistance of said plurality of resistances forming one branch of the bridge; resistances in said register connected in series and forming the other branch of the bridge; a marking switch in said register including a wiper and a contact bank, the contacts of said bank being connected, respectively, to junctions of said resistances in said register; a voltage follower including in series connection a second D. C. voltage source, an electron tube, and some of said resistances in said register; a pair of wires connecting, respectively, the grid of said electron tube and a point of said follower outside said electron tube to the terminal of said first D. C. voltage source; and a zero switch in said register arranged between the wipers of said finder and said marking switch and adapted to stop said marking switch when substantial equality of potentials between said wipers is attained.

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