March 9, 1943. V. J. TERRY ET AL 2,313,601

VOLTAGE DIVIDER

Filed April 9, 1942

FIG. 1.

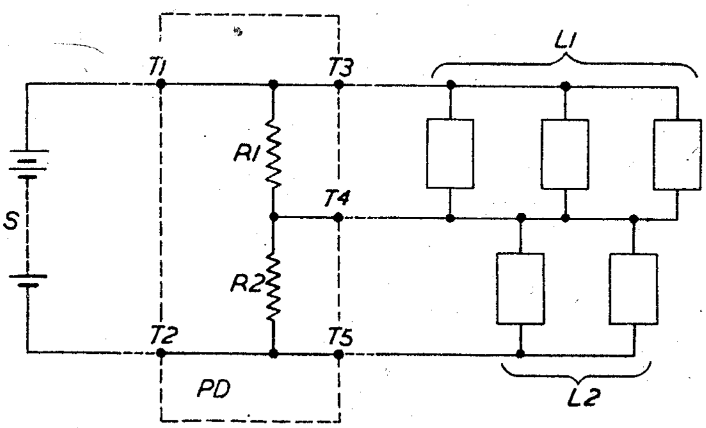
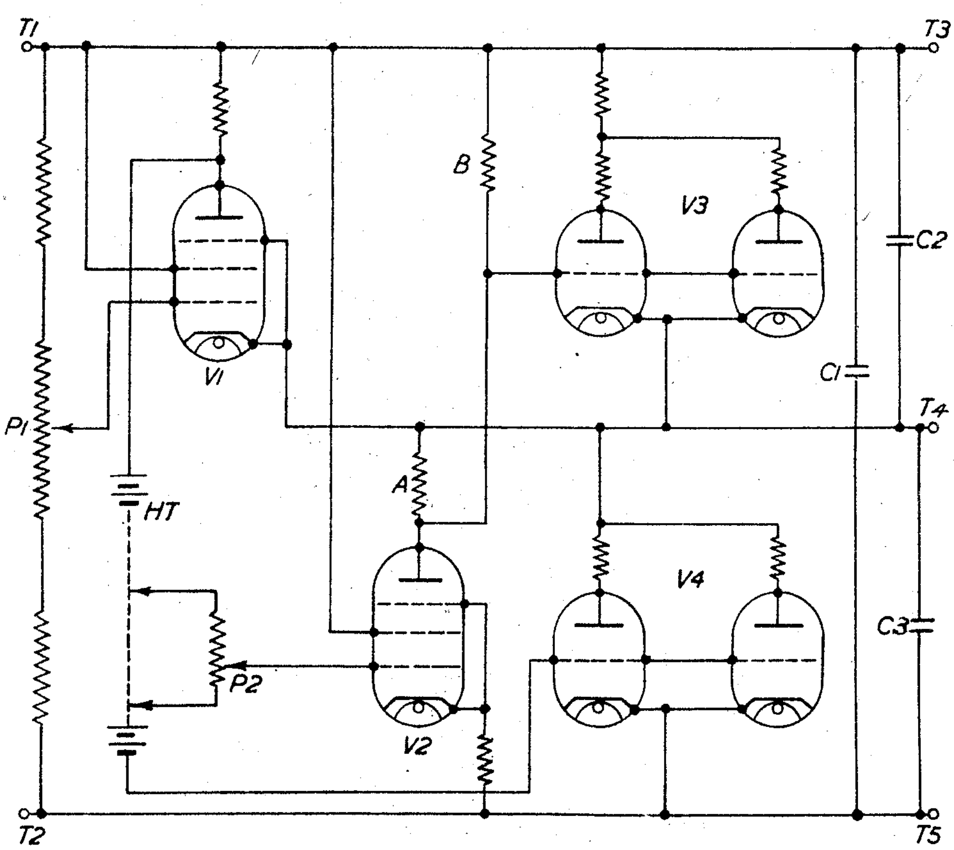


FIG. 2.



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VOLTAGE DIVIDER

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8 Claims. (Cl. 171—312)

This invention relates to the balancing of the loads on an electric supply, and is particularly useful in a telegraph system with double-current working, for the purpose of maintaining an equipotential division of the supply as between positive and negative signals.

An object of the invention is to provide an electronic potential divider capable of maintaining an equal division of potentials between approximately 140 and 200 volts with unbalanced loads varying from 0 to 120 ma. or more. Unlimited balanced loads may be added in addition to the unbalanced loads.

The invention consists in an arrangement for dividing a direct-current supply into halves of equal voltage and for maintaining the equality of said division independently of varying inequalities in the loads on the two halves, in which at least one of two voltage-dividing resistors connected in series across the supply is such that its resistance decreases and increases as the voltage across it increases and decreases.

In a double-current telegraph system, it is desirable that the potentials of both positive and negative signals should be the same. Where a common battery is supplying a plurality of senders, this desired equality may be lacking owing to the fact that the two loads, positive and negative, may be different, these loads each being the sum of the instantaneous loads due to the individual senders, and therefore each varying from instant to instant as signalling progresses.

The invention will be better understood from a reading of the following description in conjunction with the accompanying drawing in which

Fig. 1 is a schematic diagram used in the explanation of the invention, and

Fig. 2 shows one embodiment of the invention.

Fig. 1 is a rudimentary diagram showing how the common power supply of a double-current telegraph system feeds the individual senders over a potential divider. The direct current source S, of say 160 volts, is connected to the positive and negative input terminals T1 and T2 of the potential divider PD, consisting of a potentiometer with elements R1 and R2. On the output side the potential divider PD has a positive terminal T3, a centre tap T4, and a negative terminal T5.

The positive and negative loads L1 and L2, each consisting of the individual telegraph senders that at the instant under consideration are sending either positive or negative signals, are connected respectively between the positive terminal T3 and the centre point T4, and between the centre point T4 and the negative terminal T5.

Thus, if the desired equipotential division of the supply as between the two loads L1 and L2 is attained, each load will be fed at 80 volts.

Now with the positive and negative loads equal to one another, the centre-point T4 would be at a potential equidistant from the positive and negative potentials of the respective terminals T3 and T5 when R1 and R2 were equal to one another. But if the load on say the positive side L1 were to increase in relation to that on the negative side, so that the resistance on the positive side were decreased, the potential of the centre-point T4 would be displaced in the positive direction. This could be compensated for, by decreasing the resistance of the potentiometer element R2 on the negative side by an amount sufficient to restore the equality between the resistance T1—CP and the resistance CP—T2, this amount depending upon the original relationship between the quantities R1, R2, L1, L2, and to that extent varying in a complex manner.

The present invention makes use of thermionic tubes as the potentiometer resistances R1 and R2, arranging these valves so that their anode characteristic resistances shall vary in the direction, and at least approximately to the extent, that is necessary to compensate for changes in the loads; and Fig. 2 shows an electronic centre-tap stabiliser embodying the invention.

The potential dividing resistances R1 and R2 are the combined anode impedances of two triodes V3 and V4 (or two banks of triodes) connected in series and controlled by two high magnification pentodes V_2 and V_1 respectively. In the following description "triode" refers to either one triode or a bank of triodes in parallel.

The anode current of one triode is added to the more lightly loaded side of the potential divider, in order to make the load on that side equal to the larger unbalancing load. The anode circuit of the other triode is connected across the heavily loaded side in order to deal with any probable unbalance in the reverse direction, and it is normally cut-off. When the external loads are balanced, both triodes conduct slightly; but in the worst case, the total drain of the whole circuit does not exceed 10 ma. for a circuit suitable for unbalance currents up to 120 ma.

With one high magnification pentode, the phase of operation is such that it operates directly on to one of the triodes. The other triode requires a phase inversion, so that the second pentode is used to perform this function.

Under normal balanced conditions, the potential dividing triodes are almost cut off, but the two pentodes are biased for efficient amplification. If the positive side of the circuit is more heavily loaded than the negative side (i. e., L1 is greater than L2, so that the resistance of L1 is less than that of L2), then the centre point T4, and hence the cathode of the first pentode V1, tends to approach the potential of the positive side T3. This is equivalent to putting the grid of V1 more negative, so that the valve V1 will tend to be cut off. The anode potential of V1 will thus be raised, so that the grid potential of the triode (V_4) on the negative side will be made more positive and this triode will conduct more freely.

At the same time, the grid of the phase reversing pentode (V_2) becomes more positive and this valve will take more anode current. This reduces its anode potential and in turn reduces the grid potential of the triode (V_3) in the positive side, due to the increased voltage drop through the resistances A and B which will cut-off the triode in the positive side still further. The combination of these two conditions is that the triode in the positive side is cut off, and the triode in the negative side is conducting, to form a load on that side, which tends to bring the centre tap towards the negative side and hence stabilise the circuit.

Conversely, if the negative side of the circuit is more heavily loaded than the positive side; then the centre point, and hence the cathode of the first pentode V_1, tends to approach the negative side. This is equivalent to putting the grid of V_1 more positive, so that V_1 will take more anode current and its anode potential will fall. This makes the grid of the triode (V4) on the negative side more negative so that it is cut off. At the same time the grid of the phase reversing pentode V_2 is made more negative and the plate current of the valve V_2 will be reduced. As less anode current passes through the anode resistance A of this pentode, the anode potential becomes more positive with respect to the centre point of the circuit. The phase reversing pentode has a subsidiary anode resistance B connected to the positive side of the supply, whose function is to make the grid of the triode V_3 positive with respect to its cathode and hence give it a wider range of control. As the grid of the triode V_3 on the positive side is connected directly to the anode of the phase reversing pentode V_2 its potential becomes more positive and the triode conducts more freely. Thus the triode in the positive side is conducting, forming a load on that side, and the triode in the negative side is cut off; so that the centre tap tends to move towards the positive side and hence stabilise the circuit.

With a balanced load on a 160 volt supply: the grid of the first pentode V_1 is at about −3 volts, which gives an anode current of about 0.8 ma. and an anode voltage of about 30 volts. These conditions require a 120 volt battery HT with the grid of the phase reversing pentode tapped at about 15 volt. This makes the grid of the triode (V_4) in the negative side about −10 volts so that it takes about 2 ma. anode current (for each valve in the parallel circuit). The grid of the phase reversing pentode is about +5 volts with respect to the negative supply terminal but the tube takes about 0.25 ma., because the cathode is about +10 volts from this same point (i. e., the grid is about −5 volts with respect to the cathode). The voltage drop through the anode resistance A is about 10 volts, so that the anode of the phase reversing pentode and hence the grid of the triode (V_3) in the positive side is at about −10 volts with respect to the cathode of V_3 and the tube takes about 2 ma. anode current for each of the tubes in the parallel circuit.

The conditions described above have been chosen for maximum range of control consistent with close regulation and economy of current with balanced loads.

Initial adjustments

Initial adjustments are made to the potentiometers P_1 and P_2 and the grid battery tapping by observations of the plate currents, viz:

V_1=0.8 ma.; V_2=0.25 ma., V_3=2 ma. per tube (i. e., 6 ma. for 3 tubes in parallel).
V_4=2 ma. per tube.

(The anode current of V_4 will be slightly higher than that of V_3 because the surplus anode current of V_1, which does not pass through V_2, passes through V_4.)

The initial adjustments are made in order to approach the above conditions as nearly as possible, and they should be made with no unbalanced load on the circuit (the centre tap from the loads should preferably be disconnected) and the supply should be approximately at its mean voltage or with a tendency towards its lower value.

A 3.5–0–3.5 ma. meter is used in conjunction with a selector switch to measure the anode currents of all tubes in the circuit. This meter is also used to measure the unbalance voltage, by measuring the unbalance current between the centre point of the circuit and a virtual centre point formed by two equal resistances (not shown) across the supply.

The circuit need not necessarily have the same number of tubes for V_3 as there are for V_4. If a greater degree of unbalance is experienced on one side, then the heavier loaded side may have fewer tubes than the lighter loaded side, the number of tubes depending on the degree of unbalance likely to be experienced.

The speed of operation of the tube circuit is very high but it is supplemented by large condensers C1, C2, C3 in order to accommodate large transient currents.

It will have become evident from what has gone before, that the triodes **V3** and **V4** may be considered either as the potential dividing resistances R1 and R2 or as parts of the loads L1 and L2. These two ways of regarding the circuit are quite consistent with one another, since, in Fig. 1, the resistance R1 or R2 is identical in respect of its electrical connections with any one of the components of the respective load L1 or L2.

What is claimed is:

1. An arrangement for dividing a direct-current supply into halves of equal voltage and for maintaining the equality of said division independently of varying inequalities in the loads on the two halves, comprising; a potentiometer across the supply; an amplifying pentode having its control grid connected directly to an adjustable centre-tap on the potentiometer, its anode connected over a resistance to the positive

supply line, and its cathode connected directly to the output centre-point; a phase-reversing pentode having its control grid directly connected to an adjustable point in the high-tension supply to the amplifying pentode, its anode connected over a resistance to the centre-point, and its cathode connected over a resistance to the negative supply line; a bank of one or more triodes having its control grid connected directly to the anode of the phase-reversing pentode, its anode connected over a resistance to the positive supply line, and its cathode connected directly to the centre point; and a bank of one or more triodes having its control grid connected directly to the negative end of the high-tension supply to the amplifying pentode, its anode connected over a resistance to the centre point, and its cathode connected directly to the negative supply line.

2. An arrangement for dividing a direct current into halves of equal voltage and for maintaining the equality of said division independently of varying inequalities in the loads on the two halves, comprising two voltage dividing resistances connected in series across the supply at least one of said resistances comprising the anode impedance of a thermionic tube having an anode, a cathode and a control grid, means for connecting one of said loads across one of said resistances and the other of said loads across the other of said resistances, and means for rendering said control grid more or less positive as the load across said thermionic tube decreases or increases respectively in relation to the load across the other resistance.

3. An arrangement for dividing a direct current supply into halves of equal voltage and for maintaining the equality of said division independently of varying inequalities in the loads on the two halves, comprising two voltage dividing resistances connected in series across the supply, each including the anode impedance of a thermionic tube, means for connecting one of said loads across one of said thermionic tubes and the other of said loads across the other of said thermionic tubes, and means for varying the anode impedances of said tubes so that said impedances increase and decrease with increase and decrease of the loads connected across them.

4. An arrangement for dividing a direct current supply into halves of equal voltage and for maintaining the equality of said division independently of varying inequalities in the loads on the two halves, comprising two voltage dividing resistances connected in series across the supply, at least one of said resistances comprising the anode resistance of a thermionic tube having a cathode, an anode and a control grid, a connection from the negative side of said supply to said cathode, means for connecting one of said loads across one of said resistances and the other of said loads across the other of said resistances, a connection from the junction point of said resistances to said anode, and means for causing the potential of said control grid to follow the variations in potential of said junction point due to inequalities in said loads.

5. An arrangement according to claim 4 in which said last-mentioned means comprises a second thermionic tube comprising a cathode, an anode and a control grid, and further comprising a potentiometer connected across said supply, a connection from said anode of said second tube to the positive side of said supply, a connection from said cathode of said second tube to said junction point, a connection from said grid of said second tube to a center tap on said potentiometer, and a further connection from the anode of said second tube to the control grid of the other tube.

6. An arrangement for dividing a direct current supply into halves of equal voltage and for maintaining the equality of said division independently of varying inequalities in the loads on the two halves, comprising two voltage dividing resistances connected in series across the supply, at least one of said resistances comprising the anode resistance of a thermionic tube having a cathode, an anode and a control grid, means for connecting one of said loads across one of said resistances and the other of said loads across the other of said resistances, a connection from the positive side of said supply to said anode, a connection from the junction point of said resistances to said cathode, and means for causing the potential of said control grid to follow the variations in potential of said junction point due to inequalities in said loads.

7. An arrangement for dividing a direct current supply into halves of equal voltage and for maintaining the equality of said division independently of varying inequalities in the loads on the two halves comprising a potentiometer connected across the supply, an amplifying thermionic tube having a control grid connected to an adjustable center tap on said potentiometer, its anode connected to the positive side of the supply, and its cathode connected to the center point between the two loads, a phase-reversing amplifying thermionic tube having a control grid connected to an adjustable point in the high tension supply to said amplifying thermionic tube, its anode connected to said center point, and its cathode connected to the negative side of the supply, a further thermionic tube having a control grid connected to the anode of said phase-reversing tube, its anode connected to the positive side of the supply and its cathode connected to said center point, and a still further thermionic tube having a control grid connected to the negative side of the high tension supply to said first-mentioned amplifying tube, its anode connected to said center point, and its cathode connected to the negative side of the supply.

8. An arrangement according to claim 7, wherein a condenser is connected across each load.

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