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DRAWINGS ATTACHED

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(54) ELECTRONIC FLASH APPARATUS

(71) We, FRANKE & HEIDECKE G.m.b.H., a German Body Corporate, trading as ROLLEI-WERKE FRANKE & HEIDECKE, of 196 Salzdahlumerstrasse, Braunschweig, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an electrical circuit in the form of a bridge network.

Generally electrical bridge networks of a number of different types are well known.

One form of bridge network in accordance with the present invention relates to a measuring bridge regulator which operates by balance conditions causing a zero current in a measuring bridge of the network and with which the operation of the regulator is effected intermittently and at certain intervals of time for instance, in order to control temperature.

With intermittently operable regulators of this kind the duration of impulses used to obtain the intermittent operation and the time intervals between them are such that the regulating speed is adapted to the delay to which the regulating process is subject, in order to avoid oscillation.

On an alteration of the control magnitudes the measuring bridge is unbalanced, and this unbalancing is utilized to bring about the operation of the regulator to control such magnitudes. With highly delayed control processes a long time elapses before the controlled magnitude or its return to the bridge overcomes the unbalancing that has occurred. To avoid over-compensation, therefore, the control process setup by the bridge network must be delayed, or subdivided into individual steps, to the extent necessitated by the inertia of

the controlled process. Use has therefore been made of interval switches by which the measuring circuit is switched on and off at certain intervals of time. When the bridge is unbalanced, therefore, the regulation is effected in small and short steps and is delayed by the intervals between these steps to such an extent that it is adapted to the inertia of the regulated process. The switching times of the interval switch must be selected to ensure that over-regulation is avoided.

According to the present invention there is provided a bridge network comprising two resistors in series with each other and in parallel with two impedances in series with each other, the network further comprising a measuring branch connected at one end to a point between the two resistors and at the other end to a point between the two impedances, wherein the measuring branch comprises a bi-directional break down device in series with one winding of an impulse transformer and wherein a capacitor is connected in parallel with the measuring branch, whereby when the network is unbalanced the capacitor is charged until the threshold voltage of the bi-directional break down device is reached whereupon the capacitor is discharged and an impulse is given by the transformer.

Therefore in one form the bridge network may be a measuring bridge regulator which operates without moving parts and without an interval switching device of the kind mentioned above, and nevertheless generates control impulses, the pulse train or the time interval between the pulses being automatically adapted by the degree of unbalance in the measurement bridge of the bridge network. In the absence of the unbalance of the bridge, no impulses are emitted, while in the event of any considerable unbalancing the

sequence of pulses is accelerated. In this process the control impulses are produced to the same intensity and with the same duration and also selectively as regards forward or reverse regulation.

The bridge network may include a resistive element in each arm of the bridge network and a diac connected in series with the primary winding of the impulse transformer in the measuring branch, the secondary winding being connected to switch means to control the operation of a motor during unbalance of the bridge network. The intensity and duration of the impulses are determined by the dimensions of the bridge, while the duration of two successive impulses depends on the degree of unbalancing of the bridge. With a tuned (balanced) bridge no impulses are emitted, while upon the unbalancing of the bridge impulses are emitted in all the quicker succession, the greater the magnitude of the unbalancing.

Another form of bridge network in accordance with the present invention may concern electronic flash apparatus in which two arms of a bridge network are formed by storage capacitors connected in series.

With electronic flash apparatus it is of advantage to use series-connected storage capacitors, because on the one hand the dielectric strength of the customary electrolytic capacitors is limited, while on the other hand the series connection enables higher working voltages to be obtained. It is thus possible, by the use of doubling circuits on the Greinacher principle, to produce a total direct voltage amounting to 5.65 times the effective alternating voltage of the mains, with direct operation from the mains i.e. without recourse to transformers, by connecting two capacitors in series. The apparatus is usually equipped with disconnection means which interrupts the charging of the capacitors when the desired total direct voltage is reached. If, however, as a result of leakage current, for instance, the charging voltage of one capacitor decreases, then that of the other increases correspondingly, as the cumulative voltage remains the same; the said increase in voltage may exceed the dielectric strength of the other capacitor, so that this latter fails likewise.

Therefore in accordance with the present invention there may provide a circuit which takes account of asymmetry of this kind when it occurs and which, when a certain pre-selected voltage difference is exceeded, will generate an impulse by which the supply of voltage to one capacitor or to both capacitors will be shut off.

The bridge network may be provided wherein each impedance comprises a storage capacitor, the storage capacitors forming part of a voltage doubling circuit for an electronic flash apparatus, and wherein the measuring

branch comprises the capacitor in parallel with a diac connected in series with the primary winding of the impulse transformer, wherein an impulse provided by the impulse transformer is effective to control the charging of the storage capacitors. When a symmetry occurs in the bridge network a voltage is produced in the measuring branch, the polarity of the voltage indicating which of the two storage capacitors has the lower and which has the higher partial voltage. If the voltage difference reaches a certain limit, determined in advance, then the diac ignites and the measuring branch capacitor discharges via the impulse transformer. This impulse can be used for the optical indication of the fault or else for the automatic temporary interruption of the charging of the storage capacitors.

Constructional embodiments of the present invention will now be described by way of example, with reference to the accompanying drawings, wherein:—

Fig. 1 shows the charging circuit of two series connected capacitors, with trigger-controlled rectifier elements;

Fig. 2 shows the production of impulses in the event of asymmetry;

Fig. 3 shows a completed circuit in which the charging is interrupted by influencing the rectifier triggering operation; and

Fig. 4 shows a measuring bridge regulator in accordance with the present invention.

Referring now particularly to Fig. 1 there is shown a circuit for charging capacitors 1 and 2 via trigger-controlled rectifiers 3 and 4, directly from the A.C. mains. The mains connection is effected at terminals 5 and 6, the resulting D.C. being taken from terminals 7 and 8. The capacitor 1 is charged with a voltage U_1 and the capacitor 2 with a voltage U_2 . The direct voltage U supplied at the terminals 7 and 8 is equal to the sum of U_1 and U_2 .

In Fig. 2 the circuit of Fig. 1 is supplemented by a bridge circuit which interconnects central point 11 between the capacitors 1 and 2 and central point 12 between resistors 9 and 10. The capacitors 1 and 2 are normally of the same capacity and are charged up to the same voltage ($U_1=U_2$). In these circumstances the resistors 9 and 10 are likewise equal to each other. If asymmetrical distribution of voltage between the capacitors 1 and 2 is intended, the resistance ratio between the resistors 9 and 10 must be fixed accordingly. The measuring branch circuit interconnecting the central points 11 and 12 consists of a capacitor 13 as well as a diac 14 and a primary winding 15 of an impulse transformer, which diac and winding are connected in series with each other and in parallel with the said capacitor 13. If the voltage across each of the capacitors 1 and 2 is equal, i.e. if $U_1=U_2$, then the central

points 11 and 12 have the same potential. If the voltage across capacitor 1 decreases, then the other voltage, across capacitor 2, will increase, since the sum of U_1 and U_2 remains constant. In this case a difference voltage occurs between the terminals 11 and 12, and the capacitor 13 is charged up to the difference voltage. If the latter exceeds the ignition voltage of the diac 14, the capacitor 13 discharges via the winding 15 of the impulse transformer. The measuring branch circuit responds when the difference between the separate voltages is twice as great as the ignition voltage of the diac 14. The response threshold can be increased if a resistor 16 is connected in parallel with the capacitor 13. If U_1 and U_2 are the voltages across the capacitors 1 and 2, R_1 and R_2 the resistors 9 and 10 and R_3 is the resistor 16, then the voltage U_a will be as follows:

$$U_a = \frac{U_1 - U_2}{2} \times \frac{R_3}{R_3 + 1/2 \times R_1}$$

In place of this diac 14 another element with bi-directional break-down, such as a glow lamp, can be employed. If a bridge rectifier is connected in series, it is also possible to use an element with uni-directional break-down, such as a "four-layer diode", a "uni-junction transistor" or the like. The system will naturally also respond if the equilibrium is destroyed by damage to a resistor.

Fig. 3 shows a version in which the impulse generated is used for the purpose of selectively shutting off the particular capacitor which is endangered. Those parts which correspond to the circuits of Fig. 1 and Fig. 2 have been given the same reference numbers. The trigger impulses for the rectifier thyristors 3 and 4 are introduced via terminals 17 and 18. Capacitors 21 and 22, which are charged up with an auxiliary voltage via terminals 23 and 24, are connected to the trigger feed lines via diodes 19 and 20. Parallel with the capacitors 21 and 22 are thyristors 25 and 26, which can be selectively rendered conductive by the ignition impulses of secondary windings 27 and 28 of the impulse transformer 15, via diodes 29 and 30. Normally, therefore, the capacitors 1 and 2 are charged up to the same voltage, capacitors 21 and 22 being charged with an auxiliary voltage taking the opposite direction. The connection of the secondary windings 27 and 28 of the impulse transformer 15 in opposite direction ensures in conjunction with the diodes 29 and 30 that the impulse generated when the diac 14 is rendered conductive will be conveyed either to the thyristor 25 or to the thyristor 26. If the voltage of the capacitor 1 lags behind that of the capacitor 2 and an impulse is set up in the measuring bridge circuit, the thyristor 26 then is ignited. The relevant

capacitor 22 is thus discharged. By this process the trigger impulses are short-circuited via the diode 20 and the discharged capacitor 22, until the capacitor 22 has once again been charged up. As long as capacitor 22 remains uncharged the continued charging of the storage capacitor 2 is interrupted. It is naturally also possible for the interruption of the charging to be effected for both storage capacitors in each case. It is equally obvious that this control system is also applicable to cascade circuits of four, six and more capacitors, by building up a number of bridges in accordance with Fig. 2; in this case each storage capacitor can be selectively shut off in accordance with Fig. 3. It is also possible for the entire cascade system to be shut off permanently or temporarily in the event of faults in a capacitor or resistor.

Referring now to Fig. 4 there is shown an example of a bridge circuit operated by direct current and with ohmic resistors 1, 2, 3 and 4. These may consist of required resistance values which can be set by means of suitable scales, thermo-resistors or hot conductors (e.g. in the case of heating and ventilating regulators), which are adapted to one another in a manner already known in itself in such a way that in the required state equilibrium prevails in the bridge.

The measuring branch contains a capacitor 8 connected in parallel with a diac 5 which is connected in series with a primary winding 6 of an impulse transformer 7. A resistor 9 also connected in parallel with capacitor 8 serves to set the response sensitivity of the circuit. The secondary winding of the impulse transformer 7 has a central tap. The bridge is connected to a D.C. source at the points 6, D. In the balanced state the voltage between the points AB and the capacitor 8 is zero. If unbalance now occurs, e.g. in the form of a change in the resistance 1, or a readjustment of a thermo-resistor, hot wire or other resistor 2, 3, 4, then a potential difference occurs between the points A and B, and the capacitor 8 is charged up. At the moment when the capacitor voltage has approximately reached the ignition voltage of the diac 5, the latter is rendered conductive and, the capacitor 8 discharges via the primary winding 6 of the impulse transformer 7. The secondary winding of the impulse transformer, is electrically selectively connected, via diodes 10 and 11, with windings 12 and 13 respectively of self-holding relays, which switch an adjusting motor M for forward or reverse motion, for an interval of time which is determined by the delay in operating the relays 12 and 13. If the unbalancing of the bridge continues, this process is repeated after the re-charging of the capacitor 8. The time is governed by the time constant of the capacitor and of the bridge resistances; it can be influenced additionally

by the resistor 9 connected in parallel with capacitor 8.

The invention makes it possible, while avoiding moving bridge parts, and at comparatively low cost, to generate control impulses directly, and these can be directly re-utilized for the regulating process for the restoration of the bridge equilibrium.

WHAT WE CLAIM IS:—

10 1. A bridge network comprising two resistors in series with each other and in parallel with two impedances in series with each other, the network further comprising a measuring branch connected at one end to a point between the two resistors and at the other end to a point between the two impedances, wherein the measuring branch comprises a bi-directional break down device in series with one winding of an impulse transformer and wherein a capacitor is connected in parallel with the measuring branch, whereby when the network is unbalanced the capacitor is charged until the threshold voltage of the bi-directional break down device is reached whereupon the capacitor is discharged and an impulse is given by the transformer.

2. A bridge network as claimed in claim 1, including a resistive element in each arm of the bridge network and a diac connected in series with the primary winding of the impulse transformer in the measuring branch, the secondary winding being connected to switch means to control the operation of a motor during unbalance of the bridge network.

3. A bridge network as claimed in claim 2, wherein the switch means comprises a pair of relays.

4. A bridge network as claimed in claim 1, wherein each impedance comprises a storage capacitor, the storage capacitors forming part of a voltage doubling circuit for an electronic flash apparatus, and wherein the measuring branch comprises the capacitor in parallel with a diac connected in series with the primary winding of the impulse transformer, wherein an impulse provided by the impulse transformer is effective to control the charging of the storage capacitors.

5. A bridge network as claimed in claim 4, wherein the resistance ratio of the series connected resistors corresponds to a desired charging voltage ratio of the storage capacitors.

6. A bridge network as claimed in claim 4 or 5; wherein the storage capacitors are each chargeable from a source of alternating voltage via a controlled rectifier device switchable in response to a source of impulses and wherein the impulse transformer has two secondary windings each connected with a trigger circuit via a diode for triggering a further controlled rectifier device forming part of each trigger circuit, whereupon an impulse in the impulse transformer renders one of the further controlled rectifier devices conductive preventing its associated controlled rectifier device from conducting and hence the respective one of the storage capacitors from charging.

7. A bridge network substantially as hereinbefore described with reference to, and as illustrated by, Figures 1, 2 and 3 or Figure 4 of the accompanying drawings.

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- 25 2. A bridge network as claimed in claim 1, including a resistive element in each arm of the bridge network and a diac connected in series with the primary winding of the impulse transformer in the measuring branch, the secondary winding being connected to switch means to control the operation of a motor during unbalance of the bridge network.

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