March 24, 1970 M. J. JOHANSON-BROWN 3,502,910

THYRISTOR TRIGGER CIRCUITS

Filed May 5, 1967 2 Sheets-Sheet 1

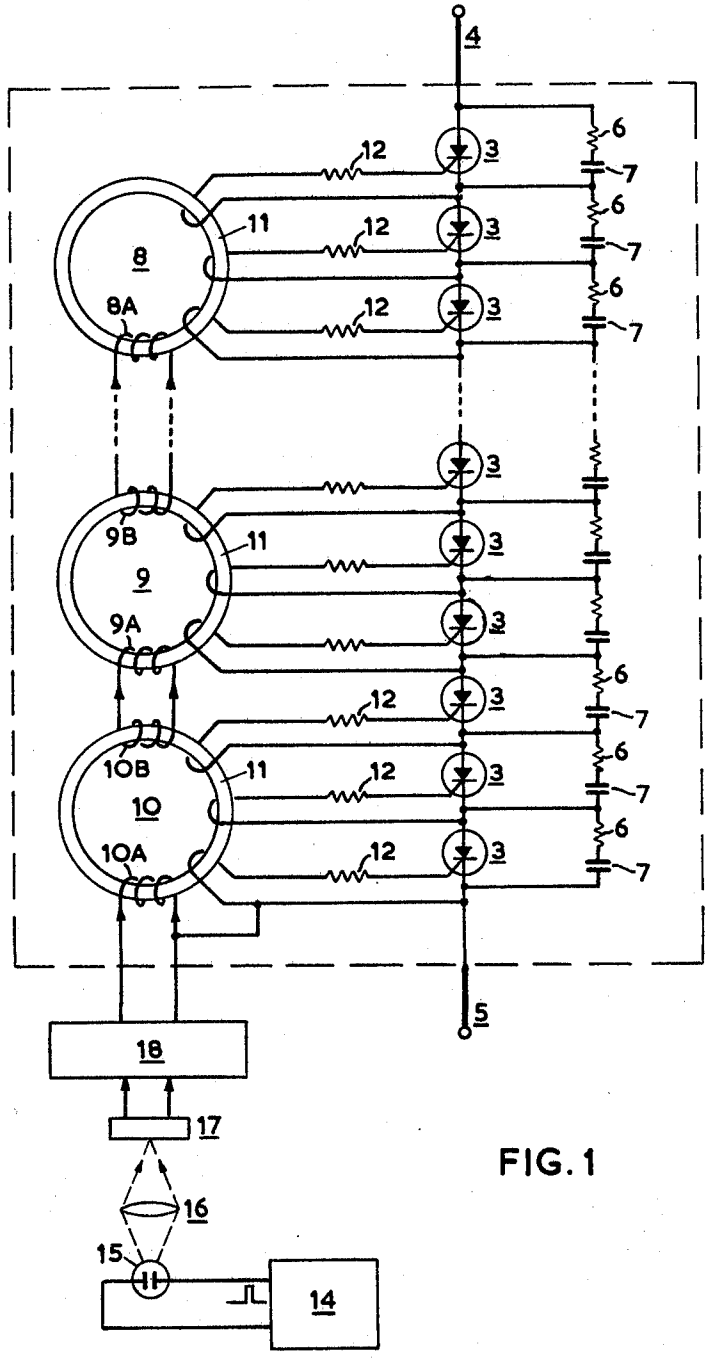


FIG. 1

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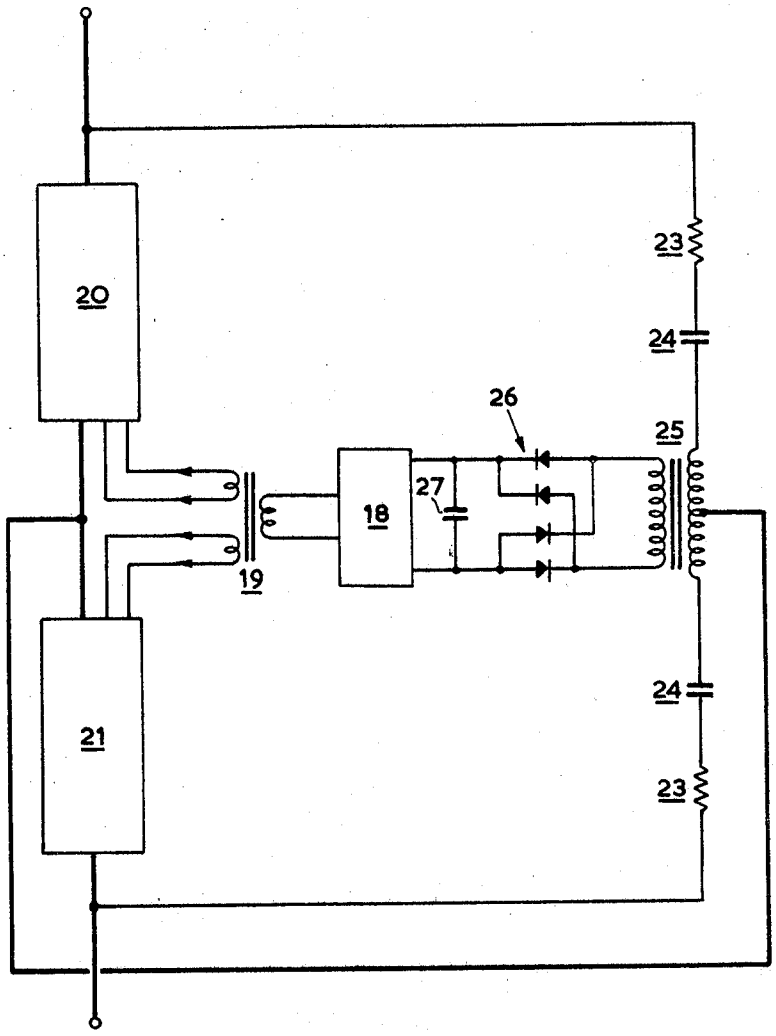


FIG. 2

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THYRISTOR TRIGGER CIRCUITS

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U.S. Cl. 307—252 4 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to a trigger circuit for firing a string of series-connected thyristors connected across a potential source. A number of pulse transformers are connected in cascade such that the secondary of one transformer is connected to the primary of another and each transformer is inductively coupled to the control electrodes of a group of the thyristors, control means being provided for applying a pulse to the primary winding of one of the transformers whereby to cause all the thyristors to be fired simultaneously with one another.

This invention relates to thyristor trigger circuits.

From one aspect, the present invention consists in a trigger circuit for firing a string of series-connected thyristors connected across a potential source, comprising a number of pulse transformers connected in cascade such that the secondary of one transformer is connected to the primary of another, each transformer being associated with a group of the thyristors and each thyristor in a group having a separate conductor connected across its gate and cathode electrode which is inductively coupled to its associated transformer, and means for applying a pulse to the primary winding of one of said transformers whereby to cause all of said thyristors to be fired substantially simultaneously with one another.

The said conductors may be auxiliary windings on the cascade-connected transformers or they may be auxiliary windings on isolating transformers each of which is coupled to one of the cascaded transformers.

This invention is of particular utility where the series string of thyristors is employed in place of high voltage mercury-arc valves in H.V.D.C. converters. In this case all the thyristors must be fired substantially simultaneously with the application of a gate control pulse at the instant of required conduction and the source of this pulse is normally at or about earth potential. Accordingly, since some of these thyristors would normally be at a considerable voltage above earth potential, e.g. 100 kv. or more, the devices employed for firing these thyristors would need to be insulated to withstand this voltage, and the cost of such insulation is considerable, increasing with increasing voltage.

By employing a circuit according to this invention however, the arrangement is such that these devices, that is, the transformers in this instance, need each only be insulated between their windings for a fraction of the voltage developed across the series string of thyristors.

In order that the invention may be fully understood, some embodiments thereof will now be described with reference to the accompanying drawings, in which:

FIG. 1 illustrates one form of thyristor trigger circuit according to the invention; and

FIG. 2 illustrates another form of trigger circuit according to the invention.

Referring now to FIG. 1, a series string of nine thyristors **3** is connected between terminals **4** and **5** across which a high potential is applied. In parallel with the

thyristors are voltage grading circuits each consisting of a resistor **6** and a capacitor **7**, which serve to equalise the voltage across these thyristors.

Three pulse transformers **8**, **9** and **10** are respectively associated with three thyristors in the string. In particular, each pulse transformer has a core **11** having three auxiliary windings which are connected, through current-limiting resistors **12**, across the gate and cathode electrodes of three thyristors **3**, respectively. These pulse transformers are connected together in cascade, pulse transformer **10** having a primary winding **10A**, one end of which is connected directly to the terminal **5**, and a secondary winding **10B** connected to a primary winding **9A** of transformer **9**, this transformer in turn having a secondary winding **9B** connected to the primary winding **8A** of transformer **8**.

The primary winding **10A** is energised in response to the operation of a pulse generator **14** which activates a light source **15**, the light beam emitted being focussed by a lens **16** on to a photocell **17**. The output from the photocell is applied to a pulse amplifier **18** which accordingly energises the primary winding of pulse transformer **10**. Since the transformers **8**, **9** and **10** are connected together in cascade the gate pulses resulting from the energisation of the primary winding **10A** are applied to all the thyristors in the string substantially simultaneously. However, in order for this to be the case, the series impedance of each transformer should be very low otherwise a considerable overall attenuation and time delay can occur along the chain. In practice, a satisfactorily low leakage reactance may be obtained by having the primary and secondary windings of the transformers distributed uniformly as toroidal windings around ring-shaped ferromagnetic, e.g. ferrite, cores **11**, so that alternate turns of the winding are constituted by the primary and the resulting intermediate turns are constituted by the secondary finely stranded conductors being used for all the windings to reduce their effective resistance at high frequencies.

Each transformer is only required to be insulated between its various windings for a fraction of the voltage across the thyristor string between terminals **4** and **5**.

The pulse amplifier **18** may be at a considerable potential above earth, and the power required for its operation may, in principle, be drawn from one of the RC voltage-grading circuits across the thyristors. In practice however, this arrangement may excessively disturb the voltage grading, and in FIG. 2 there is shown another method of obtaining this power supply.

Referring now to FIG. 2, the pulse amplifier **18** is shown to supply, through a transformer **19**, two strings (**20**, **21**) of thyristors and pulse transformers, each being the same as that enclosed within the chain lines in FIG. 1. The supply for this amplifier is derived from the voltage applied across the thyristor strings through two RC networks, each consisting of a resistor **23** and a capacitor **24**, a current transformer **25** being connected between these networks. The primary of this transformer is centre-tapped to the mid-point between the thyristor strings **20**, **21** and the secondary supplies power to the amplifier **18** through a bridge rectifier **26** across which is connected a smoothing capacitor **27**.

The D.C. power thus obtained is dependent on the alternating component of the voltage across the thyristor strings.

By "centre-feeding" the thyristor strings in this way there is a reduction in the overall attenuation and time delay of the gate pulses for those thyristors at the end of each string as compared with "end-feeding" as in FIG. 1.

It is to be understood that the invention is not limited

to the particular arrangements described and many modifications may be introduced without departing from the scope of this invention. For example, it is permissible to use many more cascaded pulse transformers than the three shown, e.g. ten, and each may have about five auxiliary windings for a corresponding number of thyristors. Furthermore, each single thyristor may be replaced by a number of thyristors in parallel, each parallel group being supplied from one auxiliary winding, and a number of thyristor strings may themselves be connected in parallel. In order to reduce the complexity of the pulse transformer winding, each group of thyristors may be supplied from auxiliary windings on an isolating transformer coupled to the secondary of the main pulse transformer.

Other methods of energising the cascaded pulse transformer may also be employed. For example, the photocell **17** may be replaced by a small light-sensitive thyristor triggered directly by the light beam. Alternatively, the coupling from ground may consist of either a single pulse transformer with full primary-secondary insulation or a chain of transformers having progressively smaller degrees of insulation to ground.

The use of a chain of pulse transformers from ground in this manner reduces insulation costs but requires voltage grading components, e.g. resistance-capacitance networks, between the primary and secondary connections on each transformer in order to equalise the voltages developed across the insulation.

By employing either of these latter methods the use of a pulse amplifier is unnecessary if the total gating power is transmitted from ground.

I claim:

1. A thyristor circuit comprising

a potential source,

a string of series-connected thyristors connected across the source, the thyristors being arranged in groups and each having anode, cathode and gate electrodes,

a number of pulse transformers having primary and secondary windings,

connecting means for coupling together the secondary winding of one transformer to the primary winding of another whereby to connect the transformers in cascade, each transformer being associated with a separate group of the thyristors,

auxiliary conductors inductively coupled to each transformer and connected across the gate and cathode electrodes of corresponding thyristors in the associated groups,

control means for applying a pulse to the primary winding of one of said transformers whereby to energise all the auxiliary conductors and fire all the thyristors simultaneously with one another, the control means comprising,

a pulse amplifier including,

a light-sensitive semi-conductor body activated from a remote point to initiate the development of the primary pulse, and

circuit means for deriving a power supply for said pulse amplifier from the said potential source.

2. A thyristor circuit according to claim **1**, comprising

a plurality of said thyristor strings connected in series across the potential source,

a said control means connected in common to all the strings, and

coupling means for coupling together the common control means to the pulse transformers associated with each string whereby all the thyristors in the strings are fired substantially simultaneously with one another.

3. A thyristor circuit according to claim **2**, wherein each string comprises both series-and parallel-connected thyristors.

4. A thyristor circuit according to claim **3**, comprising

a plurality of auxiliary transformers, each auxiliary transformer having,

one winding coupled to a corresponding one of the pulse transformers, and

a number of other windings respectively coupled to the thyristors in the parallel groups.

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