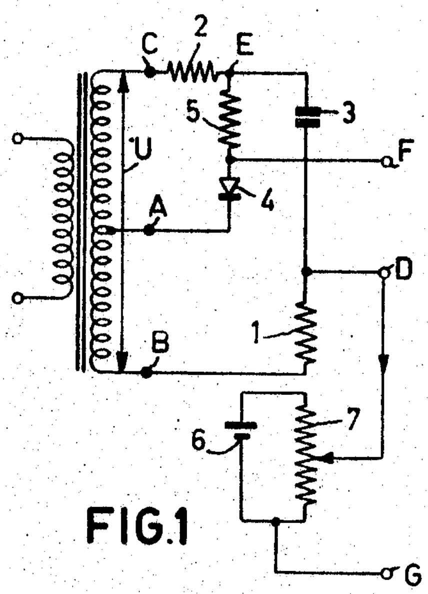

FIG.1

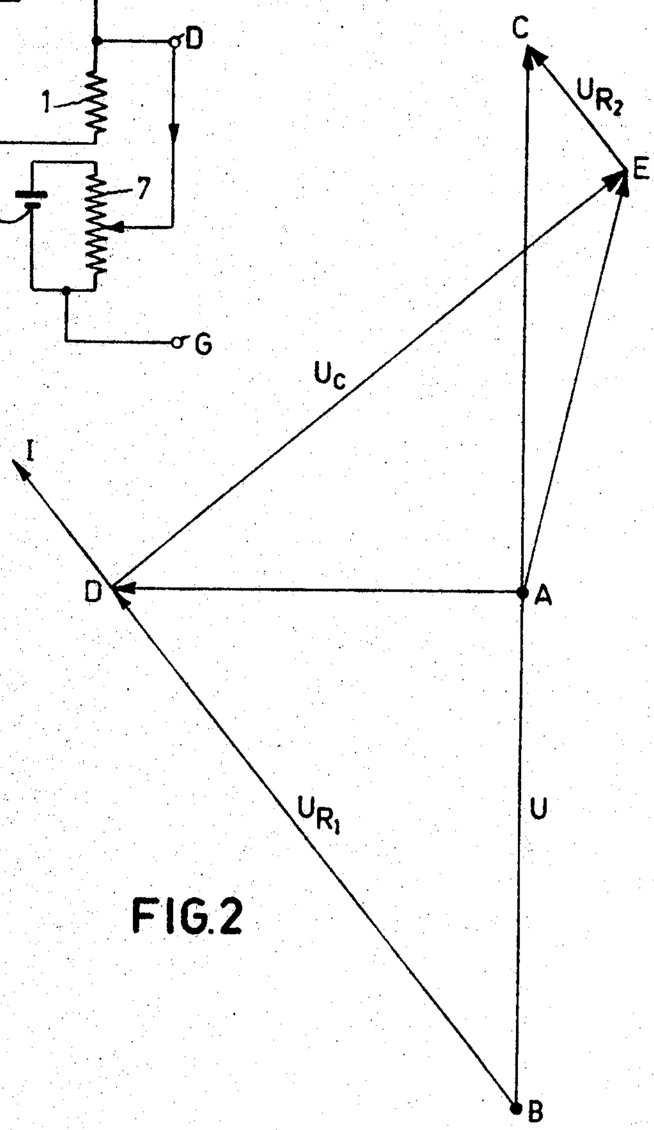

FIG.2

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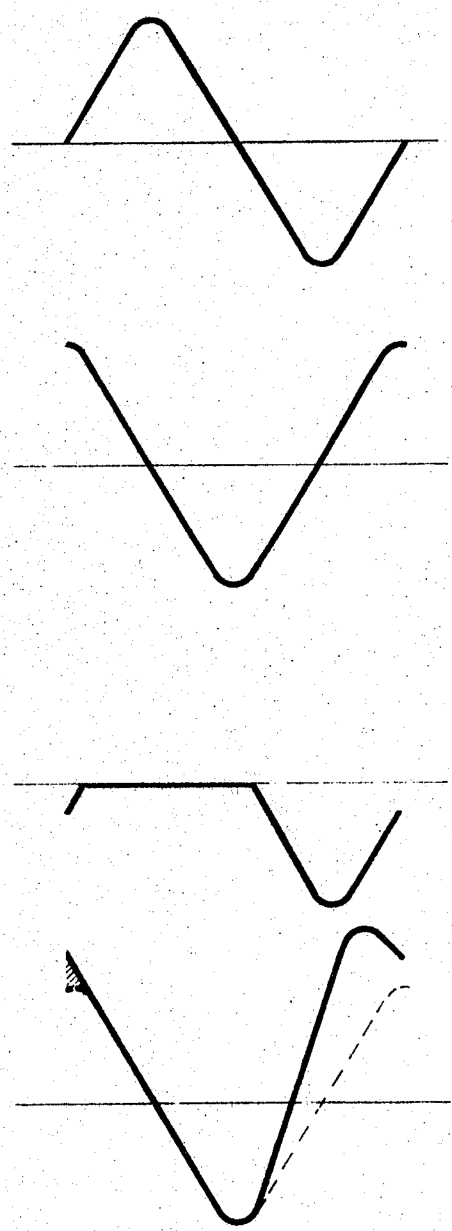

FIG.3

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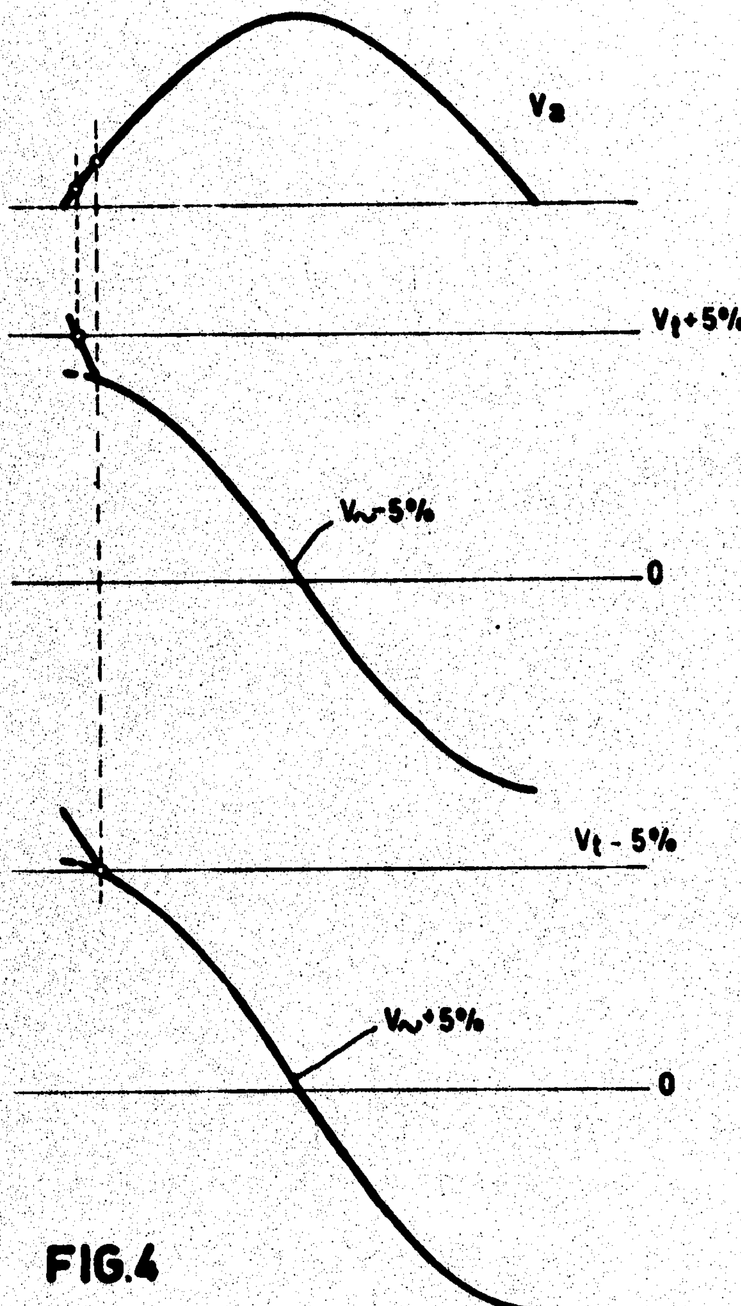

FIG.4

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3,299,318

ARRANGEMENT FOR IGNITING CONTROLLED RECTIFIERS WITH THE AID OF PULSES

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11 Claims. (Cl. 315—168)

This invention relates to arrangements for igniting controlled rectifiers, such as gas-discharge tubes or controllable semi-conductor rectifiers, with the aid of pulses.

With respect to the ignition by a sinusoidal voltage liable to be shifted horizontally or vertically, the ignition with the aid of pulses affords the advantage that the moment of ignition is independent of differences between rectifiers of the same type and can be determined accurately.

It is already known to bring about the ignition with the aid of pulses by connecting the series combination of an inductor, an ohmic resistor and a rectifier to an A.C. voltage source and deriving the pulsatory voltage from the rectifier or from the series-combination of the rectifier and the ohmic resistor. However, since neither the ohmic resistance, nor the inductance can be made zero, this known phase-shifting device can be adjusted neither to 0° nor to 90°. From this it follows that the angular range of the ignition is less than 90° and the output current of the controlled rectifier can be varied only from approximately >50% to <100%.

However, it is often necessary to control the current from zero to a maximum value. However, this requires an angular range of ignition which lies between 0° and 180°.

To obtain an ignition angle from 0° to 180°, it is also already known to use a pulse former stage having an adjustable response threshold or a trigger circuit followed by a differentiating transformer, which is controlled by a variable direct voltage or a sinusoidal voltage super-imposed on the said direct voltage and shifted in phase by 90° with respect to the alternating anode voltage of the rectifier.

When the sum of the direct voltage and the instantaneous value of the alternating voltage reaches the trigger threshold, the trigger supplies an igniting pulse to the rectifier through the transformer.

To permit the ignition angle to be adjusted between 0° and 180° by means of the direct voltage, the threshold of the trigger and the peak value of the alternating voltage must be the same and not more than half the maximum direct voltage.

Because of differences in the manufacture of the transformer and because of tolerances in the resistors used for the voltage divider in the trigger, it is unavoidable that the voltage of the trigger becomes smaller or greater than the alternating voltage.

If the voltage of the trigger is too low, the threshold of the trigger is no longer reached at 0° and the igniting pulse is just then not established when the full current is required by the rectifier on the ground of a control or regulating command. Furthermore, an ignition angle of 180° cannot then be obtained. If the alternating voltage is too high, the ignition angle can be adjusted neither to 0° nor to 180°.

It is therefore necessary for each apparatus to be adjusted during manufacture.

In an arrangement according to the invention, these disadvantages are avoided by deriving a 90° leading voltage from an alternating voltage of the same phase as the alternating anode voltage of the rectifier, preferably by means of a phase-shifting device. In addition a voltage derived from the same voltage source by means of a phase-shifting device and lagging by 15° is superimposed, after half-wave rectification onto said leading voltage. In known manner, a variable direct voltage is superimposed on the resulting alternating voltage.

In order that the invention may be readily carried into effect, it will now be described in detail, by way of example, with reference to the accompanying diagrammatic drawings, in which:

FIGURE 1 shows a circuit of the arrangement according to the invention;

FIGURE 2 shows a vector diagram of the alternating voltages occurring in the said circuit;

FIGURE 3 shows the voltages set up at the terminals of the circuit of FIGURE 1, and

FIGURE 4 shows the condition occurring at alternating voltages and/or trigger voltages which are 5% higher or lower.

Referring now to FIGS. 1 and 2, a voltage U is applied to the transformer which is in phase with the alternating anode voltage of the controlled rectifier tube, not shown. A series circuit comprising resistor **2**, capacitor **3** and resistor **1** is connected across the secondary winding of the transformer. A resistor **5** and a diode **4** are serially connected between the center tap A of the transformer secondary and a point E in the above-mentioned series circuit. The current I flowing in the series circuit leads the transformer secondary voltage U. The voltage drop across resistors **1** and **2** is in phase with the current I and is shown in FIG. 2 by the vectors U_{R_1} and U_{R_2}. The voltage across capacitor **3** lags the current I by 90 degrees and is represented by the vector U_c. The circuit is designed so that the voltage across the point A–E lags the secondary voltage U by approximately 15 degrees. A 90° leading voltage (see FIG. 2) is set up between points A and D of the phase-shifting device comprising resistors **1**, **2** and a capacitor **3**. This voltage serves for the vertical control of the trigger and on which is superimposed, after rectification by means of the diode **4**, the 15° lagging voltage set up between points A and E.

FIGURE 3 shows the two components of voltage separately, as well as the total voltage between points D and F compared with the controlled rectifier anode voltage. As can be seen from this figure, the combination of the leading voltage, V_{A-D}, and the rectified lagging voltage, V_{A-F}, produce a control voltage, V_{F-D}, having a sharply increased slope (compare the heavy line portion of the curve V_{F-D} with the dashed line portion). A more reliable and accurate trigger voltage is thereby achieved. The end of the superimposed phase, indicated by cross-hatching, prevents the igniting pulse from passing over at the beginning of the angular range of ignition. The nominal value of the trigger voltage may thus be chosen so that the 5% higher trigger voltage, due to the 5% lower alternating voltage, is just reached with certainty (FIGURE 4).

If the smallest trigger voltage and the highest alternating voltage happen to coincide, the deviation of the ignition angle with respect to the first extreme case is comparatively small because of the greater slope of the curve.

The maximum value of both voltages together, when correctly proportioned, cannot exceed the maximum direct voltage so that the ignition angle of 180° is invariably obtained.

The variable direct voltage necessary for adjusting the ignition angle is superimposed on the alternating voltage applied to terminals D–F (FIGURE 1), which direct voltage may be derived from, for example, a direct-voltage source **6** through a potentiometer **7**. The sum of the direct and alternating voltage is thus set up before terminals F and G. Terminals F and G are connected across the cathode and control electrode of the controlled rectifier to control the firing angle thereof. As a matter of fact, the phase-shifted voltages can be derived from two separate phase-shifting devices.

If the arrangement is part of a control system or the like, the direct voltage is preferably constituted by the output voltage of the regulator. As an alternative, it can be derived from, for example, a remote resistor.

What is claimed is:

1. A control circuit for a controlled rectifier of the type having an anode, a cathode, and a control electrode, comprising means for applying an A.C. supply voltage to the anode-cathode path of said controlled rectifier, means for deriving an A.C. voltage which leads said A.C. supply voltage by approximately 90 degrees, means for deriving an A.C. voltage which lags said A.C. supply voltage by approximately 15 degrees, means for rectifying the lagging voltage to obtain a rectified half-wave voltage, means for combining said lagging rectified voltage and said derived leading A.C. voltage to produce a control voltage, a source of direct voltage, and means for supplying said control voltage and said direct voltage to said control electrode so as to control the conduction of said controlled rectifier.

2. A control circuit for a controlled rectifier of the type having an anode, cathode, and a control electrode, said circuit comprising a source of alternating voltage coupled to the anode-cathode path of said controlled rectifier, means for deriving a first A.C. voltage which leads said alternating voltage by approximately 90 degrees and a second A.C. voltage which lags said alternating voltage by approximately 15 degrees, half-wave rectifier means arranged to rectify said second voltage to obtain a rectified half-wave voltage, means for combining said half-wave voltage and said first A.C. voltage to produce a leading voltage having a portion of its waveform distorted, means for producing a variable direct voltage, means for combining said direct voltage with said distorted leading voltage to obtain a composite control voltage, and means for applying said control voltage between said cathode and said control electrode of said controlled rectifier.

3. A circuit as described in claim 2 wherein said voltage deriving means comprises first and second phase shifting means for deriving said leading and lagging voltages, respectively, from said alternating voltage source.

4. A circuit as described in claim 3 further comprising control circuit means for delivering a control output voltage and means for deriving said variable direct voltage from said control circuit means output voltage.

5. A control circuit for a controlled rectifier of the type having an anode, cathode, and a control electrode, said circuit comprising means for supplying an alternating voltage across the anode and cathode of said controlled rectifier, means for deriving first and second A.C. voltages which lead and lag said alternating voltage by approximately 90 degrees and 15 degrees, respectively, means for rectifying said second A.C. voltage to obtain a rectified half-wave voltage, means for combining said rectified half-wave voltage and said first A.C. voltage so as to produce a composite alternating voltage which leads said first mentioned alternating voltage, means for producing a direct voltage, means for combining said direct voltage and said composite alternating voltage to obtain a control voltage, and means for supplying said control voltage to said controlled rectifier control electrode so as to control the conduction period thereof.

6. A circuit as described in claim 5 wherein the magnitude of said direct voltage is adjustable to vary the controlled rectifier bias level to control said conduction period and wherein said A.C. voltage deriving means comprises phase shifting means coupled to an alternating voltage source which is in phase with the alternating voltage supplied to said controlled rectifier anode and cathode.

7. A control circuit for a controlled rectifier of the type having an anode, cathode, and a control electrode, said circuit comprising means for supplying an alternating voltage across the anode and cathode of said controlled rectifier, means for deriving from said alternating voltage supplying means first and second A.C. voltages which lead and lag said alternating voltage by approximately 90 degrees and 15 degrees, respectively, means for rectifying said second A.C. voltage to obtain a rectified half-wave voltage, means for deriving a variable direct voltage, means for combining said rectified half-wave voltage, said first A.C. voltage and said variable direct voltage to obtain a control voltage which leads said alternating voltage, and means for supplying said control voltage to said controlled rectifier control electrode so as to control the conduction period thereof.

8. A control circuit for a controlled rectifier of the type having an anode, cathode, and a control electrode, said circuit comprising a source of alternating voltage coupled to the anode-cathode path of said controlled rectifier, means for deriving a first A.C. voltage which leads said alternating voltage by approximately 90 degrees and a second A.C. voltage which lags said alternating voltage by approximately 15 degrees, means for rectifying said second A.C. voltage to obtain a rectified half-wave voltage, means for vectorially combining said rectified half-wave voltage and said first A.C. voltage to produce an alternating control voltage having a portion of its waveform distorted, and means for supplying said control voltage to said control electrode of the controlled rectifier.

9. A circuit as described in claim 8 further comprising means for supplying a variable direct voltage to said control electrode to adjust the bias level thereof and wherein said control voltage is distorted so as to increase the slope of a portion of its waveform.

10. A control circuit for a controlled rectifier of the type having an anode, cathode, and a control electrode, said circuit comprising a source of alternating voltage coupled across the anode and cathode of said controlled rectifier, a transformer having a primary winding adapted to be connected to an alternating voltage which is in phase with said alternating voltage source and a center tapped secondary winding, a first series circuit comprising resistance and capacitance means connected across said secondary winding to draw a leading current, a second series circuit comprising a resistor and diode connected between said center tap and a junction point of said first series circuit such that the voltage across said second series circuit lags the secondary voltage by approximately 15 degrees, a first output terminal connected to a second junction point of said first series circuit at which the voltage with respect to said center tap leads by approximately 90 degrees, a second output terminal connected to a junction point of said resistor, and means for coupling said output terminals to the cathode and control electrode of said controlled rectifier.

11. A circuit as described in claim 10 further comprising means for supplying a variable direct voltage to said control electrode to adjust the bias level thereof.

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