Dec. 3, 1940. D. KIESEWETTER 2,223,620

WINDOW LOCK

Filed April 18, 1938

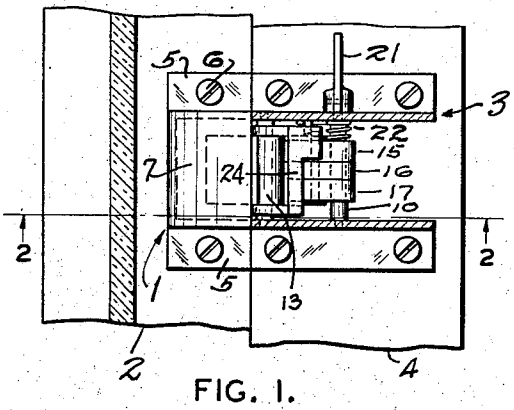


FIG. 1.

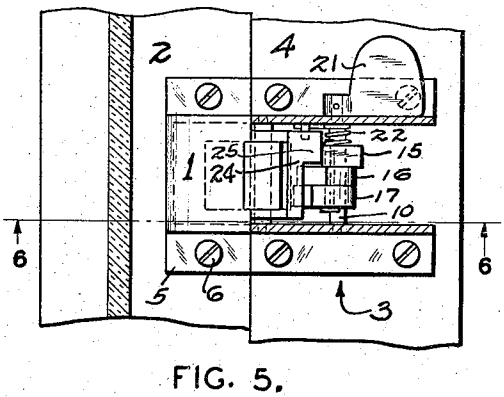


FIG. 5.

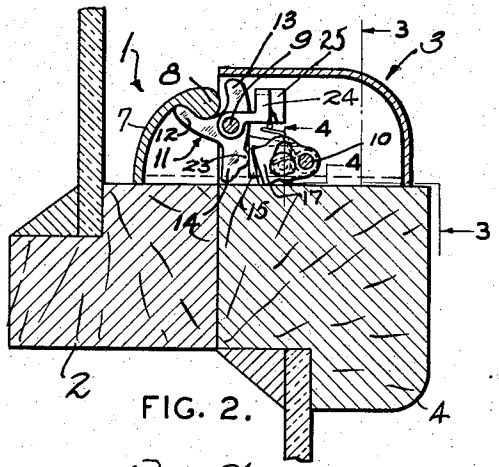


FIG. 2.

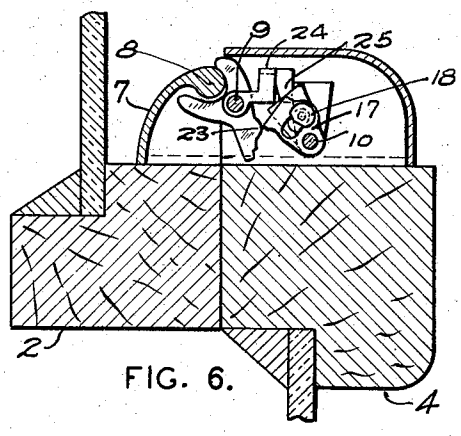


FIG. 6.

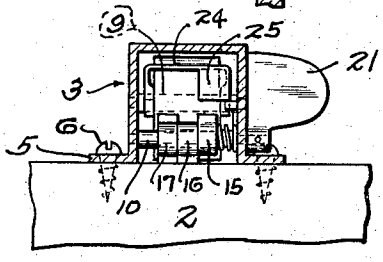


FIG. 3.

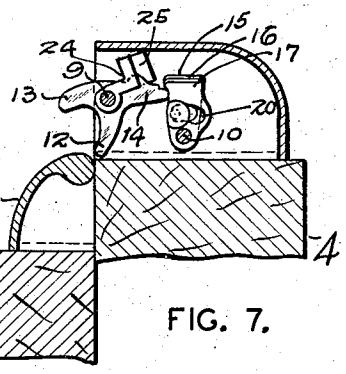


FIG. 7.

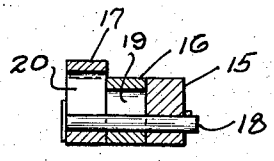


FIG. 4.

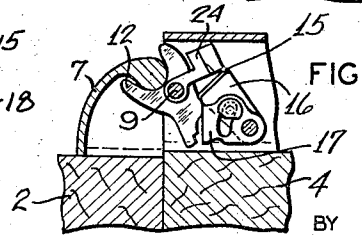


FIG. 8.

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IGNITRON STARTER CIRCUIT

Hans Klemperer, Belmont, Mass.

Application March 23, 1939, Serial No. 263,735

12 Claims. (Cl. 175—354)

The present invention relates to ignitron starter circuits and to means and methods of eliminating such auxiliary tubes as the thyratrons or the mercury type tubes.

In the usual system in which ignitrons were used, a thyratron or other auxiliary tube was used in series in the circuit of the starter electrode since the ignitron starter could not readily withstand a reverse current. This also is the reason why the ordinary peaking transformer could not be used successfully because of the difficulties offered by the negative peak. A thyratron used in this way has a very short life, and is therefore both expensive and inconvenient. The shortness of life of the tube is due to the necessity of a very high peak current required by the starter and the sharpness of the impulse which does not allow the thyratron cathode to adjust itself in time and therefore the life of the tube is very short unless an excessively large and therefore expensive tube is used. A mercury pool type auxiliary tube is also too expensive and costly to operate since it is necessary to install holding arcs and mechanical starting means in the auxiliary tube.

The means and method of the present invention eliminate the use of auxiliary tubes in the operation of ignitrons. By the present invention the necessary magnitude and wave form of current and voltage are supplied to the ignitron starting electrode through the use of iron core coils and circuits connected to the ignitron starting electrode and independently energized by both direct and alternating current sources.

In the operation of ignitron tubes, the optimum operating condition is obtained as far as the functioning of the starting electrode is concerned, if its action brings about a discharge of the tube by its momentary operation and then remains dormant, using no power until the tube is again to be discharged.

It must be appreciated that in the present invention, the action and operation of the starting electrode occur only during a very short interval as compared with the time of flow of current in the tube, and that no auxiliary means are necessary to cut the starter current after the main anode has picked up.

The circuit and means used in the present invention have this aim in view and not only is there provided a sharp peaked current to the starting electrode at the desired moments, but between these moments, the current and therefore the power consumed by the starting electrode are practically zero. In accomplishing the results of the present invention, no gaseous or vacuum tubes are necessary, and what little direct current is needed may be supplied from a dry disk rectifier, for instance, a copper oxide rectifier, shunted by a condenser, and controlled by a rheostat or by a transformer having several taps as will appear later.

The advantages and merits of the present invention will be more clearly understood from the description of the apparatus given below embodying the invention, when taken in connection with the drawing hereto annexed, in which:

Figure 1 shows a schematic wiring diagram with the ignitron controlled in accordance with the principles of the present invention;

Figure 2 shows a complete schematic wiring diagram as applied to a three phase system;

Figure 3A shows a schematic diagram of the starter electrode circuit;

Figures 3A, 3B, 3C, 3D and 3E show a group of curves as applied to the functioning of the starter electrode in Figure 3A;

Figure 4 shows modifications for by-passing reverse current; and

Figure 5 shows a means for checking the adjustment of the direct current supply.

With reference to Figure 1, the ignitron tube 1 has the usual cathode pool 3, anode 4, and starter electrode 5. The cathode and anode have impressed upon them the alternating voltage of the A. C. source 6 through the transformer 2. In accordance with the present invention, the starter electrode 5 is connected in series with the coil 7 surrounding an iron core 8 saturated by the impression upon the coil of the desired and selected alternating and direct current components. For this purpose a transformer 9 energized from the alternating current power source 6 is provided with two secondary windings 10 and 11, the winding 10 being connected in series with the coil 7 and a condenser 12, which in turn is connected to the cathode 3 of the ignitron tube 1. The winding 11 serves to supply energy for energizing the rectifier 13, which is preferably of the dry disc type of rectifier and which needs to supply only a comparatively small current. The output of the rectifier is connected across the condenser 12, preferably with an adjustable resistor 14 in series with it to regulate the current drawn from the rectifier, the positive side of the rectifier being connected to the starter electrode side and the negative side of the rectifier being connected to the cathode side of the ignitron tube. The output of the ignitron may be used in any desired way as indicated by the D. C. load 15 and may

be controlled by any external means of control, such as by short-circuiting as shown by the switch control 16. The present invention relates particularly to the starter operation and control, which will be discussed at greater length later.

In Figure 1 the control is illustrated as applied to a single-phase A. C. source, the ignitron 1 serving as one half wave rectifier and the ignitron 17 serving as the other half wave rectifier; that is, when the current in the transformer 2 is flowing to make the anode 4 positive with respect to the cathode 3, the ignitron 1 will operate, and when the current is flowing in the opposite direction, the ignitron 17 will operate.

In Figure 2 the present invention is applied to a six-phase system.

In the arrangement shown in Figure 2, there is shown a six-phase connection for an ignitron control circuit. In this circuit the primary of the transformer T is connected in Δ to the three phase A. C. supply with the secondaries connected in two three-phase Y's, displaced in phase 60° from each other and with an interphase reactor P having its mid-tap connected to the negative side of the D. C. line. In this way the two sets of Y branches 1, 2, 3, and 4, 5, 6, form six phases, 60° apart, each of which is connected to separate ignitrons 1_1, 1_2, 1_3, 1_4, 1_5, and 1_6, respectively. Each of these ignitrons has separate starting electrodes S_1, S_2, S_3, S_4, S_5 and S_6, connected each in series with saturation coils L_1, L_2, L_3, L_4, L_5 and L_6, respectively, corresponding to the coil 7 of Figure 1, and the proper corresponding alternating current component of the transformer T_2, namely, 1, 2, 3, 4, 5 and 6 of T_2, supplying the positive current peak as indicated in Figures 3A—3E, explained below.

The direct current component is supplied through the transformer winding T_3 and the rectifier R operated by it. In this circuit may be a condenser C corresponding to the condenser 12 of Figure 1 and an adjustable resistance r for proper control and operation of the current supplied to the rectifier R. While a six-phase transformer T_2 can be used for supplying the A. C. component for the starter electrodes, a six-phase phase shifter device could also be used.

A simplified arrangement of the elements of the present invention is shown in Figure 3A and curves in Figures 3B, 3C, 3D, and 3E illustrate the corresponding values of flux, current and voltage in the starting of the discharge to the starter electrode and its subsequent status until the next discharge occurs.

If pure A. C. were applied to the coil 7, a positive and negative peak would appear in the current wave as shown in Figure 3C. To suppress the negative peak 30, a D. C. E. M. F. is added to the A. C. E. M. F. by means of the rectifier 13, Figure 1. This suppresses the negative peak 30 and also sharpens the positive peak, Figure 3D, resulting in a current curve as indicated by 31, Figure 3D, which is due to the increased magnitude of magnetic flux on the positive side of the curve through the addition of the D. C. current component flowing in the coil 7. This single-sided magnetic flux on the positive side of the curve produces a saturation in the core of the coil 7 (see saturation curve, Figure 3B). It will be seen from the relationship of the curves in Figures 3C and 3D, that as the flux swings from a maximum to approximately zero (Figure 3D), the current flow with the sinusoidal voltage applied to the coil becomes very small during that portion of the flux curve that shows no saturation. During the portion of the curve Figure 3D, where saturation exists, the current flow on the other hand increases rapidly to the sharp positive peak shown by 31 in Figure 3D. Moreover the D. C. current which is sent through the coil (and the starter) in order to distort the magnetic flux, as described above, is given such a polarity and magnitude as to counterbalance remaining current.

This positive peak flows through the ignitor and, by reaching the critical current or voltage value, causes a discharge to develop between the mercury surface and the ignitor rod, as indicated in Figure 3E. The ignitor has an ohmic resistance which varies with voltage and temperature. This varying resistance is responsible for a slight distortion of the current wave (Figures 3D and 3E), but nevertheless, the ignitor operates according to the principle described.

Generally speaking, about 500 instantaneous watts are needed to cause an arc to pick up at the ignitor tip. After this short interval of power consumption, about 5 amperes at about 10 to 20 volt arc drop are needed to keep the arc burning, which power usually is supplied by the external power circuit. During this operating period of the ignitron, the ignitor current should be as near to zero as possible in order to avoid heating of the ignitor tip. In regular ignitor circuits having a thyratron tube, the interruption of the ignitor current, after pickup, is effected by extinguishing the thyratron; i. e. by lowering its voltage below the arc drop limit. At the corresponding time in the described circuit, after the current peak is over, the opposite polarity of D. C. and A. C. currents (Figure 3D) makes the remaining small current between the peaks practically equal to zero. Means of further reduction of that residual "in-between" current are described below.

The A. C. flux density in the saturated coil should be designed and afterwards adjusted to obtain minimum current in between peaks. After the coil has been installed an adjustment in the D. C. supply voltage may be necessary in order to obtain minimum reverse current with individually different ignitors. Such adjustment may be checked with a cathode-ray oscillograph, or, if this is not convenient, the dry disc (rectox) operated instrument circuit of Figure 5 is recommended. This circuit is capable of measuring small negative current in the presence of very large positive current. The instrument 40 and rectifiers 41 and 42 will pass the reverse current, but block the positive current, measuring thereby only the small negative current.

Instead of individual adjustment, any residual reverse current can also be diverted from the starter rod itself by means of the circuit shown in Figure 4, which shows one copper oxide rectifier 43 connected in series and one connected in shunt 44 with the starter rod. If the same saturated coil 7 with D. C. bias is employed, the advantage is that one copper oxide rectifier carries but little current and the other rectifier has to withstand but little inverse voltage. This is better than with normal peaking transformers which generate a large negative peak of current to be carried by the bleeder rectifier 44, in addition to the large inverse voltage on the bleeder rectifier 44 due to starter rod resistance on the positive peak. In the new circuit of Figure 4, the rectifier in series with the starter rod is not subjected to large inverse voltage, and this is the only rectifier carrying the peak current.

Variation of voltage of the A. C. mains is not harmful with the new circuits. The negligible "in-between" current changes, but no danger would occur until the iron became saturated in the negative direction also. This would require however, a very high overvoltage on the A. C. mains. The driving power or positive peak varies about proportionally to the A. C. main voltage. Such ordinary variations are not harmful to the ignitor operation.

Time is required to build up the D. C. excitation in this circuit. Rapid control requires, therefore, that the ignitor be short-circuited by the switch 16 shown in Figure 1 so that the current is not interrupted. Gradual control can be obtained by phase-shift of the A. C. supply to this control circuit. The A. C. supply of the circuit must have low impedance to avoid dulling of the peak current wave. For the same reason, windings 35 and 10 of Figure 1 should have low magnetic leakage between them.

The independent E. M. F. supply is characteristic of this circuit as contrasted with tube circuits fed from the anode, so that starting current will transfer and burn as an arc between the mercury pool and the holder of the starter 5, as shown on the wave of Figure 3E. For this reason an "arcing horn" or cap can be provided to take this arc and shield the lead-in and other delicate parts. It is also possible to use auxiliary anodes. These recommendations are not peculiar to this circuit, and really represent the construction of high voltage ignitrons, where, due to high voltages on the anode, the ignitor circuit is generally electrically independent.

Special alloys, such as permalloy, may be useful for the saturated coil. Common silicon steel was used however with good results.

Having now described my invention, I claim:

1. A circuit for starter operation of an ignitron having cathode, anode and starter electrodes having, in series with the said starter electrode, a coil with a magnetic core designed to become saturated upon the application of normal potentials thereto for supplying a starting peak of current to the starter electrode on the positive half cycle of the potential supplied to the anode, and means for supplying a direct current component in series with said coil and between cathode and starter electrodes for suppressing the negative peak that normally would otherwise be created by said coil.

2. A circuit for starter operation of an ignitron having cathode, anode and starter electrodes having, in series with said starter, means for supplying a single-sided peak of current only during the positive half cycle of the applied alternating current potential to said anode, comprising a coil with a saturable magnetic core connected to said starter electrode and energized by direct current and alternating current components from separate sources.

3. A circuit for starter operation of an ignitron having cathode, anode and starter electrodes having, in series with said starter, means for supplying a single-sided peak of current only during the positive half cycle of the applied alternating current potential to said anode, including means for supplying an alternating current component to said circuit from one source and means for supplying a direct current component to said circuit from another source of such a polarity that it substantially suppresses the reverse current that normally would otherwise flow in the starter electrode during the reverse half cycle of the alternating current potential supplied to said anode.

4. A circuit starter for operation of an ignitron having cathode, anode and starter electrodes having, in series with said starter, means for supplying a single-sided peak of current only during the positive half cycle of the applied alternating current potential to said anode, including a saturable magnetic core coil connected in series with the starter electrode, means for supplying a direct current component to said coil from one source, and means for supplying an alternating current component to said starter electrode in series with said coil from another source, and a condenser shunted across said direct current supply.

5. In combination with a polyphase supply system having an ignitron with cathode, anode and starter electrodes for each supply phase, individual saturable magnetic core coils in series with each starter electrode, means for supplying an alternating component of the desired phase for each coil from a suitable source, and a separate single source of direct current supplying neutralizing current to said coils for suppressing the reverse current in each starter and peaking the alternating current peak for each phase.

6. In combination with a polyphase supply system having an ignitron with cathode, anode and starter electrodes for each supply phase, individual saturable magnetic core coils in series with each starter electrode, means for supplying an alternating component of the desired phase for each coil from a suitable source, a separate single source of direct current supplying neutralizing current to said coils for eliminating the reverse current in each starter and peaking the alternating current peak for each phase, and a single condenser shunted across the direct current supply.

7. In combination with a polyphase supply system having an ignitron with cathode, anode and starter electrodes for each supply phase, individual saturable magnetic core coils in series with each starter electrode, a phase shifter device for supplying an alternating current component of the desired phase to each starter, and a separate single source of direct current supplying neutralizing current to said coils for eliminating the reverse current in each starter and polarizing the alternating current peak for each phase.

8. A starter circuit for operation of an ignitron having cathode, anode and starter electrodes having, in series with said starter, means for supplying a single-sided peak of current only during the positive half cycle of the applied alternating current potential to said anode, including a saturable magnetic core coil connected in series with the starter electrode, means for supplying a direct current component to said coil from one source and means for supplying an alternating component to said starter electrode in series with said coil from another source, a condenser shunted across said direct current supply, and means for adjusting the magnitude of said direct current component.

9. In a system of the type described, having an ignitron with cathode, anode and starter electrodes having, in series with said starter, means for supplying a single-sided peak of current only during the positive half cycle of the applied alternating current potential to said anode, comprising a coil with a saturable magnetic core connected to said starter electrode and energized

by direct current and alternating current components from separate sources, and means shunted directly from the starter electrode to the cathode for further suppressing and by-passing the reverse current that would otherwise flow through said coil.

10. In a system of the type described having an ignitron with cathode, anode and starter electrodes having, in series with said starter, means for supplying a single-sided peak of current only during the positive half cycle of the applied alternating current potential to said anode, comprising a coil with a saturable magnetic core connected to said starter electrode and energized by direct current and alternating current components from separate sources, and individual rectifying means in series with the starter electrode and next to it arranged in such polarity for suppressing the reverse current flowing through the starter.

11. A circuit for starter operation of an electrical gaseous discharge device, including cathode, anode and starter electrodes, having in series with the starter electrode a coil with a saturable magnetic core for supplying a starting peak of current to the starter electrode during the positive half cycle of a potential supplied to the anode, means for supplying through said coil to said core an alternating current component of magnetomotive force from a source, and means for supplying to said core a direct current component of magnetomotive force from another source, said direct current and alternating current components of magnetomotive force being of such relative magnitudes that the starting peaks of current supplied to said starter electrode are substantially unidirectional.

12. A circuit for starter operation of an electrical gaseous discharge device, including cathode, anode and starter electrodes, having in series with the starter electrode a coil with a saturable magnetic core for supplying a starting peak of current to the starter electrode during the positive half cycle of a potential supplied to the anode, means for supplying through said coil to said core an alternating current component of magnetomotive force from a source, and means for supplying to said core a direct current component of magnetomotive force from another source.

HANS KLEMPERER.