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PROTECTIVE CIRCUIT FOR OSCILLATORS

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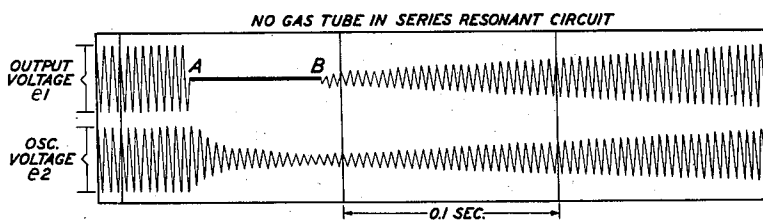
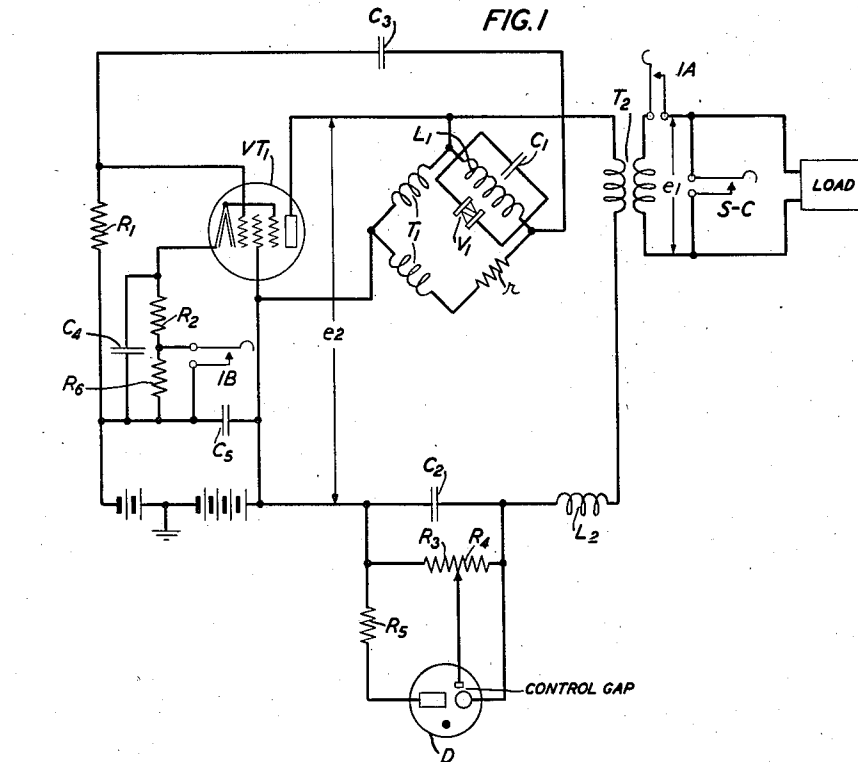


FIG. 2A

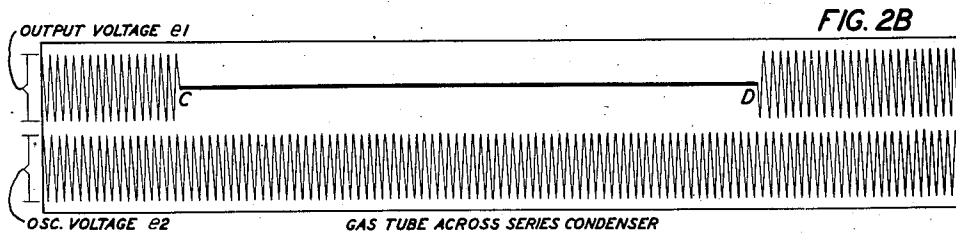


FIG. 2B

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PROTECTIVE CIRCUIT FOR OSCILLATORS

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12 Claims. (Cl. 250—36)

This invention relates to oscillators, operating under intermittent short-circuit load conditions.

A principal object of this invention is the provision of a protective system for oscillators operating with loads that alternate abruptly between normal load impedance and very low impedance. The very low impedance is due to the intermittent short-circuiting of the load.

More specifically, an object of this invention is the provision, in an oscillator, of a gas tube protective circuit whereby the oscillator will withstand short-circuit loads of any duration and return instantaneously to full working level upon the removal of the short circuit.

In one particular adaptation, the protective circuit is applied to a bridge stabilized oscillator of the type shown and described in United States patent application Serial No. 372,557, filed December 31, 1940, by L. A. Meacham.

Other auxiliary objects and advantages of the protective compensating circuit associated with the oscillator are (1) impedance compensation for reflected low load impedance; (2) instantaneous recovery of the oscillator to normal working level; (3) prevention of higher harmonics in load current during the periods of short circuit; (4) limiting excessive flow of current through the short-circuiting contacts. These results are achieved either during the short-circuit condition or during the recovery of the oscillator.

Other objects and features of the invention will be explained hereinafter and will be particularly pointed out in the appended claims.

Referring to the figures of the drawing:

Fig. 1 shows a circuit diagram of an oscillator with a gas tube protective circuit incorporated therein; and

Figs. 2A and 2B show oscillograms of oscillator performance under short-circuit loading.

Referring specifically to Fig. 1 of the drawing, a bridge stabilized oscillator is shown consisting of a vacuum tube with associated conventional power supply elements, a stabilizing bridge network, a load adapted to be intermittently short-circuited and a protective compensation circuit.

A single vacuum tube VT₁ is shown, the exact number being a matter of convenience and design. The internal elements of the tube and the associated resistors and capacitors are essentially conventional elements, typical values for an oscillator in the voice frequency range being

R ₁ -----	megohm--	0.5
R ₂ -----	ohms--	300
C ₁ -----	microfarads--	8
C ₂ -----	do--	8
C ₃ -----	do--	0.1

The resistor R₃ of 2000 ohms located in the cathode circuit reduces the current from the anode battery when the oscillator is idle. It is short-

circuited by relay 1B at the time when a load is applied to the output by the closing of relay 1A.

The bridge network associated with the vacuum tube has four arms, two of which are formed by a closely coupled inductance coil or transformer T₁ having a center tap which divides the coil into two equal portions. To this center tap the positive terminal of the battery is connected. The other two arms of the bridge are constituted by the resistance r and a network formed by the combination of the antiresonant circuit L₁C₁ with its associated varistor unit V₁. The L₁C₁ arm and the varistor unit control, respectively, the frequency and amplitude of the oscillator under normal conditions. The bridge is in balance when the combined impedance of the antiresonant arm L₁C₁ and varistor exactly equals that of the resistance r. Feedback to the control grid is taken from the junction point of L₁C₁ and r whereby any unbalance in the bridge is translated into grid potential swing of the tube VT₁.

An output transformer T₂ serves to make available to a load, oscillations produced by the oscillator.

In a specific application of this circuit in a telephone switching system, the load is intermittently short-circuited by selectors hunting over sleeve terminals, not shown directly, but schematically represented by contacts S—C adapted to short-circuit the load for a definite time interval. When such a short circuit is placed across the load, it appears as a corresponding impedance drop in the load circuit of the tube.

To compensate for this impedance drop, there is provided a protective compensation system which includes a series resonant circuit L₂C₂ having the same natural frequency as L₁C₁. At the operating frequency of the oscillator, L₂C₂ has very low impedance—for other frequencies, its impedance is high. Across one element, capacitance C₂ in this case, a gaseous discharge tube D is connected, together with a voltage divider R₃, R₄ to control its breakdown point. The voltage drop across C₂ increases with increasing load current until the peak voltage across R₄ equals the control gap breakdown voltage of D. Breakdown across the control gap is followed by the breakdown of the main gap which is established across all of C₂. The current limiting resistor R₅ is in series relation to C₂.

The protective gas tube D functions as a constant-voltage breakdown device remaining at its characteristic value as long as it is broken down. During the time that the protective tube operates to dissipate energy the series resonant circuit L₂C₂ is effectively detuned and its over-all impedance is relatively high. The increase in impedance of the protective circuit prevents over-

load of the oscillator and excessive current flow in the short-circuiting means. The inductance L_2 is also effective in blocking harmonic frequencies which may be introduced by the gas tube D during its operation. This blocking action maintains the output current essentially sinusoidal as short-circuit conditions are approached.

Referring to Fig. 2 of the drawing, the oscillograms illustrate the effectiveness of the protective circuit. The alternating current output voltage e_1 is shown on the upper trace and the oscillator plate voltage e_2 on the lower. The first record (2A) shows the behavior of the circuit during and after a momentary short circuit with the protective circuit rendered inoperative by removing the gas discharge tube from its socket.

The alternating current plate voltage e_2 is shown as dropping to a fraction of its normal value and taking more than 0.2 second to build up again after the short circuit condition is removed, imposing the same lag on the output voltage.

The short-circuit condition is shown in the upper trace by horizontal line AB.

The lower record (2B) of the oscillograms, shows how independent and indifferent the oscillator plate voltage becomes to short circuits when the protective circuit system is in operation. The drop in oscillator voltage e_2 is very small and recovery is almost instantaneous. The output voltage, upon removal of the short circuit condition, recovers steady state conditions within about 6 milliseconds.

As also indicated by the oscillograms, the frequency changes are extremely small with changes of load, even under short-circuit conditions.

The short-circuit condition in Fig. 2B is represented by the horizontal line CD.

Because of the filtering action of C_2 and L_2 , the current and voltage in the output remain essentially sinusoidal for any value of terminating impedance.

The varistor unit V_1 which may be of silicon carbide accomplishes voltage regulation by controlling the state of resistive balance of the bridge. Its resistance varies inversely as the cube of the voltage across it. When power is first applied to the oscillator, the varistor is at its highest resistance value and the bridge is very much off balance, whereby a large voltage is initially fed back to the grid. This serves to start up the oscillator very quickly. As the plate voltage increases, it lowers the varistor's resistance. The bridge becomes more nearly balanced and the grid swing correspondingly reduced. A drop in plate voltage, such as might be caused by a load on the oscillator, produces the converse effects resulting in a rise in the unbalanced voltage of the bridge, in expansion of the grid swing, and in increase of the plate current amplitude.

Thus a restoring force comes into play for displacements in either direction. Equilibrium tends to become established at a definite amplitude of alternating plate voltage and the grid swing maintains this value.

The antiresonant arm of the bridge is also responsible for frequency control. In this, as in any oscillator, the steady-state frequency is that for which the net phase shift about the oscillating loop is zero or a multiple of 360 degrees. In the bridge, the transformer arms are closely coupled and introduce only a small and constant phase shift. With the third arm a resistance, the tuned circuit must operate at a frequency for

which its impedance is also a resistance to satisfy the phase requirements.

Above the resonance frequency, the antiresonant circuit is capacitive and below the resonance frequency, inductive. Any small change in frequency causes a large phase shift in the unbalance voltage fed to the grid, and in the proper direction to effect a correction. The result is a very large restoring force for a small displacement in frequency.

What is claimed is:

1. A combined oscillator and protective system comprising an oscillation generator, a load alternating between normal impedance and very low impedance, and impedance means adapted to compensate for the effects of the low impedance load, connected in the oscillator output circuit, said impedance means containing portions adapted to maintain the operation of the oscillator constant and sinusoidal during the low impedance intervals and the recovery intervals.

2. A combined oscillator and protective system comprising an oscillation generator, a normal load and short-circuiting means for said load, protective impedance means connected to the oscillator, and adapted to compensate for the effects of said short-circuiting means, the value of said protective impedance being sufficiently high to prevent excessive current flow in said short-circuiting means.

3. A combined oscillator and protective system, comprising an oscillation generator, a load therefor and intermittent short-circuiting means for said load, a protective impedance circuit adapted to compensate for the effects of the short-circuiting means, said protective circuit including a constant voltage discharge device adapted to break down as the load increases.

4. An oscillator adapted to maintain normal operation under short-circuited load conditions, comprising an oscillation generator and a protective compensation circuit associated with said oscillator and adapted to operate during the short circuit interval, said protective circuit including an impedance network having normal low impedance at the oscillator frequency, a portion thereof being shunted by a constant voltage limiting device, said device adapted to increase the over-all impedance of the network when said load is short-circuited.

5. A combined oscillator and protective system, comprising generator means for producing constant oscillations, an impedance load adapted to shift from a normal state to a short-circuited state and back again, a protective compensation circuit having low impedance when the load is normal, and increased impedance when the load is short-circuited.

6. An oscillator protective system comprising a bridge-stabilized oscillator adapted to maintain constant oscillations, and protective impedance means adapted to maintain said oscillations substantially constant during short-circuit load conditions and for the recovery period, comprising an impedance which is low under normal operation and which increases to compensate for a low load impedance resulting from the short circuit.

7. An oscillatory system adapted to operate with substantially constant performance under short-circuited load conditions, comprising an oscillator, a load adapted to alternate abruptly between a normal operating impedance value and substantially zero impedance, a protective circuit having normally very low impedance and

adapted to vary its impedance abruptly and simultaneously with the alternations in load impedance.

8. An oscillator comprising a vacuum tube generator adapted to operate under normal and short-circuit conditions, and compensating impedance means adapted to operate under the short-circuit condition comprising a series resonant circuit located in the plate circuit of said generator and having low impedance at the normal oscillator frequency, a constant voltage gas discharge device shunting a portion of the series resonant circuit and adapted to break down and detune said series-resonant circuit, thereby compensating for the reflected low impedance caused by the short-circuit condition.

9. An oscillatory system adapted to operate under short-circuit load conditions, comprising a generator of oscillations, a protective impedance circuit adapted to compensate the reflected low impedance load comprising a series resonant circuit having low impedance at the normal generator frequency, a breakdown constant voltage gas tube associated therewith, a portion of said resonant circuit operating to block harmonics from the gas tube as the generator load becomes short-circuited.

10. An oscillator protective system comprising an oscillator, a load therefor adapted to operate under short-circuit conditions, and protective

circuit impedance means adapted to compensate for the reflected low load impedance, said protective circuit including a breakdown discharge device and means associated with said breakdown device for blocking harmonic frequencies and maintaining the output current of said oscillator substantially sinusoidal as the short-circuit condition is approached.

11. An oscillatory system comprising an oscillator provided with bridge stabilization, an intermittently short-circuited load and compensating impedance means comprising a series circuit of inductance and capacitance resonant at the oscillator frequency located in the plate circuit of said oscillator, a gas discharge breakdown device shunting the capacitance, and resistance potentiometer means adapted to control the breakdown voltage of said discharge device.

12. A combined oscillator and protective system, comprising a generator of oscillations, a load therefor adapted to intermittently vary between a normal condition and a severe overload, and protective means connected to said generator and adapted to compensate for said severe overloading, said protective means including variable impedance actuated by the overload and adapted to maintain the generator oscillations constant during the overload and recovery intervals.

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