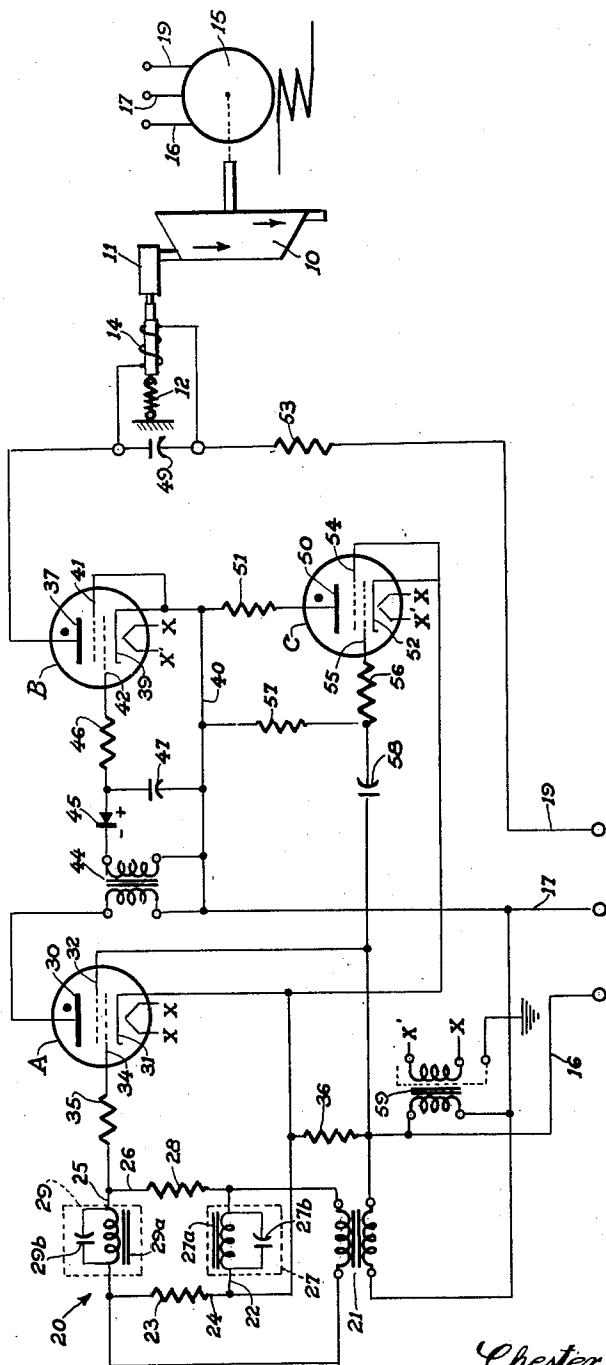


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 TRIGGER TYPE FREQUENCY SENSITIVE CONTROL
 NETWORK AND TURBO-GENERATOR CONTROL
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TRIGGER TYPE FREQUENCY SENSITIVE CONTROL NETWORK AND TURBO-GENERATOR CONTROL

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This invention relates to electronic networks of the trigger type, and, more particularly, to such networks which respond to variations in the frequency of a source of current for the network to control the operation of electrically responsive means.

An object of the present invention is to provide such a network which responds instantly to frequency variations of a predetermined magnitude and effects actuation of an electrically responsive device.

Another object is to provide such a network in which the effects of random signals are minimized.

Another object is to provide such a network which operates automatically.

Another object is to provide such a network which fails safe in that the electrically responsive means will be de-energized in case of failure of the network.

A further object is to provide such a network which is simple and compact in arrangement, economical to manufacture and reliable in its operation.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawing, forming a part of the specification, wherein the single figure is a wiring diagram of a network in accordance with the invention, for controlling the throttle of a prime mover coupled to an alternator shown schematically.

Referring to the drawing in detail, there is shown a prime mover, such as a steam turbine 10, controlled by a throttle 11 which is normally maintained closed by the action of a spring 12 and which is connected to a solenoid 14 for opening the throttle against the action of the spring.

An alternator 15 is coupled to the turbine 10 and serves as a source of power for a network which operates the throttle 11 in response to frequency variations due to changes in the speed of the prime mover. The power is delivered through a neutral line 16, a first phase line 17 and a second phase line 19.

The network generally comprises a frequency sensitive phase shift bridge 20 electrically coupled to a thermionic tube A controlled by the output of the bridge, a second thermionic tube B for energizing the solenoid 14 to open the throttle and arranged to be shut off upon firing of the tube A, and a third thermionic tube C for preventing the tube A from conducting or firing and shutting off the tube B during a predetermined portion of any cycle, for example, in the last 315° thereof.

The bridge 20, is coupled to the power source through a transformer 21 which has its primary winding energized by a first phase circuit, as shown, and serves to isolate the bridge from a direct line potential. This bridge comprises four arms 22, 24, 25 and 26. The arm

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22 is electrically connected at its respective ends to one end of the arms 24 and 26, and the arm 25 is electrically connected at its respective ends to the other end of the arms 24 and 26. The arms 22 and 25 each include a capacitively tuned reactor 27 and 29, respectively, and the arms 24 and 26 each include a conventional resistance 23 and 28, respectively. The reactors 27 and 29 each comprise an iron core reactor 27a and 29a in parallel with a condenser 27b and 29b, respectively. This bridge may be tuned to any desired frequency, for example, 400 cycles per second.

The input to the bridge 20 is delivered from one side of the secondary winding of the transformer 21 to the point of juncture of arms 24 and 25 and from the other side of the secondary winding to the point of juncture of arms 22 and 26 and the output is delivered from the point of juncture of arms 25 and 26 and of arms 22 and 24.

Tubes A, B and C are tetrodes of the hot cathode, gas type. For example, tubes identified in the electronic field as 2D21 may be advantageously utilized.

The tube A has an anode 30 connected to the first phase line 17, a cathode 31 connected to the neutral line 16, a suppression grid 32, and a control grid 34 connected to one side of the output of the bridge through an isolating resistance 35 which serves to limit the flow of grid current back through the bridge. The other side of the bridge output is connected to the cathode 31 of tube A and to the neutral line 16 which is provided with a resistance 36 serving to apply a small bias potential to the cathode to establish the operating point of the tube A and effecting the operation of the tube A, when the tube C is firing or conducting, in a manner to be described hereinafter.

The tube B has an anode 37 connected to the second phase line 19, a cathode 39 connected to the first phase line 17 through the line 40, a suppression grid 41, and a control grid 42 connected to one end of the secondary winding of a transformer 44, the primary winding of which is in series with the anode 30 of tube A. The other end of the secondary winding is connected to the line 40. A rectifier 45 and an isolation resistance 46 are connected in series with the control grid 42 and a condenser 47 is connected in parallel with the control grid 42.

The solenoid 14 is connected in the second phase line 19 in series with the anode 37 of the tube B and in parallel with a condenser 49, the purpose of which will be discussed hereinafter. A resistance 53 is provided in the line 19 in series with the solenoid to establish proper operating characteristics for the solenoid and may be omitted where the solenoid has impedance and/or resistance characteristics which are suitable for the current flowing therethrough.

The tube C has an anode 50 connected through a suitable loading resistance 51 and the line 40 to the first phase line 17, a cathode 52 connected through the resistance 36 to the neutral line 16 in a manner similar to the cathode 31 of tube A, a suppression grid 54, and a control grid 55 connected through an isolating resistance 56 and a condenser 58 to the neutral line 16. A resistance 57 and a condenser 58, are connected in parallel with the tube C and constitute phase shift components, the characteristics of which are such so as to prevent the tube C from conducting during approximately the first 45 degrees of any cycle, for example.

The suppression grids 41 and 54 of tubes B and C, respectively, are connected to the cathodes 39 and 52, respectively, so that each such grid operates at the cathode potential of its respective tube. It will be understood that these suppression grids could be used to effect

different control characteristics if different potentials were applied thereto by tying them in at other points in the network. The suppression grid 32 of tube A is connected to the control grid line of the tube C.

The tubes A, B and C each derive heater current through lines xx', not fully shown, from the secondary winding of the transformer 59 which has its primary winding connected between the neutral line 16 and the first phase line 17.

When turbine 10 is idle and it is desired to put the same into operation, the throttle 11 is partially opened by inserting a removable shim (not shown) to permit the flow of sufficient steam through the throttle to start the turbine. The throttle is spring biased in his position until it is fully opened by the solenoid 14 in the manner about to be described, whereupon the shim is removed to permit the throttle to be closed fully thereafter by the spring 12.

In operation of the turbine, the alternator 15 generates power which is delivered to the control network through lines 16, 17 and 19 and the bridge 20 through the transformer 21. The thyatron circuit begins to warm up as soon as the turbine is started, and, upon reaching operating temperatures the tube B begins to conduct, whereby its anode potential energizes the solenoid 14 to fully open the throttle and causing the turbine speed to increase. As the alternator current frequency goes above the selected frequency to which the bridge is tuned, an error signal is generated by the frequency sensitive bridge effecting a phase shift in the control grid voltage of tube A relative to the plate potential thereof which causes that tube to start conducting or firing.

The signal from the tube A is transmitted through the transformer 44, the rectifier 45, which rectifies the signal and provides proper negative polarity thereof relative to the other potentials in the tube B at any given instant to insure that the tube B will cease firing, through the condenser 47 which smooths the signal, through the isolating resistance 46 and to the control grid 42 of the tube B, which, by reason of its disposition in the network, had been conducting. This causes the tube B to cease firing immediately and to de-energize the solenoid 14, whereupon the spring 12 tends to close the throttle 11 and the turbine and alternator speed is decreased.

The transformer 44, the rectifier 45, the condenser 47 and the resistance 46 also insure stable operation of the tube B and compensate for any minor undesirable phase shifts which might occur. During conduction, the wave form of the anode current of tube B is pulsating D. C. which is smoothed by the condenser 49 to provide a steady solenoid current.

As soon as the decreasing alternator frequency goes below the selected frequency to which the bridge is tuned, the supply power frequency drops to below 400 cycles per second. As this occurs, the control grid voltage for the tube A shifts back to its original position with respect to the anode voltage therein and the tube A ceases firing and allows the tube B to again conduct causing solenoid current to flow which energizes the solenoid to open the throttle 11 whereby the turbine and alternator speed is increased.

As described heretofore, the tube B is connected phase-to-phase. This arrangement provides a higher plate voltage in the tube B which is necessary to draw sufficient current to actuate the solenoid 14.

Since controlled firing of tube A must be effected by the tuned-bridge error signal only, the tube C is provided to prevent tube A from firing at the end of any cycle as a result of changes in the phase relation of the potentials in the tube A due to random signals in the network. Tube C is connected in a self-firing circuit except that its control grid voltage is derived across the first phase, as described heretofore, through phase shift components comprising the resistance 57 and the con-

denser 58, the characteristics of which are such so as to prevent this tube from conducting during approximately the first 45° of each cycle, for example. During the last 315° of any cycle, the tube C conducts or fires, whereupon the potential distribution of the circuit is such that the bias on the suppressor grid of the tube A is altered by the potential drop through the common cathode resistance 36 to prevent the tube A from firing and changing the operating state of the tube B. This insures that, in any operating cycle, the tube A controls the circuit only if it fires during the first 45° thereof. Any random signals occurring after this period in any cycle do not cause malfunction in the circuit to enable the tube A to commence firing. Inasmuch as the operating frequency of the circuit is determined by the power supply frequency, the thyatron circuit samples an error voltage which is developed across the phase shift bridge at a rate of 400 cycles per second, for example, and the loss in the last 315° of each operating cycle is negligible.

The duration of the periods of conduction or non-conduction of the anode 37 of the tube B will be determined by the load on the turbine or prime mover at any given time. For instance while a heavy load is applied to the turbine, the turbine will tend to slow down more rapidly and speed up more slowly than under a light load or no load. However, since the speed of the alternator is governed by the speed of the turbine, and since the network reacts to the frequency generated by the alternator, it will be seen that the throttle will remain open longer when the turbine is under a load than when it is under a smaller load or no load and that the period of conduction and non-conduction will automatically vary as required to maintain a constant speed. The desired constant speed is therefore maintained under conditions of no load, changing load and full load.

Actual tests have indicated that the network reacts to variations in the supply frequency of such small magnitude above or below the frequency to which the bridge 20 is tuned whereby it is impossible to read the degree of such variations on a conventional Weston frequency meter graduated in five cycle increments. In other words, the desired constant speed of the turbine can be maintained to a point wherein variations thereof cannot readily be measured.

While, for purposes of illustration, the present invention has been described herein as a throttle control for a prime mover such as a turbine in which it is desired to maintain constant speed at no load, changing load and full load, it will be appreciated that the invention has many varied applications.

From the foregoing description, it will be seen that the present invention provides a compact, efficient, economical and fail-safe network in which a continual series of conduction and non-conduction periods is automatically instantly established in response to frequency variations of a predetermined magnitude in a source of supply, and in which malfunction by reason of random line signals is minimized.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

I claim:

1. In combination, a prime mover; means for controlling said prime mover; an alternator driven by said prime mover providing a source of alternating current power supply; and a network comprising a bridge tuned to a predetermined frequency and having its input connected to be supplied by power from said source, a thermionic tube having an anode and a cathode and grid means connected across the output of said bridge, said bridge in response to a change in a predetermined direc-

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tion in frequency of the power supplied effecting a phase shift in the grid means voltage relative to the anode voltage of said tube to fire said tube, and electrically responsive power operated means connected to be actuated by anode signals of said tube to control said prime mover controlling means.

2. In combination, a turbine; a throttle for said turbine including a spring normally closing said throttle; an alternator driven by said turbine providing a source of alternating current power supply; a network comprising a bridge tuned to a predetermined frequency and having its input connected to be supplied by power from said source, a normally inactive first thermionic tube having an anode and having a cathode and control grid means connected across the output of said bridge, said bridge in response to a change in frequency of the power supplied effecting a phase shift in the grid means voltage relative to the anode voltage of said tube to fire said tube, a normally active second thermionic tube having an anode, a cathode connected to be supplied by power from said source and control grid means connected to the anode of said first tube whereby said second tube is rendered inactive when said first tube is fired, the output of said second tube being connected to said solenoid for normally energizing the same, a third thermionic tube having an anode connected to be supplied by power from said source, a cathode connected to the cathode of said first tube and control grid means, and phase shift components connecting the control grid means of said third tube to be supplied by power from said source, whereby said third tube is rendered inactive for a predetermined period in the initial portion of each cycle and active in the remainder portion of each cycle to prevent said first tube from firing in the remainder portion of each cycle.

3. A network of the class described comprising a source of alternating current power supply, a bridge tuned to a predetermined frequency and having its input connected to be supplied by power from said source, a normally inactive first thermionic tube having an anode and having a cathode and control grid means connected across the output of said bridge, said bridge in response to a change in frequency of the power supplied effecting a phase shift in the grid means voltage relative to the anode voltage of said tube to fire said tube, a normally active second thermionic tube having an anode, a cathode connected to be supplied by power from said source and control grid means connected to the anode of said first tube whereby said second tube is rendered inactive when said first tube is fired, and electrically responsive means connected to be supplied by power from said source and to be controlled by the anode of said second tube.

4. A network of the class described comprising a source of alternating current power supply, a bridge tuned to a predetermined frequency and having its input connected to be supplied by power from said source, a normally inactive first thermionic tube having an anode and having a cathode and control grid means connected across the output of said bridge, said bridge in response to a change in frequency of the power supplied effecting a phase shift

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in the grid means voltage relative to the anode voltage of said tube to fire said tube, electrically responsive means connected to be supplied by power from said source and to be controlled by the anode of said first tube, a second thermionic tube having an anode connected to be supplied by power from said source, a cathode connected to the cathode of said first tube and control grid means, and phase shift components connecting the control grid means of said second tube to be supplied by power from said source, whereby said second tube is rendered inactive for a predetermined period in the initial portion of each cycle and active in the remainder portion of each cycle to prevent said first tube from firing in the remainder portion of each cycle.

5. A network according to claim 4, wherein the components for controlling said second tube are constructed and arranged for rendering said second tube inactive in the first 45° of each cycle and active in the remaining 315° of each cycle.

6. A network of the class described comprising a source of alternating current power supply, a bridge tuned to a predetermined frequency and having its input connected to be supplied by power from said source, a normally inactive first thermionic tube having an anode and having a cathode and control grid means connected across the output of said bridge, said bridge in response to a change in frequency of the power supplied effecting a phase shift in the grid means voltage relative to the anode voltage of said tube to fire said tube, a normally active second thermionic tube having an anode, a cathode connected to be supplied by power from said source and control grid means connected to the anode of said first tube whereby said second tube is rendered inactive when said first tube is fired, electrically responsive means connected to be supplied by power from said source and to be controlled by the anode of said second tube, a third thermionic tube having an anode connected to be supplied by power from said source, a cathode connected to the cathode of said first tube and control grid means, and phase shift components connecting the control grid means of said third tube to be supplied by power from said source, whereby said third tube is rendered inactive for a predetermined period in the initial portion of each cycle and active in the remainder portion of each cycle to prevent said first tube from firing in the remainder portion of each cycle.

7. A network according to claim 6, wherein the components for controlling said third tube are constructed and arranged for rendering said third tube inactive in the first 45° of each cycle and active in the remainder 315° of each cycle.

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