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[54] MOMENTARY POWER SUPPLY SHUTDOWN SYSTEM

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[52] **U.S. Cl.**.......... **321/14**; 178/7.5 R; 178/DIG. 11; 317/33 SC

[51] **Int. Cl.** **H02m 7/00**

[58] **Field of Search** .... 321/11–14, 321/2 HF; 178/7.5 R, DIG. 11; 315/27 R; 317/27 R, 51, 31, 33 SC

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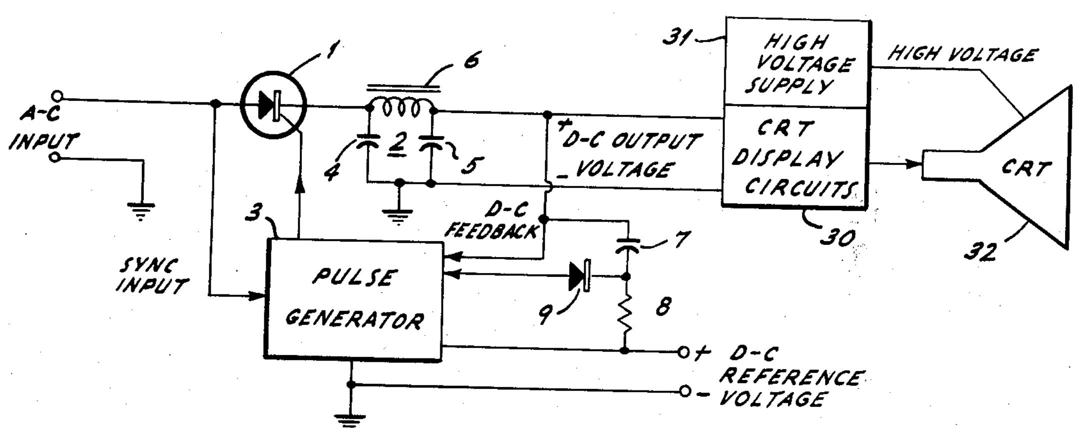
[57] **ABSTRACT**

A power supply contains a circuit, including a switch device, which responds to a sudden increase in load current and turns the power supply off for a short predetermined time interval. Such an arrangement is useful in a color television display wherein a cathode ray tube subject to arcing is used. Such arcing can be destructive, particularly where a well regulated power supply is used. The shutoff feature permits the arc to clear before power is reapplied.

5 Claims, 4 Drawing Figures



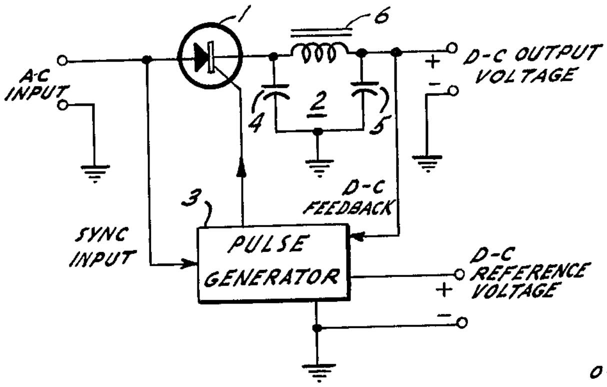


FIG. 1.
PRIOR ART

FIG. 2.
PRIOR ART

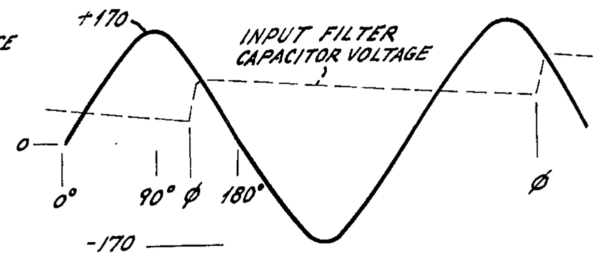
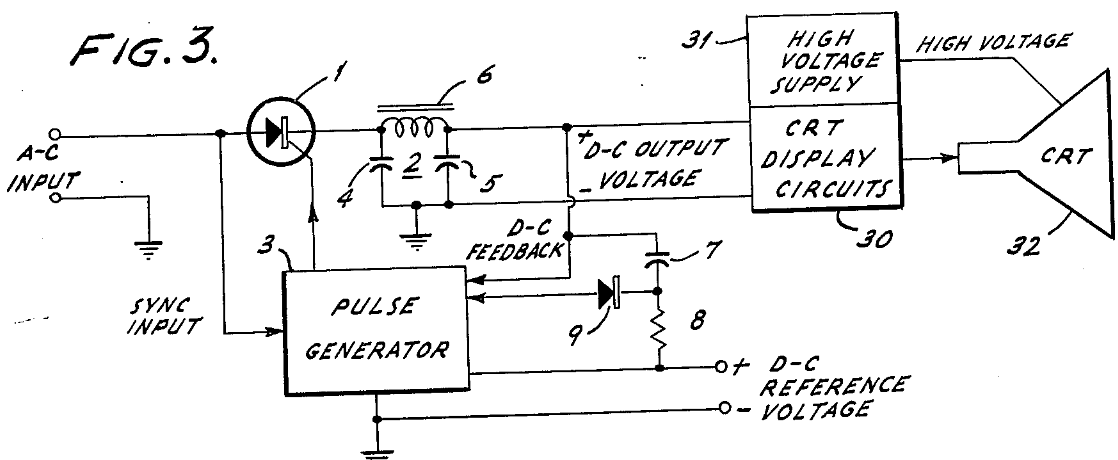


FIG. 3.



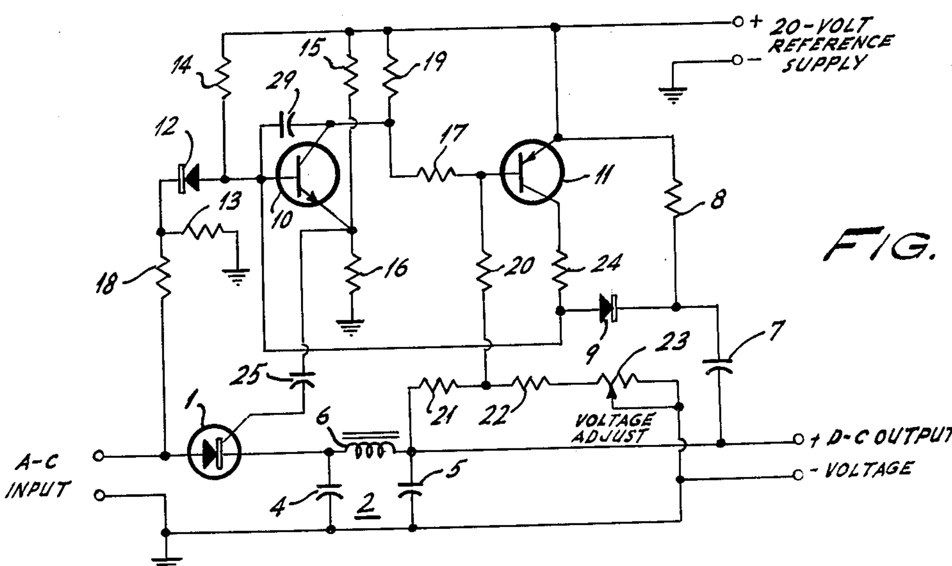


FIG. 4.

MOMENTARY POWER SUPPLY SHUTDOWN SYSTEM

RELATED APPLICATIONS

Patent application Ser. No. 384,116, which was filed July 30, 1973, and assigned to the present assignee, discloses a regulated power supply using an SCR as a combined rectifier and control device. The present invention is useful in such a power supply, particularly where protection against load device arcing is desired.

BACKGROUND OF THE INVENTION

Arcing in a cathode ray tube (CRT) is a well-known phenomenon although the detailed cause is not well enough understood to produce a complete cure. Monochrome CRT's arc on occasion, but color CRT's due to their higher operating potentials, tend to arc more frequently. Accordingly, color TV receivers commonly employ an extensive array of spark gaps to act as protective elements for the circuit devices associated with the CRT.

In the manufacture of a CRT, stringent quality control measures are taken in the various processes to avoid the conditions that lead to arc production. In addition a process known as spot knocking is employed. In this technique a much higher than normal voltage is applied to the finished CRT and this will enhance arcing. Each arc tends to destroy the arc-producing mechanism so that, after a short period of intense arcing at a higher-than normal voltage, the tube will be substantially arc-free at normal voltage. While the measures taken during manufacture have reduced arcing to a very low incidence it still occurs, particularly after the CRT has been handled extensively as it is in shipment and/or mounting in a TV receiver.

In conventional TV receivers, the starting of an arc will quickly reduce the high voltage, due to poor supply regulation, and the arc will tend to be self-extinguishing. However in modern solid state TV receivers much better high voltage regulation is being achieved in order to produce more satisfactory picture reproduction performance. For example in a conventional switching-type solid state TV deflection circuit, the circuit is regulated to provide deflection that is substantially independent of power line voltage. In some circuits regulation is accomplished by the use of a regulated low voltage power supply. In either case the high voltage is regulated usually by controlling the deflection circuit. While these modern circuits provide much more satisfactory picture performance, they tend to make arcing a more serious problem. In effect, when an arc does occur, the energy discharged is much greater. Under some conditions the regulation is good enough that the arc will be sustained for an extended period. This can be harmful to the CRT as well as the horizontal deflection and high voltage components. Fast acting circuit breakers can be used to interrupt the applied voltage when the current drawn by the circuit exceeds some predetermined value. However such devices are expensive, difficult to set properly, and are subject to false triggering. In addition they must be reset manually, thereby making them a nuisance.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a regulated power supply that will sense a sudden large increase in current drain and respond by shutting off momentarily.

It is a further object to provide a regulated power supply for a TV receiver in which a CRT arc will be sensed and the power supply turned off long enough to relieve the arc and then be turned back on again.

It is a feature of the invention that the above objects are accomplished by adding a small number of inexpensive components to a known regulated power supply circuit so that very little cost is associated with the invention.

These and other objects and features are achieved in a power supply using an SCR as a combined rectifier and voltage regulator. A conventional SCR is connected as a rectifier between the a-c line and a capacitor-input filter. The SCR is triggered by means of a pulse generator that produces a trigger pulse delayed with respect to the zero crossing of the a-c input. The delay is made a function of the d-c output voltage so that the SCR fires at a time that will vary to produce a constant d-c output voltage. This action produces a circuit that is regulated against load changes as well as a-c line in-put variations. A switching circuit is connected to the power supply so that in the presence of a sudden load increase, such as would be encountered in a CRT display device when a CRT arc occurs, the switching device is actuated thereby shutting off the pulse generator and hence the SCR. A time constant circuit is incorporated so that after a suitable off interval, the power supply operation is automatically restored.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of a prior art circuit;

FIG. 2 is a graph showing the operation of the circuit of FIG. 1;

FIG. 3 is a schematic diagram of a circuit employing the invention; and

FIG. 4 is a schematic diagram showing in greater detail a power supply employing the invention.

DESCRIPTION OF THE PRIOR ART

Referring to FIG. 1, SCR 1 is connected as a half wave rectifier to the a-c input line. This input can be the secondary of a transformer, but in the interests of economy, and if no voltage transformation is required, it is convenient to connect the SCR directly to the 120-volt a-c line. The half-wave rectified output is applied to a conventional filter 2 which smooths the rectifier output to provide a steady d-c output voltage. If the circuit used a simple diode, or if the SCR gate electrode were returned through a suitable resistor to the anode, a conventional half-wave rectifier would result. In such a circuit the rectifier would turn on during the rise of the positive excursion of the a-c input voltage and would charge filter capacitor 4 to the peak a-c line voltage. The rectifier would turn off when the a-c input voltage drops to the cathode voltage level. The filter capacitor would discharge until the next positive a-c input excursion whereupon the cycle repeats. Clearly, the d-c output voltage would be a function of the peak input voltage.

By adding the pulse generator 3 to the circuit, the SCR can be fired when desired by a controlled gate pulse. As shown in FIG. 2, the SCR is fired somewhere near the a-c input peak, the firing angle being designated ϕ. ϕ will be located in the range extending from shortly ahead of the 90° point to shortly ahead of the 180° point on the input waveform. This is because the maximum power supply energy capability will occur when the SCR is fired slightly ahead of the 90° point on the input wave, and to have any output at all the SCR must be fired ahead of the 180° point. The dashed line shows the voltage waveform across the input filter capacitor **4.** At **100,** when the SCR is fired by a pulse from generator **3,** the capacitor will quickly charge along an exponential rise to whatever voltage is present at the SCR anode. Then the capacitor will discharge between positive input alternations until the next firing interval. It can be seen that the capacitor charge is no longer related to peak line voltage. In addition, the magnitude of charge can easily be controlled or varied by changing the firing angle ϕ.

As shown in FIG. **1,** the pulse generator is synchronized by connecting it to the a-c input. The generator supplies a pulse, delayed with respect to the a-c input, that will turn the SCR on in the range of less than 90° to less than 180°. The delay is made variable in response to the difference between the d-c output voltage and a separate fixed d-c reference voltage applied between the indicated terminals. If the d-c output voltage is too low, the delay is reduced so that the SCR fires sooner; this will locate the firing point closer to the a-c input peak. If the d-c output voltage is too high, the delay is increased so that the SCR fires later and, therefore, lower down on the a-c input waveform. By making the firing angle ϕ a strong function of d-c output, close control of the output voltage is obtained. Clearly, the circuit will compensate for input or power line variations as well as load variations.

GENERAL DESCRIPTION OF THE INVENTION

FIG. 3 shows the components that are added to the circuit of FIG. **1** to practice the invention and how the power supply is connected to a CRT display.

Capacitor **7** charges through resistor **8** to the difference between the d-c output voltage and the d-c reference voltage. Thus the cathode of diode **9** will be at the positive potential of the d-c reference voltage. Because the anode of diode **9** is at a substantially lower potential (as will be apparent from the more detailed description of the circuit of FIG. **4**), diode **9** will be reverse biased and in its open switch state. For these conditions the circuit will function normally as a regulated power supply. The power supply operates the CRT display circuits **30** which include a high voltage supply **31.** The display circuits and high voltage output are connected to CRT **32.**

If for some reason, such as an arc in CRT **32,** the d-c voltage output drops suddenly so that capacitor **7** will not have time to discharge, the cathode of diode **9** can be driven more negative than its anode and it will be driven into its on switch state. This action causes pulse generator **3** to stop supplying pulses to SCR **1** which will then remain off. The d-c output voltage will then continue to fall thereby holding diode **9** conductive until the energy stored in filter **2** is discharged. This means that when a CRT arc occurs the influx of energy to the system is halted and the arc will only trigger the dissipation of the energy stored in the power supply filter, the CRT horizontal deflection circuit and the high voltage supply. Once that energy is dissipated, the arc will be relieved and the circuit restored to normal operation. If this arc termination were not accomplished, the regulated power supply could drive a considerable quantity of energy into the system possibly damaging the CRT or its associated components.

Once the d-c output voltage has dropped to some low value and capacitor **7** has discharged through resistor **8** to a value that will no longer hold diode **9** in its on switch state, the diode will cease to conduct and the pulse generator will resume its functioning. This will again turn SCR **1** on periodically and filter **2** will again become charged and the system will resume normal functioning. The time constant of capacitor **7** and resistor **8** is established to give the circuit an off interval of about 2 seconds. This period will be long enough to make sure that any arc will be completely interrupted but is short enough to have only a small effect on TV viewing. Clearly this interval can be selected within wide limits to achieve the desired action.

Many times a single arc occurance will, as described above in Background of the Invention, destroy the arc-producing mechanism and the system will operate normally after a single interruption cycle. However if the arc-producing mechanism still exists, an arc will develop again and the shutdown sequence repeated. Only in rare cases will the arcproducing mechanism survive several arc sequences with the interposed shutdown intervals. In the event that the arc-producing mechanism remains present, the shutdown sequence will continue to operate until the display is turned off manually.

FIG. 4 is a complete power supply schematic showing how the pulse generator of FIG. 3 can be implemented using a combined pulse generator-variable delay circuit.

SCR **1** is connected directly to the a-c input and provides rectified d-c output by way of filter **2** which is composed of input filter capacitor **4,** output filter capacitor **5,** and series filter inductor **6.** Under typical conditions, the d-c output voltage may be of the order of 100 volts. Complementary transistors **10** and **11** are connected into a well known bistable latching complementary pair configuration. Transistor **10,** in addition to being part of a latching pair, also acts as a Miller effect delay device. When transistor **10** is turned on from its off state, it will come on slowly due to the Miller effect. After a delay period, its output will become sufficient to turn transistor **11** on and the complementary pair will then rapidly switch on to saturation. This latter turn on action provides a pulse that is coupled by way of coupling capacitor **25,** to the SCR so as to fire it. Since the turn on of transistor **10** is synchronized to the a-c input by way of the network consisting of resistors **13** and **18** and diode **12,** the SCR firing angle is then controlled by the duration of the Miller effect delay. The delay is in turn controlled by applying (by way of resistance **17, 19, 20, 21, 22** and **23**) a fraction of the d-c output voltage to the base of transistor **11** to act as a bias or threshold control. As the d-c output voltage varies, the threshold at which the complementary pair switches on will be varied. This action varies the duration of the Miller effect delay. The sense of this feedback loop is such that the d-c output voltage will tend to remain nearly constant as will be discussed hereinafter.

A 20-volt reference supply is shown operating the delay and switching circuits. In applications where a suitable regulated voltage is available it would be used. If no such regulated voltage is available, the reference can be obtained from any convenient unregulated source that supplies more than the required value at the lowest a-c line voltage condition. A dropping resistor and zener diode having the required voltage rating are connected in series across the unregulated source. The voltage present across the zener diode is then used as the reference. If no such unregulated source is available an additional rectifier diode and filter capacitor combination can be connected to the a-c input line and the above mentioned resistor-zener diode combination connected across the filter capacitor. These latter components, associated with the 20-volt reference supply, are conventional and are not shown in the drawing.

In the quiescent state when the a-c input is near zero, diode **12** is forward biased by electron flow due to the 20-volt reference supply. Electrons will flow from ground through resistor **13**, from the cathode of diode **12** to its anode, and then up through resistor **14** to the positive supply terminal. Resistor **13** is made quite small, about 0.1% of the value of resistor **14**, so that the drop across it is negligible. Diode **12** being forward biased will develop about 0.6 volt at the base of transistor **10.** Resistors **15** and **16** are proportioned to apply a positive voltage of about 2 volts to the emitter of transistor **10.** Thus, transistor **10** will not conduct until its base is more than about 2.7 volts positive. For these quiescent conditions transistor **10** will be cut off and its collector will rest at almost 20 volts. This will apply a high positive potential to the base of transistor **11** through resistor **17** and transistor **11** will be held in its off state. This is a stable state for both transistors.

Resistors **13** and **18** form a voltage divider across the a-c input and are proportioned to apply about 2% of the input to the cathode of diode **12.** This will be about 3.4 peak volts for a 120-volt line condition. As the a-c inputs swings from zero toward its positive peak, at some point along the excursion, diode **12** will be cut off or reverse biased. When this occurs, the base voltage on transistor **10** will rise toward the positive 20-volt supply because of resistor **14.** When this rise exceeds about 2.7 volts, transistor **10** will start to conduct and its collector will start to fall toward ground potential. However, as soon as the collector starts to fall, capacitor **29** will couple the fall back into the base and oppose the change. This circuit configuration is called a Miller-effect circuit. As far as the base of transistor **10** is concerned, the circuit behaves as if a large capacitor were connected between base and ground. This effective capacitor has a value approximately equal to the value of capacitor **29** multiplied by the circuit gain of transistor **10.** Thus, a relatively small capacitor **29** will act in conjunction with resistor **14** to form a relatively long time constant integrator. In effect, a 0.02 microfarad capacitor can be made to act as if it were a 0.4 microfarad capacitor if the transistor circuit gain is only **20,** an easily achieved value.

It will be noted that the emitter of transistor **11** is returned to the 20-volt reference. Thus, when its base drops to about 19.3 volts it will begin to conduct. Resistors **17, 19,** and **20** are selected, along with the valves of voltage divider resistors **21, 22,** and **23** so that transistor **11** will be well below cutoff when transistor **10** is cut off. As the collector voltage of transistor **10** falls, at some point the base of transistor **11** will reach the 19.3-volt level. When this occurs and transistor **11** starts to conduct, collector conduction will tend to drive the base of transistor **10** positive. This in turn lowers the collector voltage of transistor **10** so as to turn transistor **11** on even harder. This regenerative action terminates the Miller-effect ramp and both transistors are quickly driven into saturation. At this time the collector of transistor **10** will have dropped to about 5 volts. Ramp termination can occur rapidly because resistor **24** is made much smaller than resistor **14** which, in conjunction with the Miller-effect capacitance, established the ramp rate. In practice, the value of resistor **24** is made as about equal to the value of resistor **15.** Thus, if resistors **15** and **16** produce a quiescent off state voltage of 2 volts at the emitter of transistor **10,** the value will increase to about 5 volts in the saturation or on state.

Thus, when the complementary transistor pair switches on, a positive pulse will appear at the emitter of transistor **10.** This pulse will be coupled to the gate of SCR **1,** by capacitor **25,** thereby causing it to fire. As the a-c input continues to fall, a time is reached at which point diode **12** becomes again forward biased and cuts off transistor **10.** This, in turn, cuts off transistor **11** because the collector of transistor **10** quickly returns to its 20-volt level where it will remain until the above sequence is repeated on the next positive half of the a-c input cycle.

If, for some reason, such as an increased load, the d-c output voltage were to decrease, it can be seen that a less positive quiescent bias will appear at the base of transistor **11.** This means that less ramp action is needed at the collector transistor **10** to produce the level at which the complementary transistor pair switches on. This means that an early switching pulse occurs at the emitter of transistor **10.** Since firing SCR **1** earlier will produce more d-c output voltage, the output voltage will be increased by the reduced firing angle to compensate for the postulated d-c output voltage reduction.

Conversely, if the d-c output voltage were to rise, for example as a result of reduced loading, a more positive bias will be applied to transistor **11.** This means that the ramp on the collector of transistor **10** will have to run longer to cause switching. Since the SCR is now fired later and lower on the a-c input waveform, the d-c output voltage will be reduced to compensate for the postulated rise.

For a given set of component values the circuit will act to maintain nearly a constant d-c output voltage value. It will, in fact, act to maintain a nearly fixed difference between the d-c output voltage and the reference voltage. Thus, it is responsive to variations of a-c input as well as load variations.

As a matter of convenience, such regulators usually include an adjustable element because otherwise each part would have to be held to excessively strict tolerance. In the circuit of FIG. **4** resistor **23** is made variable. As this resistor is varied, a variable fraction of the d-c output voltage is supplied to the base of transistor **11.** This will vary the length of the ramp needed to drive transistor **11** into conduction and will, therefore, vary the SCR **1** firing angle. For a given set of input conditions resistor **23** can vary the d-c output voltage over a substantial range. The circuit will then act to maintain the d-c output voltage constant at nearly the set value.

The circuit thus far described constitutes the prior art and is disclosed in detail in above-mentioned application Ser. No. 384,116. That application also shows further circuit refinements that enhance power supply performance. These refinements are not shown here because they are not necessary to understand the present invention which will now be detailed.

DETAILED DESCRIPTION OF THE INVENTION

Components **7, 8,** and **9** comprise the elements added to the prior art power supply to practice the invention. Capacitor **7** will charge through resistor **8** to the difference in potential between the 20-volt reference supply and the d-c output voltage. Thus if the power supply were to be set at 100 volts, capacitor **7** would charge to 80 volts. This would place the cathode of diode **9** at a positive 20 volts. Since the anode of diode **12** is connected to the base of transistor **10** which operates at a positive potential of only a few volts, the diode will be biased in its off switching state. Thus for normal operating conditions the circuit behaves as if components **7, 8,** and **9** were not present.

If a sudden increase in power supply loading occurs, such as would be produced by an arc in a color CRT operated by the power supply, capacitor **7** will not have time to discharge and the voltage change is coupled directly to the cathode of diode **9.** If the drop in power supply voltage is sufficient to drive diode **9** into its on switch state the base of transistor **10** will suddenly become connected to capacitor **7.** This will drive the base of transistor to negative with respect to its emitter thereby cutting it off. This will halt the pulsing of SCR **1.** The elements of filter **2** will then start to discharge and the output voltage will continue to fall. This falling output will keep diode **9** turned on by way of action of capacitor **7.** Thus the filter section **2** will discharge, the power supply output will be terminated, and the causal arc extinguished. As soon as the d-c output drops, capacitor **7** will start to discharge through resistor **8.** At some point along the discharge curve, the cathode of diode **9** will be driven to a potential with respect to its anode that will turn it off. The values of resistor **8** and capacitor **7** are selected to have a time constant that will establish a suitable power supply off interval. A value found to be useful is 2 seconds. Once diode **9** is driven to its off switch state, the pulse generator will resume functioning, SCR **1** will again receive pulses, and filter **2** will be recharged to where the regulator action takes over circuit operation as described above.

A suitable set of component values for the circuit of FIG. 4 is as follows:

SCR 1	C107D1 (General Electric)
Capacitor 4	400 microfarads 175 volts
Capacitor 5	400 microfarads 150 volts
Inductor 6	0.2 henry
Capacitor 7	10 microfarads 150 volts
Resistor 8	100K Ohms
Diode 9	1N456
Transistor 10	2N4424
Transistor 11	2N5366
Diode 12	1N456
Resistor 13	1K Ohms
Resistor 14	910K Ohms
Resistor 15	3.3K Ohms
Resistor 16	330 Ohms
Resistor 17	82K Ohms
Resistor 18	47K Ohms
Resistor 19	6.8K Ohms
Resistor 20	18K Ohms
Resistor 21	160K Ohms
Resistor 22	33K Ohms
Resistor 23	15K Ohms
Resistor 24	3.3K Ohms
Capacitor 25	.047 Microfarad

This circuit of FIG. 4 with the above component values functioned with good regulation. With the inception of a sudden load increase such as would be occasioned by a CRT arc, the output voltage was interrupted for a period of about 2 seconds.

The invention has been described in detail and a set of component values has been shown to provide suitable performance. Numerous modifications will occur to a person skilled in the art. For example, while the invention has been shown in connection with a half-wave line-connected rectifier, transformer operation could be employed and a full wave rectifier could be used. Further, resistor **8** could be returned to a source of potential other than the 20-volt reference or even a fraction thereof. The lower the potential to which resistor **8** is returned, the more sensitive the circuit will be to a drop in d-c output potential. For the conditions given a drop in d-c output of slightly less than 20 volts will initiate momentary shutoff. If resistor **8** were returned to a 10-volt supply (or ½ of the 20-volt reference supply) shutoff would occur when a drop of slightly less than 10 volts occurred. It is clear that still further modifications could be made within the scope and intent of the invention. It is intended that the invention be limited only by the following claims.

We claim:

1. A momentary shutdown circuit for a regulated power supply, said power supply including at least one SCR connected as a rectifier between an a-c input source and a smoothing filter, a pulse generator synchronized by said a-c input source and connected to fire said SCR, a reference supply source connected for comparison with said power supply output, a variable pulse delay circuit connected into said pulse generator so as to vary the timing of firing said SCR, said pulse delay connected to sense the difference between the potentials of said power supply and said reference supply and to reduce said delay as said difference decreases, said shutdown circuit comprising:

a storage capacitor having two terminals, one terminal of said capacitor being connected to the output of said power supply and the second terminal being connected through a series resistor to a shutdown source of potential independent from said power supply and having a potential value substantially lower than the nominal potential of said power supply, and

a unidirectional switch connected between said second terminal of said capacitor and a control element of said pulse generator, said switch being connected in a polarity such that said shutdown source biases said switch to be normally nonconductive but conductive when a sudden drop in power supply voltage is coupled by way of said capacitor to said switch, said switch when conductive acting upon said control element to render said pulse generator inactive thereby shutting down the operation of said power supply for a period of time determined by the time constant of said resistor-capacitor conbination.

2. The circuit of claim 1 wherein said switch is a semiconductor diode.

3. The circuit of claim 2 wherein said shutdown source is obtained from said reference supply.

4. A circuit of claim 2 wherein the time constant of said capacitor and said resistor is adjusted to produce a shutdown duration of about 2 seconds.

5. The circuit of claim 2 wherein the nominal voltage of said power supply is about 100 volts and the momentary shutdown action is triggered in response to a drop in output of about 20 volts.

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