May 4, 1954

H. L. REHKOPF ET AL

2,677,805

PROTECTIVE DEVICE

Filed Jan. 5, 1946

FIG. 1

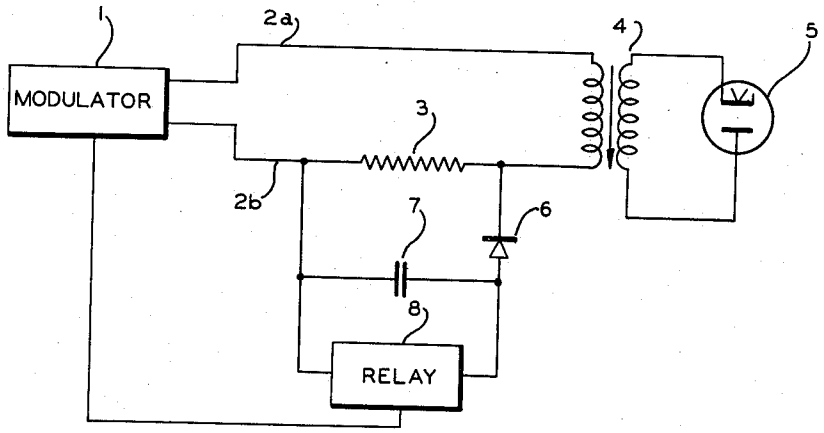
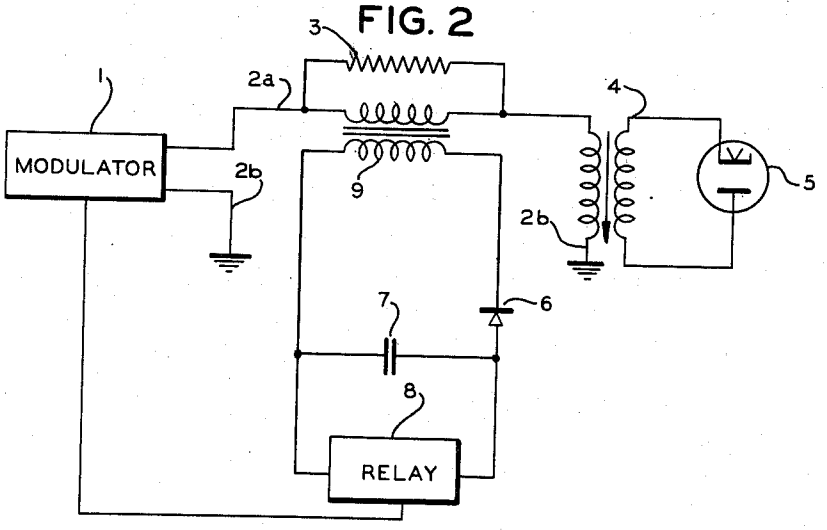


FIG. 2



INVENTORS
HAROLD L. REHKOPF
WINSTON H. BOSTICK

BY

M. O. Hayes

ATTORNEY

Patented May 4, 1954

2,677,805

UNITED STATES PATENT OFFICE

2,677,805

PROTECTIVE DEVICE

Harold L. Rehkopf, Seattle, Wash., and Winston H. Bostick, West Medford, Mass., assignors, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Application January 5, 1946, Serial No. 639,457

7 Claims. (Cl. 332—5)

1

This invention relates to apparatus for protecting modulators and pulse transformers from overload currents, and more particularly for protecting modulators and pulse transformers as used in a radar system.

In the radar art a magnetron oscillator requires an actuating pulse that must be of a short duration and large amplitude. One way of securing such a high power short duration pulse is to feed the output from a modulator to a pulse transformer which is designed to pass such a pulse and is insulated to withstand the voltages and to pass the amplitudes of current ordinarily needed.

A magnetron, however, will often become gassy or short circuited and this places an abnormally heavy load across the secondary of the pulse transformer. This overload will cause the charge on the primary of the pulse transformer and the pulse forming network to discharge at twice the normal current rate. This process leaves an opposite charge on the network which then discharges in the reverse direction and is reflected from one end of the pulse forming network to the other. If the energy is not removed from the modulator and these reflections continue, they will cause sufficient dissipation of power to damage the primary winding of the pulse transformer. The design of a transformer to withstand these overload currents would be difficult due to the unknown reflected quantity which would vary in different systems. In any event a transformer so designed would be a large and cumbersome device.

It is an object of this invention to provide apparatus for protecting modulators and pulse forming devices from overload reverse currents.

It is another object of this invention to provide such a protective device which may be adjusted to operate at a selected amplitude of reverse current.

It is another object of this invention to provide such protective apparatus that may be adapted to a variety of pulse forming networks such as are used in radar systems.

Other and further objects will be apparent upon consideration of the following description together with the accompanying drawing, in which:

Fig. 1 is a circuit diagram of an embodiment of the invention; and

Fig. 2 is a circuit diagram of a second embodiment of the invention.

In Fig. 1 energy is transferred from a modulator 1 through any conventional transmission line 2a and 2b to a pulse transformer 4 in order to

2

modulate a magnetron 5, and the normal current flow direction is as indicated by the arrow. A coupling means 3 for monitoring the pulse energy is connected to a rectifier 6 which is polarized to conduct only with a reversed current. The output from this rectifier is fed to storage condenser 7, which, when sufficiently charged, provides a voltage to actuate a relay 8 so connected as to disable the modulator 1.

In Fig. 2 is shown another type coupling means 9 which may be used in systems where one side of the transmission line 2b is grounded to a chassis or panel and it becomes necessary to insert the coupling means 3 into the high voltage side 2a of the line.

Considering Fig. 1, in greater detail, a reverse current flow will cause a voltage to be produced across the resistor 3, and this voltage is applied to a rectifier 6 which is so polarized as to conduct only reverse currents. These occur when a magnetron becomes gassy or shorted. The aforementioned IR drop across the resistor 3 will be of a varying amount dependent on the amount of current flow through the system. It is not desirable to have the system interrupted by minute or stray reverse currents, and to overcome this a storage condenser 7 is placed across the rectifier 6 and is charged at a stepped rate depending on the frequency of the reversed current. The relay 8 is thus actuated when the condenser 7 stores up sufficient voltage to reach that required for the type relay used. The relay is connected in such a manner that when actuated it interrupts the power supply to the modulator.

The rectifier 6 is preferably a selenium cell. For a normal peak current of 300 amperes and with a ½ ohm resistor in the circuit only 150 volts are across the selenium cell rectifier in its non-conducting direction during a pulse. If the magnetron should become gassy or short circuited a voltage of 300 volts is placed across the rectifier in its conducting direction. With a rectifier resistance in its conducting direction of 5 ohms, and a reflected current, usually about 600 amperes, one tenth of this current will flow through the rectifier and also the storage condenser. For a 20 microfarad condenser and with a 1 microsecond pulse the storage condenser would immediately start accumulating a charge in 3 volt steps for each full, reverse current reflection. However, these steps become smaller because the 10,000 ohms of the relay discharges the condenser between pulses, and the increasing condenser voltage opposes the voltage developed across the ½ ohm resistor. Using a 4 milliampere, 10,000

ohm relay, 40 volts are necessary to cause it to be actuated, and in observed operation the modulator was disabled in about one half a second when a magnetron became gassy or short circuited. The delay time in causing the relay to operate is determined by the size of the condenser, and considerable stray arcing may occur before the relay is actuated.

Considering Fig. 2 in greater detail, this system has one side of the transmission line grounded to the metal panel or chassis. In this case it becomes necessary to place the resistor in the high side of the line, and to insert an isolation transformer into the line to permit the connection into the circuit of the rectifier and relay. In a specific example, a 1:2 ratio step-up isolation transformer was used with a ½ ohm resistor across the primary, less than 1% of the total modulator power being wasted by such a resistor. To avoid insulation difficulties, this resistor can be mounted directly on the high voltage bushing of the transformer.

Thus is achieved a very efficient protective apparatus adaptable to many types of high power line-type modulator systems.

The invention is to be limited only by the appended claims.

What is claimed is:

1. In an electrical circuit including a modulator and a pulse transformer connected by a conventional feed line, a magnetron connected to said pulse transformer, a resistor in said line, a rectifier responsive to a voltage developed across said resistor, a storage condenser connected to said rectifier, a modulator protecting relay connected to said storage condenser, said rectifier being polarized in such a manner as to conduct only in the event of reverse currents in the line, a voltage output from said rectifier being stored in said condenser until of sufficient amplitude to actuate said relay and thereby interrupt operation of said modulator in order to protect the system.

2. In an electrical circuit including a modulator, a line, and a pulse transformer, said line connecting said modulator and said pulse transformer, a magnetron oscillator connected to said pulse transformer, a voltage pick-up means in said line including an isolation transformer, a rectifier, a voltage output from said isolation transformer being coupled to said rectifier, a storage condenser, a relay, voltage from said rectifier being impressed on said storage condenser until a voltage sufficient to actuate said relay is obtained, said relay being so connected as to interrupt the operation of said modulator, and said rectifier being so polarized as to respond only to reverse currents and thus provide an effective protection device for said reverse currents.

3. An electrical circuit including a modulator, a modulation transformer, a magnetron oscillator connected to said transformer as a load, a transmission line connecting said modulator to said transformer, means connected in said transmission line responsive only to current flow in a direction reversed to the flow of current in normal operation of said oscillator to develop a unidirectional voltage pulse and means responsive to a predetermined number of said pulses to shut off the operation of said modulator, whereby said electrical circuit protects said modulation transformer from overload currents resulting from a defect in said oscillator.

4. An electrical circuit including a pulse modulator, a pulse transformer, a magnetron oscillator connected to said transformer as a load, a transmission line connecting said modulator to said transformer, rectifying means connected in said line, said rectifying means being connected to be responsive only to current flow in a direction reversed to the flow of current in normal operation of said oscillator, and a safety relay operated by said rectifying means to shut off the operation of said modulator in response to said reversed flow of current, whereby said electrical circuit protects said pulse transformer and said pulse modulator of said magnetron oscillator from overload currents resulting from a defect in said oscillator.

5. In an electrical circuit including a modulator, a pulse transformer and a line connecting said modulator to said pulse transformer, a magnetron oscillator modulated by said pulse transformer, a resistor connected in said line, a rectifier responsive to the voltage developed across said resistor by the flow of current in said line, said rectifier being so polarized as to respond only to reverse currents in said line, and a relay actuated by the output of said rectifier to shut off said modulator.

6. A protective circuit for a magnetron oscillator modulated by a high power, short duration, unidirectional voltage pulse applied through a pulse transformer connected by a transmission line to a modulator comprising, an impedance connected in said line and developing a voltage drop in response to the current therethrough, a rectifier connected across said impedance and polarized to conduct only for reverse current flow in said line, a storage capacitor charged by conduction of said rectifier, and means responsive to a predetermined potential on said capacitor to shut off said modulator.

7. A protective circuit for a magnetron oscillator modulated by a high power, short duration, unidirectional voltage pulse applied through a pulse transformer connected by a transmission line to a modulator comprising, an impedance connected in said line and developing a voltage drop in response to the current therethrough, a rectifier connected across said impedance and polarized to conduct only for reverse current flow in said line, a storage capacitor charged by conduction of said rectifier, and a relay shunting said capacitor and responsive to a predetermined potential on said capacitor to shut off said modulator.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,135,199	Ponte et al.	Nov. 1, 1938
2,415,302	Maxwell	Feb. 4, 1947
2,469,977	Morrison	May 10, 1949