

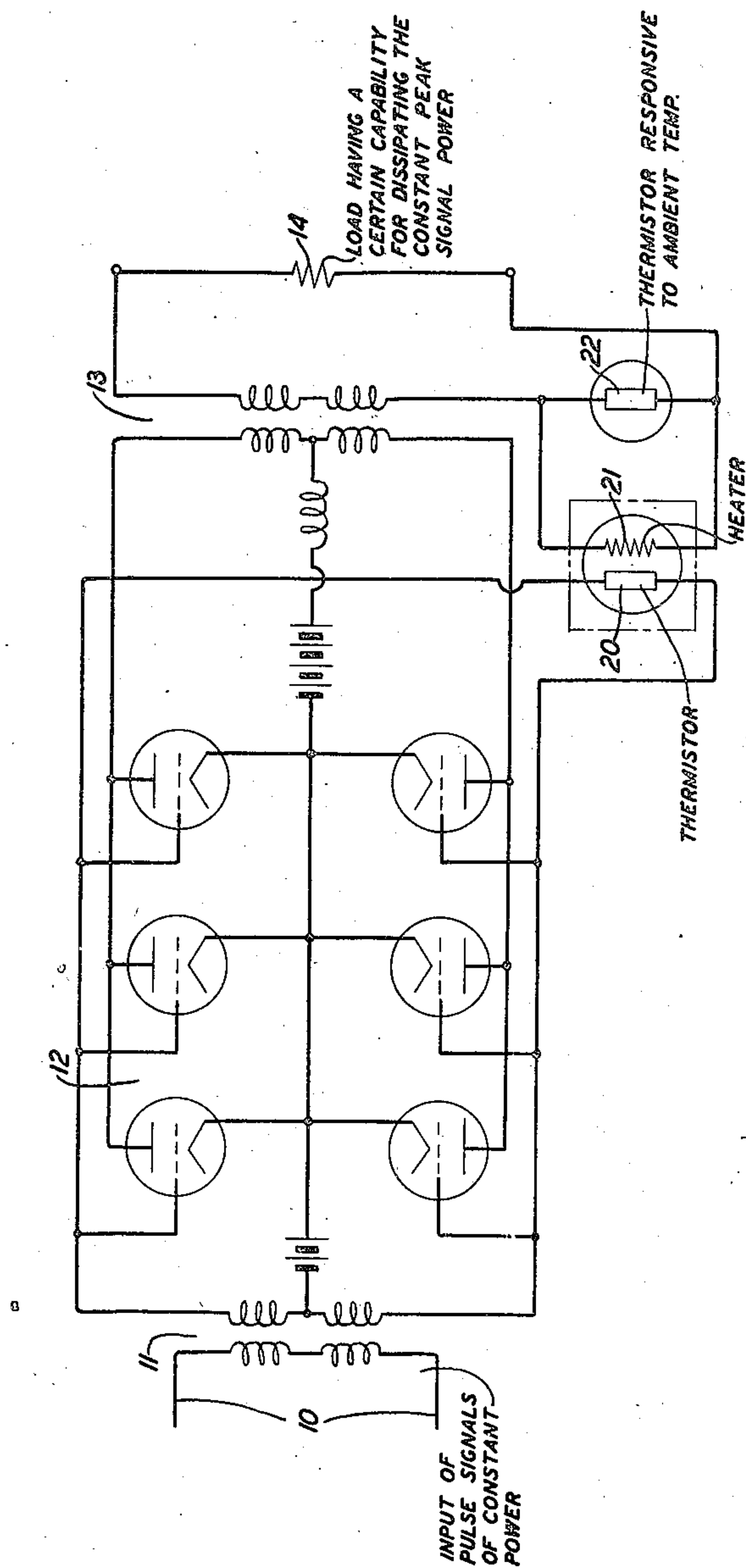
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J. H. BOLLMAN

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CONTROL OF SIGNAL POWER IN A SIGNAL TRANSMISSION CIRCUIT

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INVENTOR
J. H. BOLLMAN
BY *H. A. Burgess*
ATTORNEY

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CONTROL OF SIGNAL POWER IN A SIGNAL TRANSMISSION CIRCUIT

John H. Bollman, Rutherford, N. J., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

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1

This invention relates to a variable control of transmission in a circuit for supplying signal power to a wave translating device subject to damage from overheating when supplied with a high average amount of signal power for a time in excess of a certain time interval. More particularly, it relates to a control embodying a thermosensitive element for supplying a high average amount of signal power to the translating device for a certain time interval but a low average amount of signal power for a further time interval which includes the certain time interval.

The invention will be described with reference to its embodiment in an underwater ranging system of the type in which a wave translating device imparts the signal pulses to the seawater, and echoes are utilized to actuate receiving apparatus for obtaining information regarding distant submerged objects. These pulses must be sufficiently powerful to produce measurable echoes within the range of the system. As the duration of individual pulses may vary, the average power for a pulse of relatively long duration may be large enough to cause dangerous overheating of the wave translating device unless protection is provided to preclude such overheating.

In one underwater echo ranging system of recent design, the wave translating device comprises piezoelectric crystal material which tends to become overheated and thereby to be damaged. One wave translating device of this type is disclosed in the copending application of A. C. Keller, Serial No. 493,177, filed July 3, 1943. The capability of this translating device for dissipating signal power is such that maximum power may be applied for a certain time interval without causing damage from overheating, but not for longer intervals without causing damage.

One way of protecting the translating device would be to use a limiter, such as shown in the patent of G. T. Ford, No. 2,084,135, issued June 15, 1934, for limiting the pulse power to so low a value that the echo ranging system could operate indefinitely without overheating the piezoelectric crystal material. This is undesirable as it would tend to limit the power of the signal pulses and thereby the range of the system. Another way would be to cut-off the transmitter when the temperature of piezoelectric crystal material attained a maximum safe value. This is undesirable as it might disable the transmitter at a moment when continued operation would be vitally important. Furthermore, as manual operation is

2

contemplated, automatic shut-off is obviously undesirable.

When the signal pulses are applied to the crystal translating device on a manual basis, for example, by a manually operated telegraph key, it may happen that the signal pulses will be inadvertently continuously applied with substantially maximum power for too long a time interval thereby overheating the crystal translating device and causing damage to it. This may mean that when a ship equipped with an echo ranging system goes to sea for a long period of duty, it would be required to carry a supply of spare crystal translating devices unless some means were provided for giving effective protection to the crystal translating device against overheating. Apart from the cost of spare crystal translating devices, the replacement of a damaged translating device means that the echo ranging system must be taken out of service, and this might be hazardous under some conditions.

In accordance with the present invention, there is provided an automatic control system (specifically including a thermosensitive element) which allows operation of the transmitting apparatus at substantially full signal power output until overheating of the crystal translating device is threatened, and thereafter operation at a reduced signal power output such that the operation may continue indefinitely without the danger of overheating the crystal translating device. Thus, the echo ranging system may be operated at its full signal output for a normal operational period without concern on the part of the operator that the system may be damaged by overheating or that the system may be automatically disabled at any moment, and with the knowledge that the system can continue to be used beyond the normal period, with reduced signal output, for as long as desired. Hence, the safe temperature of the crystal translating device for dissipating the signal pulse power in the seawater is not exceeded regardless of the time duration of individual signal pulses.

The present invention contemplates an automatic arrangement embodying a thermosensitive element for controlling the amount of signal power supplied to a load whereby the maximum amount of signal power is effective for a certain time interval but a lesser amount of signal power becomes effective as the certain time interval is exceeded.

The object of the invention is to control the power of signal pulse waves transmitted through an amplifier under control of the amplifier out-

put such that the average amount of signal power supplied to the load is high for a certain time interval and such that the average amount of signal power supplied to the load is low for the time in excess of the certain time interval.

In a specific embodiment of the present invention, a thermosensitive element comprising a resistor having a preselected temperature coefficient of resistance is applied in shunt of the input of the amplifier, and a heating coil is connected in series with the secondary winding of the output transformer and positioned in heat-transfer relation to the thermosensitive element.

In operation, the characteristics of the thermosensitive element and heating coil therefor are so preselected that the maximum amount of signal power is continuously supplied to the load for a certain time interval, but a lesser amount of signal power is continuously supplied thereto as the certain time interval is exceeded. During the certain time interval, the time lag is such that the heating effect of the amplified signal current flowing in the heating coil is insufficient to influence the effective resistance of the thermosensitive element to any appreciable extent, and this resistance is high so that substantially no unamplified signal current is shunted there-through.

As the certain time interval is exceeded, the heating effect of the heating coil due to the continuous flow of the amplified signal current therein is such that the temperature of the thermosensitive element tends to increase to an appreciable extent. As a consequence, the effective resistance of the thermosensitive element tends to decrease whereby a certain amount of the unamplified signal current is caused to be shunted off. This decreases the input signal voltage to the amplifier whereupon the latter decreases its voltage output. This continues until a condition of equilibrium is established in the circuit, at which condition the rate of the heat lost to the environment of the thermosensitive element by the heating coil equals the rate at which heat is supplied to the thermosensitive element by the heating coil.

The invention will be readily understood from the following description taken together with the accompanying drawing which shows a power amplifying circuit embodying the invention.

Referring to the drawing, line 10 is a transmission line for supplying signal pulses through an input transformer 11 to a familiar multistage class B amplifier 12 whose output is applied through output transformer 13 to a load 14. The amplifier may be of any suitable type including one or more stages as desired. The load comprising the Keller wave translating device or projector, supra, possesses a capability for dissipating the power of the signal pulses such that its temperature tends to remain at or below a safe value from the standpoint of damage due to overheating, so long as the signal pulses are caused to sustain their maximum power for not more than a certain time interval during each of a plurality of successive predetermined time intervals which are substantially longer in duration than the certain time interval. In other words, the Keller projector will not sustain heat beyond the safe temperature value, provided sufficient time is allowed after each signal pulse for the projector to dissipate a certain amount of heat.

In the operation of the circuit, signal pulses may be supplied on an automatic basis to the

load such that their maximum or peak power is sustained at a high constant value for a certain time interval which constitutes a portion of each successive predetermined time period and such that their power is zero during the remaining portion of each successive predetermined time period. As a consequence, a tolerable average amount of pulse power is supplied to the load during individual predetermined time periods. The load, as previously pointed out, possesses a capability for dissipating the tolerable average power at a rate such that its temperature is substantially maintained at or below a safe value from the standpoint of damage due to excessive heating occasioned by the signal pulses.

In the foregoing operation, in one particular installation, it was found that individual signal pulses of maximum or peak value of about 100 watts could be supplied to the load for a certain time interval of approximately 35 milliseconds during individual predetermined time periods of about 1250 milliseconds. During each of the latter periods, the average amount of signal power supplied to the load was 2.8 watts. This power was found to be within the power dissipating capability of the load so that the temperature of the latter was maintained at or below the safe operating value.

It has been further found that when the signal pulses were supplied to the load by a manually operable telegraph key, their maximum or peak power may at times be sustained for too long a period. This results in the application of signal pulse power to the load at a rate faster than the load could dissipate it. Hence, the temperature of the load tends to increase beyond the safe operating value, possibly resulting in damage to the load. Such damage would, of course, depend on the amount of time in excess of the certain time interval during which the maximum signal pulse power was supplied to the load and might be great enough to put the projector out of service.

In accordance with the present invention, a thermosensitive element 20 is applied in shunt of the control grids of associated tubes of the individual amplifier stages, and a heating coil 21 is connected in series with the secondary winding of the output transformer and positioned in heat-transfer relation to the thermosensitive element. Thus, the thermosensitive element 20 is effectively disposed in shunt relation to the amplifier input and load, and the heating coil is effectively arranged in series relation to the amplifier output and load. The latter including the heating coil associated therewith may be constructed in the manner disclosed in the patent of K. C. Black et al., No. 2,178,548, issued November 7, 1939.

In the operation of the circuit on the basis of the automatic transmission of signal pulses, the negative temperature coefficient of resistance of the thermosensitive element and the characteristics of the heating coil are preselected such that the operation of the circuit is substantially maintained as set forth hereinbefore. Under this condition, the peak power impressed on the heating coil by individual signal pulses is about 3.0 watts during each certain time interval of 35 milliseconds, and the average power supplied to the heating coil by the individual signal pulses during each predetermined time period of 1250 milliseconds is approximately 0.084 watt. This means that the effective resistance of the thermosensitive element 20 is substantially unchanged by the heating effect of the heating coil and the thermo-

sensitive element 20 in nowise influences the operation of circuit in so far as the amplification of the signal pulses is concerned. This is so for the reason that the magnitude of the effective resistance of the thermosensitive element 20 is such that substantially no unamplified signal pulse current is shunted therethrough; and that the time lag between the thermosensitive element 20 and the heating coil is such that the temperature of the thermosensitive element 20 is substantially unchanged during the 35 millisecond interval.

However, in the event the maximum power of 100 watts for one signal pulse is delivered to the load for a time in excess of the certain time interval of 35 milliseconds, the peak power of 3.0 watts for that signal pulse is also supplied at the same time to the heating coil. The heating effect of the heating coil is such that the temperature of the thermosensitive element 20 now tends to increase. As a consequence, the effective resistance of this element tends to decrease thereby causing a certain amount of the unamplified signal pulse current to be shunted therethrough. This reduces the amount of the signal pulse voltage available at the input of the amplifier whereupon the latter is caused to decrease its output.

This continues until a condition of equilibrium is established, at which condition the rate of the heat lost to the environment of the thermosensitive element 20 by the heating coil equals the rate at which heat is supplied to the thermosensitive element 20 by the heating coil. Now, the maximum pulse power delivered to the load is approximately 30 watts, which power is inadequate to overheat the load when continuously supplied thereto for a time in excess of the certain time interval of 35 milliseconds.

As the load tends to be damaged due to overheating by the amplified signal pulse power in the manner hereinbefore explained, it is noted that control embodying the thermosensitive element 20 functions on the basis of increased heating occasioned by the amplified signal pulse power when it is effective for a time in excess of 35 milliseconds. Hence, the time constant of such control is so preselected as to establish the equilibrium condition in the circuit at a magnitude of signal pulse power less than that magnitude of signal pulse power which would tend to overheat the load. Thus, such control tends to anticipate the damaging magnitude of amplified signal pulse power from the standpoint of the load, and automatically operates to reduce the magnitude of the amplified signal pulse power to a value less than such damaging magnitude. In this connection, it is obvious that the time constants of the thermosensitive element 20 and heating coil may be so preselected as to change the power supplied to the load with the speed desired.

As the temperature of the thermosensitive element 20 is affected by changes in ambient temperature, in addition to its variations due to the effect of the heating coil, a thermosensitive element 22 is connected in bridge of the heating coil to compensate the former element for its ambient temperature changes in a manner that will now be explained. The thermosensitive element 22 may be constructed in the manner disclosed in the patent of G. L. Pearson, No. 2,184,847, issued December 26, 1939.

Assuming the operation of the circuit as previously pointed out at a certain ambient temperature, the effective resistance of the thermosensitive element 22 is high as compared with

that of the heating coil. Hence, there is substantially no amplified signal current shunted through the thermistor 22 and thereby away from the heating coil; and the operation of the thermosensitive element 20 is unaffected. As the ambient temperature tends to increase, the effective resistance of the thermosensitive element 22 would tend to decrease to shunt therethrough a portion of the amplified signal current. This causes a corresponding decrease in the amount of amplified signal voltage being supplied to the heating coil, and accordingly a decrease in the heating effect thereof. As the temperature of the thermosensitive element 20 would also tend to increase due to the ambient temperature increase, the amount of the decrease in the heating effect of the heating coil is substantially equal to the amount of heating effect required to bring about the aforementioned increase in the temperature of the thermosensitive element 20 due to the ambient temperature increase. In the event of a decrease in ambient temperature, the thermosensitive elements 20 and 22 function in the opposite sense. Thus, the thermosensitive element 22 compensates the thermosensitive element 20 for changes in ambient temperature.

It is understood that the power control hereinbefore described could also be embodied in loudspeaker systems, telephone circuits and the like wherein it is desired to transmit large peak signal power for one interval of time but small average signal power for a longer interval of time including the one time interval and at the same time to preclude damage to preselected apparatus in the systems as a result of overheating in the event the large peak signal power were supplied thereto for a time in excess of the certain time interval.

What is claimed is:

1. A transmission circuit including a wave translating device, and means for supplying alternating current waves of substantially constant peak power to said device such that the temperature of said device tends to remain at a safe value when waves of peak power are supplied to said device for not more than a certain time and such that the temperature of said device tends to exceed the safe value when waves of peak power tend to be supplied to said device for a time in excess of said certain time, and thermosensitive means for maintaining the temperature of said device within the safe value when waves of peak power tend to be supplied to said device for the excessive time, comprising a resistor having a temperature coefficient of resistance and connected in shunt relation to said device, and a heating winding positioned in heat-transfer relation to said resistor and connected in series relation to said device, said heating winding varying the temperature of said resistor and thereby the effective resistance of said resistor at such rate during the excessive time that said power means is caused to supply to said device waves whose power is less than the peak power.

2. In combination, a source of alternating current waves of substantially constant power, means for amplifying said waves to a substantially constant peak power, wave translating apparatus connected to the output of said amplifying means and having a capability for dissipating the peak power such that the temperature of said apparatus tends to remain at a safe value so long as waves of the peak power are supplied to said apparatus for a certain time or less and such that the temperature of said apparatus tends to exceed the safe value when waves of the peak power tend

7

to be supplied to said apparatus for a period of time in excess of said certain time, and means for maintaining the temperature of said apparatus within the safe value when waves of the peak power tend to be supplied to said device for the excessive time, comprising a resistance element having a temperature coefficient of resistance connected in shunt relation to the input of said amplifying means, and a heating winding positioned in heat-transfer relation to said element and connected in series relation to the output of said amplifying means, said element varying its effective resistance under control of said heater during the excessive time such that a portion of the waves from said source is shunted through said element for so controlling the power of the waves supplied to said apparatus as to maintain the temperature of said apparatus within the safe value.

3. In a transmission system including a source of discrete signal waves of substantially constant peak power and varying time duration, a wave translating device having a capability for dissipating waves of peak power such that the temperature of said device tends to remain at a safe value from the standpoint of damage from overheating so long as individual waves of the peak power are supplied to said device for not more than a certain time and such that the temperature of said device tends to exceed the safe value

8

when individual waves of the peak power tend to be supplied to said device for a time in excess of said certain time, and means interposed between said source and said device for controlling the power of the waves applied to said device, comprising a resistor having a negative temperature coefficient of resistance and connected in said controlling means in shunt relation to said device, and a heating coil positioned in heat-transfer relation to said resistor and connected in said controlling means in series relation to said device, said resistor having the characteristic of varying its temperature under control of said heating winding at a rate such that substantially no change takes place in the temperature and effective resistance of said resistor so long as individual waves of peak power are supplied to said device for said certain time, and such that a change is effected in its temperature of said resistor and thereby in the effective resistance thereof when individual waves of peak power tend to be supplied to said device for a time in excess of said certain time, the change in the effective resistance of said resistor during the excessive time causing a portion of the current of the individual waves to be shunted therethrough whereby the power of the individual waves supplied to said device is controlled.

JOHN H. BOLLMAN.