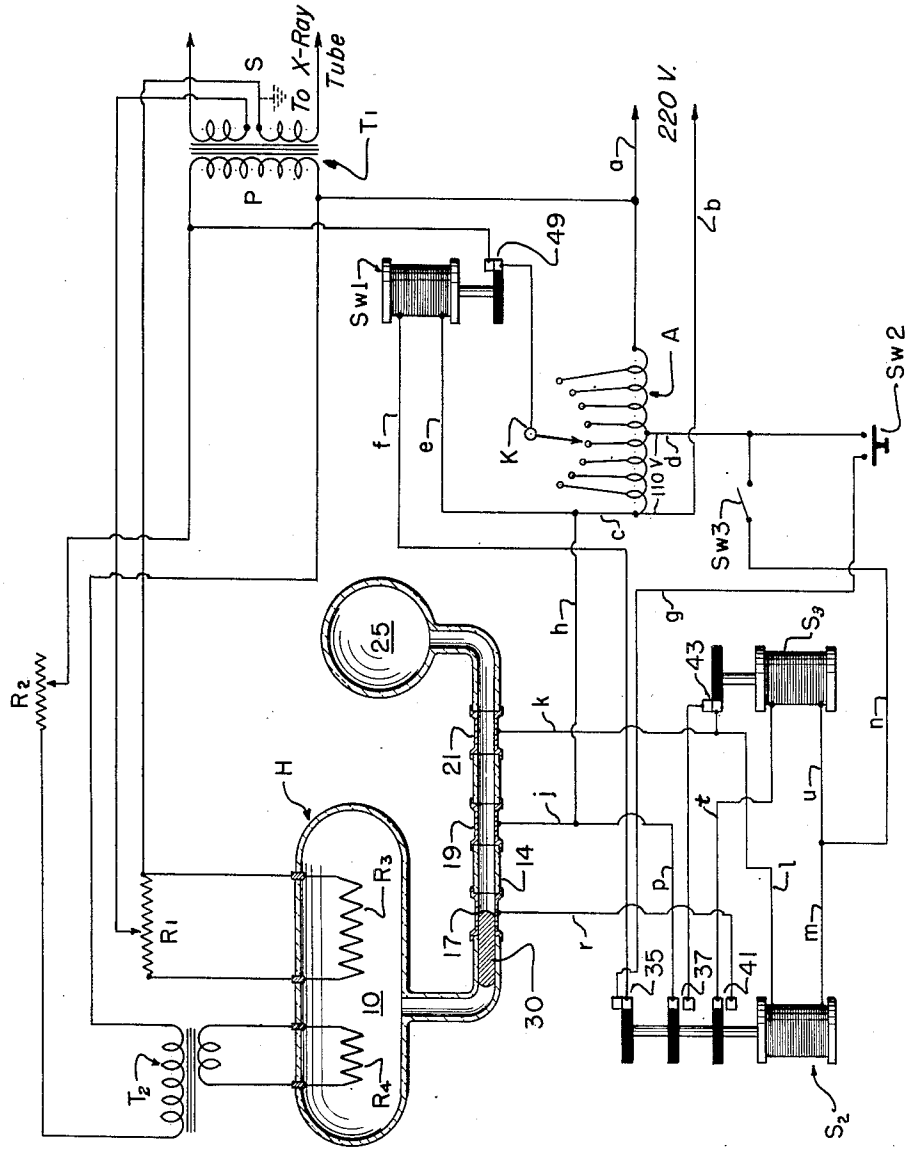
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SYSTEM FOR PREVENTING OVERHEATING OF X-RAY TUBES AND THE LIKE

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SYSTEM FOR PREVENTING OVERHEATING OF X-RAY TUBES AND THE LIKE

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This invention relates to overheat control systems for electrical devices and more particularly to a system for preventing overheating of X-ray tubes.

It is an object of my invention to provide a system usable in conjunction with any electric current consuming apparatus for the purpose of interrupting current in the apparatus circuit in response to a predetermined heating effect in a portion of the system constituting my invention, whereby undue heating of the apparatus is prevented.

It is another object of my invention to provide a system to be used in conjunction with a conventional X-ray tube for the purpose of interrupting current to said tube to prevent the tube from becoming unduly overheated.

It is a further object of my invention to provide an electrical system for interrupting current to an X-ray tube in response to functioning of an element so devised as to close contacts at a predetermined point corresponding to a predetermined temperature of an X-ray tube.

It is a still further object of my invention to provide my system with a thermal element so devised as to simulate the heating characteristic of any particular X-ray tube and operative to cut off current to that tube at a predetermined point prior to heating of the tube to a detrimental degree.

According to the invention, I provide a system which comprises an element having contacts which are closed in response to heat developed in a pair of resistors associated with conventional X-ray apparatus and so contrived as to utilize the power feed to an X-ray tube to cause contact closure at a predetermined point which corresponds to a selected degree of temperature of the X-ray tube. More specifically the system embraces a thermal element having a plurality of resistances adapted to be connected to an X-ray transformer so that the voltage across the primary and the current flowing in the secondary are commuted into heat energy causing expansion of air in a chamber housing the resistances. The air thus expanded compels motion of a mercury globule or pellet in a capillary tube connected to the housing but against the reaction of an air pressure dome, the combination being mechanically and electrically arranged so that motion of the mercury globule is operative to electrically bridge a pair of spaced contacts disposed within the capillary under conditions predetermined by design to cut off power to the transformer prior to overheating of the X-ray tube. Incorporated in the system are various elements operative to re-energize the transformer after a due period of cooling has been allowed, such re-energization taking place automatically in response to cooling and contraction of the previously expanded air as heat is dissipated from the thermal element, all as hereinafter described.

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My invention is illustrated in the accompanying drawing which shows an X-ray transformer T1 in conjunction with an auto transformer A which is manually controllable to determine the strength of the rays in a well known manner. A solenoid operated switch Sw1, a push button or timer unit, Sw2, and on-off switch, Sw3 are connected to the transformers as shown. The elements thus described are conventional, commercially obtainable devices and are generally provided as part of a complete X-ray outfit.

My invention utilizes in addition to the aforementioned elements, a thermal element H, together with ballast resistors R1, R2, and a voltage transformer T2, as well as a pair of relays S2 and S3.

The element H comprises a comparatively large, thick-walled glass enclosure 10 in which is secured in any suitable manner a pair of resistances R3 and R4. Adjoining the chamber 10 and in communication therewith is a capillary tube 14 having spaced metallic sleeves 17, 19 and 21 fixedly secured and sealed therein and which tube 14 communicates with a pressure reactance dome 25. A globule or pellet 30 of mercury is provided in the lumen of the tube and is adapted to flow easily in either direction through the sleeves, being proportioned in quantity so as to be capable of extending between the sleeves 17—19 or 19—21 to provide an electrical contact therebetween under certain conditions to be hereinafter described. The resistances R1 and R2 are provided for the purpose of matching the resistances R3 and R4 to the secondary and primary, respectively, of the transformer T1 so as to convert the secondary current and primary voltage into heat energy in proper proportion to reflect the heating characteristic of the X-ray tube. The transformer T2 functions to increase the current in resistance R4 whereby to slightly raise the temperature of that resistance in order to assist in the proportioning effect. The dome 25 is of such dimensions as to provide a proper pressure reaction to the mercury pellet 30 when it is forced to the right by heat expanded air in chamber 10 so as to ensure the ultimate result, i. e., close simulation of the heat characteristic of any particular X-ray tube in terms of

motion of the mercury pellet. It will be understood that the various values for the resistances R1 and R4, transformer T2, and the size of dome 25 may be suitably proportioned as a matter of design to achieve the effect of causing motion of the mercury pellet 30 to a predetermined extent for bridging contacts at 17—19 or 19—21 in accordance with certain conditions as will be hereinafter described. In general, resistance R3 should have a higher value than resistance R4 since it is connected in the secondary of the transformer T1 (at ground potential point), the milliammeter leads provided on the secondary of conventional transformers being suitable for connecting R3 in series with the secondary coil. The ratio values between R3 and R4 is dependent inter alia upon the ratio of voltages across the primary and secondary and should be of such value as to jointly produce a temperature in the chamber 10 fluctuating in accordance with voltage and current variations in the transformer primary and secondary so as to reflect proportionally the resultant variations in temperature of the X-ray tube used in conjunction with the system.

The relay S2 comprises a normally closed contact arrangement 35 and normally opened contact arrangements 37 and 41 while the relay S3 has the single normally closed contact arrangement 43. It will be understood that the reference characters 35 through 43 refer in each case to a pair of contacts each of which consists of an armature and a fixed point as symbolized on the drawing.

In the present instance it is assumed that the system is fed by a 220 volt line, as indicated by the conductor legs *a* and *b*, which 220 volts may be fully applied across primary transformer T1 but is generally reduced in value by manipulation of a knob K of the auto-transformer A in a manner and for a purpose well understood by persons skilled in the art. As will be apparent, contact arrangement 49 of switch *Sw1* is normally closed when circuit continuity is provided at *Sw2* and *Sw3*, there being a potential of 110 volts provided by transformer A to energize *Sw1* under the conditions shown on the drawing. The energizing current from the transformer A is tapped off through legs *c* and *d* which are indicated as plus and minus, respectively, to indicate polarity at an assumed instant. Accordingly, with push button *Sw2* and switch *Sw3* closed, a current flows through *Sw1* energizing it, such current following a course through various conductors legs (assuming the current to flow from positive to negative) of *c—e—Sw1—f*—contact 35—*g—d*. At this time relays S2 and S3 are not energized and the complete system may be assumed to be operating normally, no undue heating of the X-ray tube taking place.

In the event that the voltage across the primary and current in the secondary of transformer T1 become such due to increase in line voltage, etc., that the X-ray tube would become unduly heated, proportional currents flowing in resistances R3 and R4 cause a heating of the air in chamber 10. Accordingly, expansion of air in chamber 10 forces the mercury pellet 30 from its normal position, as shown, toward the right through sleeve 17 and along the lumen of the capillary tube 14. Although the mercury provides a bridge across the sleeves 17—19 at this time no effect is produced thereby owing to the normally open contact 41 of relay S2. However continued expansion of the air in chamber 10 ultimately

causes the mercury pellet to bridge the gap between sleeves 19—21. When this occurs the relay S2 is energized, the circuit thus formed consisting of conductor legs *c—h—j*—mercury 30—sleeve 21—*k—l*—the solenoid of S2—*m—n*—*Sw3—d*. Energization of S2 in this manner causes interruption of contact 35 breaking the circuit heretofore described through solenoid *Sw1* and interrupting, by virtue of opening of contact at 49, the current to the primary of transformer T1. Energization of S2 also serves to cause contact engagement at 37 which sets up a holding circuit via the conductor legs *c—h—p*— contact 37—contact 43—*l*—solenoid of S2—*m—n—Sw3—d*, whereby S2 is maintained energized. As long as the temperature in chamber 10 is such as to maintain the mercury pellet 30 in abridgement across sleeves 19—21 against the reaction of the air which has been compressed in dome 25 by the piston like effect of the travel of the mercury pellet in passing from the normal position to the abridging position, relay S2 will remain energized and solenoid switch *Sw1* will be in open condition at 49. However, a further effect of the energization of relay S2 is to close contact at 41, thereby connecting sleeve 17 to the negative side of the 110 volt source through the solenoid of S3. Accordingly, when the temperature drops as heat is dissipated from chamber 10, and it will be understood that the chamber is so designed as to dissipate heat at substantially the same rate as the X-ray tube in conjunction with which it is used, the reaction pressure in dome 25 forces mercury pellet 30 to move to the left against the decreasing pressure in chamber 10. Ultimately the mercury pellet bridges the contact 17—19 thereby closing a circuit comprising the solenoid of relay S3 to energize that relay. The circuit thus set up consists of conductor legs *c—h—j*—sleeve 19—mercury 30—sleeve 17—*r*—contact 41—*t*—solenoid S3—*u—n—Sw3—d*. Accordingly, energization of relay S3 breaks the contact engagement at 43 thereby breaking the holding circuit of relay S2 whereby relay S2 is de-energized and normal conditions, as shown on the drawing, are restored.

It will now be appreciated that I have disclosed a system to be used in conjunction with conventional X-ray equipment for protecting an X-ray tube from overheating and which system is simple, effective and easily installed. However, I believe that the essential teaching of my invention is not limited to use with X-ray apparatus, but may, in fact, with suitable modification find utility in any circuit where overheating of an element presents a problem.

Further, it will be obvious to persons skilled in the art that various changes in my disclosure may be made as to the several elements of my invention. For example, the thermal element H is illustrated as utilizing a capillary tube 14 whereby a large movement of the mercury pellet 30 is effected for small changes in air pressure in chamber 10, which in conjunction with a properly proportioned dome 25 constitutes a very sensitive device. However, it will be appreciated that fluids other than air could be utilized, e. g., gases or liquids of suitable expansion characteristics. Also the sensitivity of the device is dependent inter alia on the volume of chamber 10 and the relative volume of dome 25, which volumes are subject to design suitable for specific installations, the particular proportioning shown in the drawings being for purely illustrative purposes.

Accordingly, I do not intend to be bound by the

specific illustration hereinabove described except as set forth in the appended claims.

Having thus described my invention, I claim:

1. A system for protecting current consuming devices such as X-ray tubes and the like from overheating, comprising a thermal element for commuting current energy to heat energy and having a series of spaced contacts serially arranged and movable conductor means responsive to changes in volume of a thermoexpansive gas and positioned thereby for successively bridging pairs of said contacts in the series and rendering them electrically conductive in response to a predetermined degree of heat energy commuted within said element, and relay means adapted to be energized when a first pair of said spaced contacts are bridged to interrupt current to said current consuming device, said relay means comprising a first contact means adapted to be normally closed and through which current normally passes and adapted to be opened to break current passage when said relay means is energized, means whereby said current consuming device is energized during continuance of said current through said first contact means, said relay means also comprising a second contact means adapted to be normally open and adapted to be closed when said relay is energized, means whereby said relay means remains energized responsive to continuance of current through said second contact means, and said relay means having a third contact means arranged to be normally open and adapted to be closed upon energization of said relay means, and circuit means comprising a second pair of said spaced contacts and said third contact means for de-energizing said relay means on bridging of said last mentioned contacts in response to dissipation of heat energy from said thermal element.

2. In a device as set forth in claim 1 wherein said circuit means comprises an additional relay operative by said thermal element upon dissipation of heat therefrom to de-energize said first relay, said additional relay having contact means in series with said second contact means.

3. A system for protecting current consuming devices such as X-ray tubes and the like from overheating comprising, in combination, a current responsive element for commuting current enery into heat energy and adapted to be connected to a current consuming device in such a manner as to generate heat energy in proportional response to the current energy consumed by said current consuming device, said element having movable current conductor means responsive to changes in volume of a confined thermoexpansive gas and positioned thereby relative to three spaced contact members serially engageable by said movable means, said movable means being adapted to bridge a first and second contact member or said second and third contact member, in the order named and in reverse order, and means responsive to bridging of said second and third member for interrupting current to said current consuming device and restoring means responsive to bridging of said first and second members to restore current to said current consuming device.

4. In a device as set forth in claim 3, wherein said movable means has a normal nonbridging position adjacent said first contact member.

5. In a device as set forth in claim 3 wherein said means responsive to bridging of said second and third contact members comprises a relay energizable by current through said second and

third contact members and said movable member, and having a normally closed contact means adapted to be interrupted upon energization of said relay, said current consuming device being adapted to be de-energized upon interruption of said contact means, said relay having a normally open contact means adapted to be closed upon energization of said relay and said restoring means comprising said last named contact means and said first contact member for de-energizing said relay when said movable element is in subsequent position bridging said first and second contact members.

6. In a device as set forth in claim 3, wherein said means responsive to bridging of said second and third contact members comprises a relay energizable by current through said second and third contact members and said movable member, and having a normally open contact means adapted to be closed upon energization of said relay, and a holding circuit including said contact means adapted to maintain said relay energized by current through said contact means.

7. In a device as set forth in claim 3 wherein said means responsive to bridging of said second and third contact members comprises a relay having a normally open contact means, said relay being adapted to be energized when said movable member bridges said second and third contact members, whereby said normally open contact means is closed, and said restoring means comprising said contact means and being operative in response to bridging of said first and second contact members to conduct current through said contact means to de-energize said relay.

8. In a device as set forth in claim 3 wherein said means responsive to bridging of said second and third contact members comprises a relay having a normally open contact means, said relay being adapted to be energized when said movable member bridges said second and third contact members whereby said normally open contact means is closed and said restoring means comprising said contact means and being operative in response to bridging of said first and second contact members to conduct current through said contact means to de-energize said relay, and wherein said restoring means comprises an additional relay, having normally closed contact means adapted to be opened upon energization of said additional relay, said additional relay being energizable only when said first-mentioned relay is energized upon abridgement of said first and second contact members by said movable member, including a holding circuit for said first-mentioned relay comprising said normally closed contact means of said additional relay whereby said first-mentioned relay is de-energized upon energization of said additional relay.

9. A system for protecting current consuming devices, such as X-ray tubes and the like, from overheating, comprising a power supply means including a transformer having a primary and a secondary, the secondary of which is adapted to be connected to an X-ray tube or the like, a safety current responsive device comprising a closed air chamber having a heater resistance therein connected in series with said secondary and responsive to the passage of electrical energy therein to heat and expand the air in said chamber, a tubular extension communicating with said chamber and having spaced contact means secured therein, a movable conductor element in said tube in normally non-bridging relation to said contact means but adapted to be moved by

heated air expanding from said chamber to bridge said contact means in response to a predetermined degree of expansion of air in said chamber, relay means adapted to be energized when said conductor element bridges said contacts, relay contact means being operative to control the current to said current consuming device, said relay contact means being adapted to open and interrupt current to said current consuming device when said relay means is energized.

10. A system for protecting current consuming devices as set forth in claim 9 and a second heater resistance in said chamber connected in parallel with the primary of said transformer, the energization of said secondary heater resistance being controlled by the operation of said relay means.

11. A system for protecting current consuming devices such as X-ray tubes and the like from overheating comprising, in combination, a current responsive element for commuting current energy into heat energy and adapted to be connected to a current consuming device in such a manner as to generate heat energy in proportional response to the current energy consumed by said current consuming device, said element having means movable by generation of heat, and three spaced contact members serially engageable by said movable means, said movable means being adapted to bridge a first and second contact member or a second and third contact member, in the order named and in reverse order, and means responsive to bridging of said second and third member for interrupting current to said current consuming device and restoring means responsive to bridging of said first and second members to restore current to said current consuming device, said contact members comprising sleeves secured within a capillary tube, and said movable means comprising a mercury pellet in said tube adapted to flow from a normal nonbridging position through at least one of said sleeves to a bridging position.

12. A system for protecting current consuming devices such as X-ray tubes and the like from overheating comprising, in combination, a current responsive element for commuting current energy into heat energy and adapted to be connected to a current consuming device in such a manner as to generate heat energy in proportional response to the current energy consumed by said current consuming device, said element having means movable by generation of heat, and three spaced contact members serially engageable by said movable means, said movable means being adapted to bridge a first and second contact member or a second and third contact member, in the order named and in reverse order, and means responsive to bridging of said second and third member for interrupting current to said current consuming device and restoring means responsive to bridging of said first and second members to restore current to said current consuming device, said contact members comprising sleeves secured within a capillary tube and said movable means comprising a mercury pellet adapted to flow in said tube from a normal nonbridging position through said first contact member to a bridging position within the second contact member, thence through said second contact member to a bridging position with said third contact member.

13. A system for protecting current consuming devices such as X-ray tubes and the like from overheating comprising, in combination, a current responsive element for commuting current energy into heat energy and adapted to be connected to a current consuming device in such a manner as to generate heat energy in proportional response to the current energy consumed by said current consuming device, said elements having a series of spaced contacts serially arranged and movable gas pressure responsive means positioned by changes in volume of a thermoexpansive gas for successively bridging pairs of contacts in the series and means responsive to bridging of one pair of said contacts for interrupting current to said current consuming device and restoring means responsive to bridging of another pair of said contacts to restore current to said current consuming device.

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