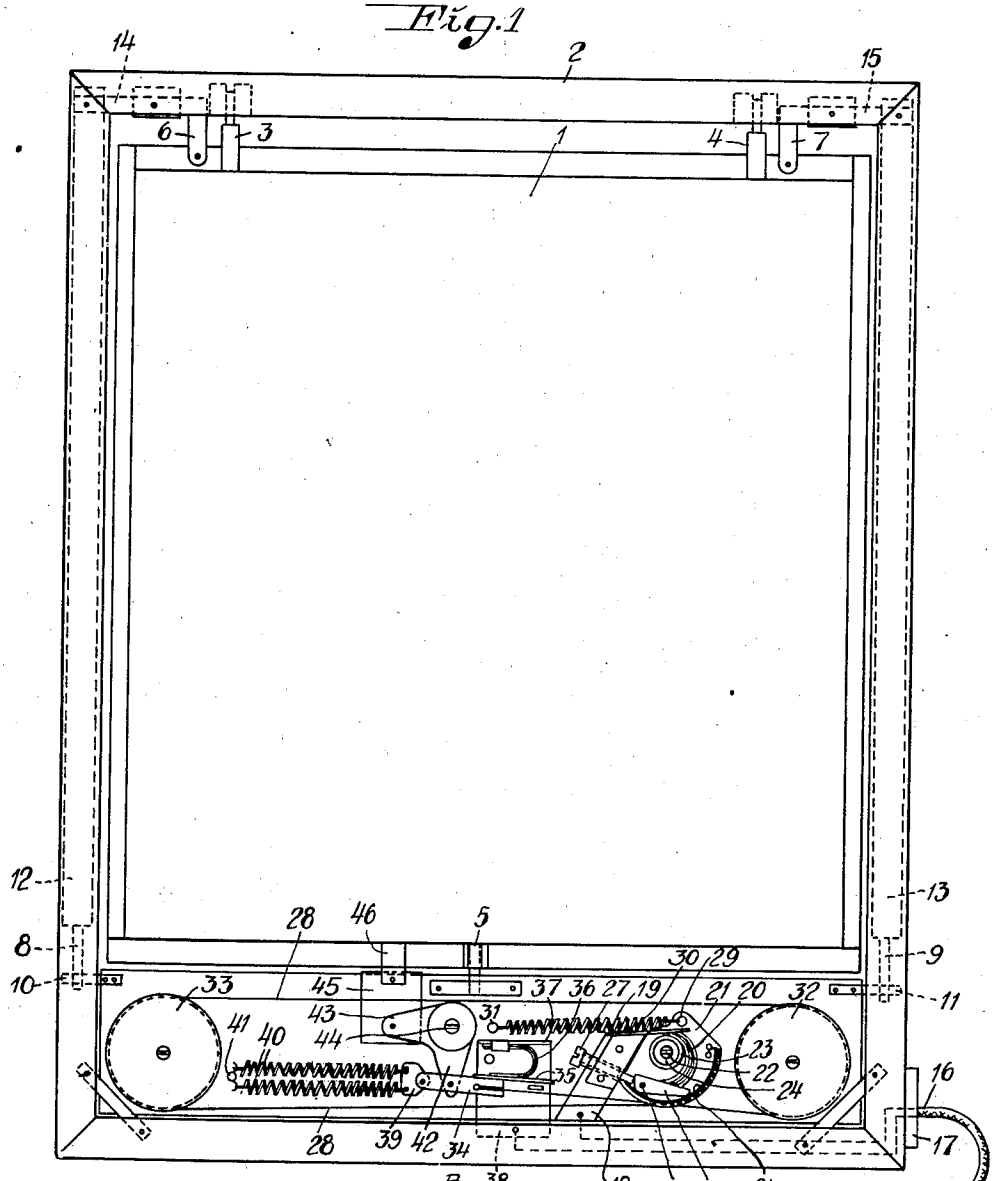
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X-RAY SECONDARY DIAPHRAGM

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Fig. 1



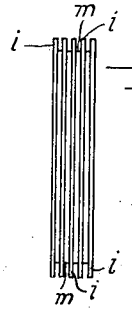


Fig. 2

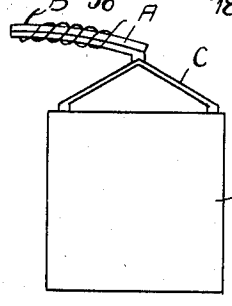


Fig. 3



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Fig. 4

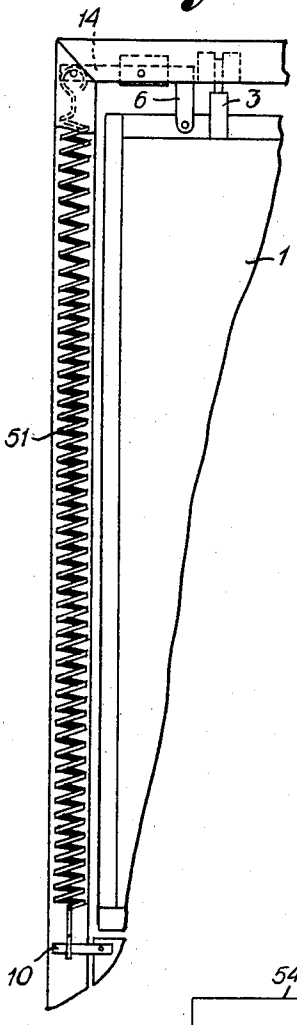


Fig. 5

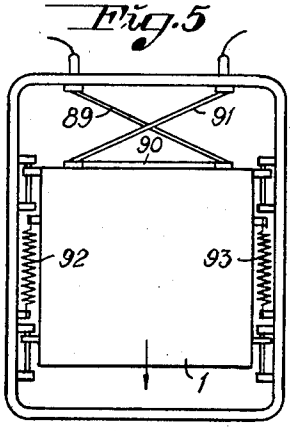
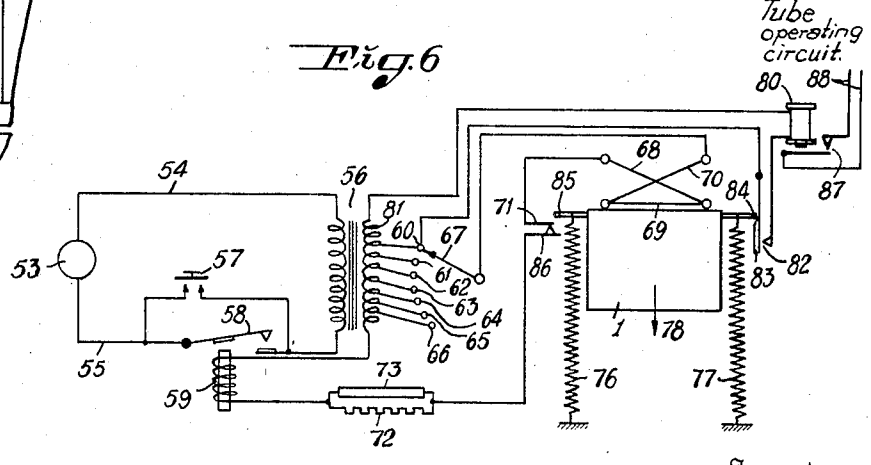


Fig. 6



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2,241,516

X-RAY SECONDARY DIAPHRAGM

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18 Claims. (Cl. 250—62)

The present invention is concerned with improvements in X-ray secondary diaphragms for use in X-ray examinations such as X-ray-photography, wherein a grid composed of material suitable for passing primary radiation but excluding secondary radiation, for example parallel laminations of light metal alternating with lead laminations, is designed to be moved in a rectilinear direction between the source of X-rays and the subject of the examinations.

Apparatus of the type described is already known in which the movement of the grid designed to exclude secondary radiation is effected counter to the action of a spring or springs either mechanically, for instance by clockwork devices or oil damped hydraulic braking devices, or electrically by means of a small electric motor.

According to the present invention, however, there is provided in apparatus for X-ray examinations a grid of material suitable for passing primary X-rays but excluding secondary radiation, in association with mounting means therefor and means operable to effect within the said mounting means the displacement of the grid controlled by the thermal expansion of a heat-sensitive element. The term "heat-sensitive element" as used in the specification and claims is intended to define an element which, when heated, expands in such a manner as to produce measurable movement of at least some part thereof, as in the case of elongation of a metal wire or band having a high coefficient of expansion, or flexing of a bimetallic spring.

The invention may be more easily understood with the aid of the accompanying drawings illustrating a preferred embodiment of the invention, wherein Fig. 1 represents a front elevation of the apparatus according to the invention, Fig. 2 a side elevation of one of the reels shown in Fig. 1, Fig. 3 a diagrammatic representation of an alternative form of heat-sensitive element, Fig. 4 a front elevation of a portion of a modification of the apparatus shown in Fig. 1, wherein the counterweights are replaced by springs, Fig. 5 a diagrammatic representation of a modification of the arrangement of the heat-sensitive element, and Fig. 6 a diagram of the current regulating or controlling means, including means for cutting in and cutting out the X-ray tube operating circuit.

Referring to Fig. 1, 1 represents the grid composed of materials suitable for passing primary X-rays but excluding secondary radiation, for instance of parallel laminations of light metal alternating with lead laminations, and adapted according to the invention to be moved between the source of X-rays and the subject of the X-ray examinations. The grid 1 is fitted in the frame structure 2 which may be of light metal, for example aluminum, by suitable guides 3, 4, 5 and link elements 6, 7 of similar material in such a way as to be capable of being raised or lowered or moved reciprocally in the said frame to an extent equal to the distance between the shoulders of the guides 3, 4 and the lower edge of the top of the frame 2, which in the specific embodiment illustrated may, for example, be 15 mm. maximum. The specific embodiment as here described to which, however, as will hereinafter be readily apparent, the invention is by no means restricted, is primarily intended to be used in those cases where the frame structure, and hence the grid moving therein, are to be placed in an upright or substantially upright position, for example in the X-ray examination of a person or other subject standing more or less erect. Therefore, extending downwards in the hollow sides of the frame structure 2 and held in position therein by their extremities 8, 9, respectively, fitting in guides 10, 11 are two counterweights 12, 13 dependently articulated to the lever arms 14, 15, respectively, connected to the link elements 6, 7, the combined total weight of which counterweights is equal to that of the grid, and the purpose of which is to balance the grid during the movement thereof. In the case, however, of the X-ray examination of a person or subject in a more or less recumbent position, the apparatus may be of a type intended to be placed in a horizontal or substantially horizontal plane, and in which the counterweights 11, 12 can appropriately be replaced by resilient means, such as springs accommodated in the frame structure and operatively connected to the grid on both sides thereof and tensioned counter to the movement of the grid in the frame structure. A suitable construction of this type is shown in Fig. 4 wherein a spring 51, housed in the frame and connected at its ends to the lever arm 14 and the guide 10, respectively, is substituted for the counterweight 12. A similar spring (not shown) would replace counterweight 13. Situated in the lower section of the frame structure 2 are the various elements comprising the apparatus for effecting the movement of the grid 1 in the frame structure 2. A cable 16, connected to the terminals of a suitable source of current, such as a battery 52, enters this lower section of the frame structure 2 through a cable inlet 17, and one of the cable conductors is connected to a

contact plate 18 of copper, bronze or other metal suitably insulated on its underside from the frame material on which it is mounted. A spring holder 19 comprising a strip of phosphor-bronze attached to the contact plate is riveted to the spring contact 20 made up of several resilient copper strips and mounted on a current-carrying segment 21 of copper, bronze or other suitable conductor material rotatably fixed to the frame material by a spindle 22 with set screw and insulated therefrom for example by means of an intermediate plate of insulating material. One end of the spring contact 20 is pressed by the holder 19 against a washer 23 of insulating material on the spindle 22 held in position by a fibre washer 24 also mounted on the spindle 22. At its other end the spring contact 20 is fixed in a current-carrying triangular clamp 25 secured by the screw 26 in which the tension of the spring contact 19 may be adjusted by means of an insulated screw pin 27 mounted on the contact plate 18 and bearing against the clamp 25 so as to regulate the position of the segment 21 about the spindle 22 and hence also the tension of the heat-sensitive element or wire 28 of nichrome, or any other suitable metal with a high coefficient of expansion, which is riveted to one side of the segment 21. Also fixed to the segment 21 by a stud 29 is one end of a coil spring 30 which at its other end is fastened to a lug 31 of insulating material mounted on a pin fixed to the frame. The tension of this spring is also dependent upon the position of the segment 21 about the spindle 22 and hence adjustable by the screw 27. The purpose of this spring 30 will be explained further below.

It is necessary for the increment in length of the wire due to thermal expansion under normal conditions of heating and standard current strengths to be relatively substantial in extent, for example in the present case 15 mm., in order to carry the invention into effect. Therefore, the initial length of the wire will by comparison also have to be considerable, for example in the present case some 3 metres in length. Hence, in order to accommodate the wire within the confines of reasonable space, it is passed from a groove formed by a raised portion 21*a* on the segment 21 and thence in four turns over the reel 32, having a metal core and having four grooves, one for each turn, formed by ebonite plates on the core so that each turn of wire passing over this reel to the respective grooves on a similar reel 33 is insulated from the other turns (see Fig. 2 wherein *i* represents insulation and *m* metal). The other end of the wire 28 is secured to a current-carrying link member 34 of conductor metal, for example copper, bronze or the like, engaged by a contact strip 35 riveted to a second spring contact 36 which is similar to the spring contact 20 and is riveted at its other end to a phosphor-bronze strip holder 37 fixed to the contact plate 38 connected to the second cable conductor and completing the circuit through the heat-sensitive wire 28. At its other end the link member 34 is pivoted to a spring holder 39 of insulating material to which one end of a double coil spring 40 is fixed, the other end of the spring 40 being secured by a stud 41 to the frame material. At its centre the link 34 is articulated by a pivot pin of insulating material to one arm 42 of a double-armed lever 42, 43 mounted on the screw pin 44 and arranged normally to assume the position as illustrated, that is when the apparatus is not in use. The other arm 43 of the double-armed lever is suitably articulated to a member 45 mounted on the frame structure 2 and operatively connected to a member 46 attached to the grid 1.

The operation of the apparatus is now as follows:

Let it be assumed that the apparatus is ready for use. The X-ray source, for example an X-ray tube (not shown) is switched on and current may appropriately be supplied at the same time from a suitable source through the cable 16 to the contact plates 18, 38, respectively, completing a circuit through the contact plate 18, the spring holder 19, the spring contact 20, the segment 21, the spring adjusting clamp 25, and the heat-sensitive wire 28 to the link member 34, the secondary contact holders 35, 37, the spring contact 36 and the contact plate 38. As the current flows through the wire 28, the wire will be heated up and expand or become elongated and thus tend to counteract the tension of the coil spring 30, thereby causing the arm 42 of the lever 42, 43 to move to the left, whereby the other arm 43 will move in a clockwise direction to raise the link members 45, 46 and hence the grid 1 until finally this latter has moved through its maximum path of travel and the shoulders of the upper guide members 3, 4 abut the lower edge of the top of the frame structure. At the same time the link elements 6, 7 will be raised and together therewith the counterweights 12, 13 for balancing the weight of grid when the frame is in an upright or substantially upright position. It may inadvertently happen that current continues to flow through the wire after the grid has reached its maximum position and the elongation of the wire is no longer taken up by the spring 40. As a precaution against the risk in that event of the wire expanding to form a wide slack loop between the reels, possibly entering into contact with the metal of the frame structure and thereby causing short-circuits, the spring 30 is caused to take up any such slack in the wire, by the elongation of the wire causing the segment 21 to rotate counterclockwise about its spindle 22 and counteract the tension of the said spring 30.

It will be appreciated that if the current is kept constant the speed of the grid will be most rapid at the start, but by suitably increasing the strength of the current in proportion to the temperature rise a constant speed for the grid movement can be obtained. Variation of the current strength may suitably be effected by interposing a series resistance in the circuit. A suitable method of effecting continuous reduction of the resistance may, for example, be to employ, as a secondary resistance, a substance which has a negative temperature coefficient, for example graphite or carborundum.

The modifications just mentioned are illustrated purely diagrammatically in the wiring plan shown in Fig. 6. From a source of current, for instance an alternating generator 53, wires 54, 55 lead to the primary of a transformer 56. The wire 55 includes a push button 57 and in parallel thereto a contactor 58 to be operated by a relay 59. This relay is inserted in the circuit of the secondary of the transformer 56. The secondary coil of the transformer 56 has a number of connecting contacts 60—66 by means of which the strength of the current may be regulated, a contacting arm 67 being arranged to cooperate with said contacts. In series with the contacting arm 67 is the heat-sensitive wire

68, 69, 70, a contact device 71 and a resistance 72 of metal, while in parallel with the latter is coupled a resistance 73 of graphite or carborundum. The heat-sensitive wire is attached to the grid 1, and two springs 76, 77 tend to draw the grid in the direction of the arrow 78.

The grid can also be provided with a device known per se, for example a relay 80, Fig. 6, simultaneously switching in the X-ray tube when the grid starts to move and also similar means for switching off the current supply to the wire and the X-ray tube when the grid has reached its maximum limit of travel, whereupon the grid will gradually resume its initial lower position as the wire 68, 69, 70 cools.

Reverting to Fig. 6, a portion 81 of the secondary coil of the transformer 56 may be utilized to feed the relay 80, the coil of which is in series with a contactor 82. The movable part 83 of this contactor is mounted to be operated by a member 84 attached to the frame of the grid 1, and a similar member 85 also attached to the frame of the grid is arranged to cooperate with the movable part 86 of the contactor 71. The relay 80 is provided with a contactor 87 which closes and breaks the circuit 88 leading to the Roentgen tube, not shown.

The operation of the circuits shown in Fig. 6 is as follows. Normally the contactor 71 is closed while all other contactors are open. When a Roentgen examination is to take place or a photograph is to be taken, the push button 57 is pressed down, so that the primary of the transformer 56 is excited and current is induced in the secondary the circuit of which is closed. Current then flows from the secondary through contact 60, contact arm 67, the heat-sensitive wire 70, 69, 68, the contactor 71, the parallel resistances 72, 73 and the coil of the relay 59 back to the secondary coil of the transformer. The relay 59 attracts the contactor 58 so as to also close the circuit of the primary of the transformer 56 by this contactor 58, whereupon the push button 57 may be released. The current in the wire 68, 69, 70 causes the latter to expand, and the springs 76, 77 draw the grid in the direction of the arrow 78. At the beginning of this movement, the contactor 82 is closed which energizes the circuit for the relay 80 and thereby closes the contactor 87 and the tube operating circuit 88. After the course of the time specified for the examination, the member 85 presses the movable member 86 away from the stationary member 71 of the contactor, so that the circuit of the secondary will be interrupted. As a consequence thereof, the relay 59 will be without current and the circuit of the primary of the transformer will also be broken, thereby de-energizing the entire installation.

Finally, it will, of course, be appreciated that the invention is not necessarily confined to the specific embodiment as described and illustrated above but is capable of various modifications such as those mentioned in the foregoing and below within the scope of the invention as claimed.

For example, the heat-sensitive element need not necessarily be constituted by a simple wire of the type above described and shown in Fig. 1, but may, as shown diagrammatically in Fig. 3 of the drawings, consist of a bimetal spring A heated by a resistance coil B surrounding it and adapted by its expansion or elongation to transmit movement through any suitable interconnecting means C to the grid D. Again, the heat-sensitive element in the form of a wire as described above need not be adapted to pass round reels, but may quite simply be arranged in some other way, for example in the form of wires or bands arranged diagonally cross-wise, as in the embodiment indicated in Fig. 6, or as shown in Fig. 5 wherein the crossed wires 89, 90, 91 are adapted by thermal expansion to move the grid 1 against the action of springs 92, 93 which are associated with the grid to influence its movement in the frame structure, and may be accommodated in the hollow sides of the frame structure.

Furthermore, without departing from the principle and spirit of the invention in any way the control apparatus may be disposed in the upper part of the frame, as indicated in Fig. 5, and be caused to lower the grid, instead of raising it, against the action of a spring tending to keep the grid in a raised position when not in use, in which case, of course, the counterweights referred to in the above description will not be necessary. Other variations in the form of constructional details are also possible within the scope of the invention, and as an example it may be mentioned that the counterweights need not be articulated to the lever elements as shown in the embodiment illustrated but may simply depend therefrom in some other suitable way.

The advantages exhibited by the present invention over the prior constructions referred to above, involving the control movement of a grid excluding secondary radiation for use in X-ray examinations are those of a simpler and more efficiently operating design, for not only does the arrangement according to the present invention eliminate unnecessarily complicated devices such as clockwork control gear, damped hydraulic braking devices, small electric motors and all the mechanical difficulties and possibilities of breakdown associated therewith, but, what is even more important, the invention affords a more readily responsive and flexible control of the extent and rate of movement of the grid corresponding to the variations in current strength applied, and hence in the thermal expansion of the wire, thus obviating any inertia or delay of the responsive movement of the grid due to friction, back-lash or the like such as are necessarily encountered on occasion even with the best gear or driving elements as might be expected to be employed between the grid and the clockwork, electric motor drives, respectively, in prior constructions.

What I claim is:

1. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a mounting for said grid, and means for effecting movement of said grid relatively to said mounting including a heat-sensitive expansible element operatively connected to said grid and so constructed and arranged as to control the movements of the grid according to the expansion of said element when heated.

2. X-ray apparatus according to claim 1 wherein the heat-sensitive element consists of a wire which elongates when heated.

3. X-ray apparatus according to claim 1 wherein the heat-sensitive element consists of a bimetallic spring which varies in flexure when heated.

4. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding sec-

ondary radiations, a mounting for said grid, means for effecting movement of said grid relatively to said mounting including a heat-sensitive expansible element operatively connected to said grid and so constructed and arranged as to control the movements of the grid according to the expansion of said element when heated, a source of electric current, and means for heating said element by the current from said source.

5. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a mounting for said grid, means for effecting movement of said grid relatively to said mounting including a heat-sensitive elongatable element operatively connected to said grid and so constructed and arranged as to control the movements of the grid according to the elongation of said element when heated, and means for compensating for elongation of said element beyond an amount corresponding to the maximum desired movement of said grid.

6. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a mounting for said grid, means for effecting movement of said grid relatively to said mounting including a heat-sensitive expansible element operatively connected to said grid and so constructed and arranged as to control the movements of the grid according to the expansion of said element when heated, a source of electric current, means for heating said element by the current from said source, and means for regulating the flow of heating current from said source.

7. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a mounting for said grid, means for effecting movement of said grid relatively to said mounting including a heat-sensitive expansible element operatively connected to said grid and so constructed and arranged as to control the movements of the grid according to the expansion of said element when heated, a source of electric current, means for heating said element by the current from said source, and means for automatically increasing the flow of heating current from said source in proportion to the rise in temperature of said element so as to maintain the speed of movement of said grid substantially constant.

8. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a mounting for said grid, means for effecting movement of said grid relatively to said mounting including a heat-sensitive expansible element operatively connected to said grid and so constructed and arranged as to control the movements of the grid according to the expansion of said element when heated, a source of electric current, means for heating said element by the current from said source, means for regulating the flow of heating current from said source, and means for automatically interrupting said flow after movement of said grid through a predetermined distance.

9. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a mounting for said grid, means for effecting movement of said grid relatively to said mounting including an electrically conductive wire element adapted to elongate upon being heated by the passage of electric current therethrough, said element being operatively connected to said grid and so constructed and arranged as to control the movements of the latter according to the elongation of said element, a source of electric current, means for establishing a flow of current from said source through said element, and means for automatically interrupting said flow after movement of said grid through a predetermined distance.

10. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a mounting for said grid, means for effecting movement of said grid relatively to said mounting including an electrically conductive wire element adapted to elongate upon being heated by the passage of electric current therethrough, said element being operatively connected to said grid and so constructed and arranged as to control the movements of the latter according to the elongation of said element, a source of electric current, means for establishing a flow of current from said source through said element, an electrical circuit for operating the source of the radiations controlled by said grid, and means for automatically interrupting the flow of heating current through said element and simultaneously opening said operating circuit after movement of said grid through a predetermined distance.

11. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a frame in which said grid is mounted and is adapted to be moved in a substantially vertical plane, means within said frame for counterbalancing the weight of said grid during movement thereof, means for effecting movement of said grid within said frame, and means for controlling said movement including a heat-sensitive element adapted to elongate when heated, said element being so arranged and operatively associated with said grid moving means as to render the movements of the grid proportional to the elongation of said element.

12. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a frame in which said grid is mounted and is adapted to be moved, means for effecting movement of said grid in one direction, resilient means mounted in said frame operatively connected to said grid and tensioned counter to the movement thereof in said direction, and means for controlling the movement of said grid including a heat-sensitive element adapted to elongate when heated, said element being so arranged and operatively associated with said grid moving means as to render the movements of the grid proportional to the elongation of said element.

13. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a hollow-sided frame in which said grid is mounted and is adapted to be moved in a substantially vertical plane, means for guiding the movements of said grid in said frame, means housed in the hollow sides of said frame and operatively connected to said grid for counterbalancing the weight of the latter during movement thereof, means tending to move said

grid in one direction including a spring operatively connected at one end to said grid and at the other end to said frame, and means for counteracting the force of said spring comprising a heat-sensitive element adapted to elongate when heated and thereby permit a proportionate movement of said grid under the influence of said spring.

14. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a frame in which said grid is mounted and is adapted to be moved, means tending to move said grid in one direction including a spring operatively connected at one end to said grid and at the other end to said frame, and means for counteracting the force of said spring comprising a heat-sensitive, electrically conductive element electrically insulated from said spring and adapted to elongate when heated by the passage of electric current therethrough so as to permit a proportionate movement of said grid under the influence of said spring.

15. X-ray apparatus according to claim 14 wherein the heat-sensitive element consists of a metal wire having a relatively high coefficient of expansion.

16. In X-ray apparatus of the character described, the combination of a grid capable of passing primary radiations but excluding secondary radiations, a frame in which said grid is mounted and is adapted to be moved, means tending to move said grid in one direction including a spring operatively connected at one end to said grid and at the other end to said frame, means for counteracting the force of said spring comprising a heat-sensitive, electrically conductive metal wire electrically insulated from said spring and adapted to elongate when heated by the passage of electric current therethrough so as to permit a proportionate movement of said grid under the influence of said spring, a plurality of insulated reels around which said wire passes in a plurality of turns, and means for connecting the ends of said wire to a source of electric current.

17. X-ray apparatus according to claim 16 including means for maintaining said wire under tension, and means for adjusting said tensioning means.

18. X-ray apparatus according to claim 16 including a plate rotatably mounted with respect to, and insulated from, the frame and having one end of said wire connected thereto, means for adjusting the position of said plate to vary the tension of said wire, and a spring tending to rotate said plate in such direction as to compensate for elongation of said wire beyond an amount corresponding to the maximum desired movement of said grid.

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