United States Patent

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[54] **NUCLEONIC MEASURING APPARATUS WITH AUTOMATIC FIRE SAFETY RADIATION SOURCE SHUTTER CLOSING AND LOCKING MEANS COMPRISING A SPRING RETAINED BY A FUSIBLE BARRIER WHICH MELTS AT HIGH TEMPERATURES**
7 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **250/106,** 250/83.3, 250/105; 220/89
[51] **Int. Cl.** **G01t 1/17**
[50] **Field of Search** 250/83.3D, 106S, 105; 220/89B, 55.3, 47; 180/107; 292/327; 70/440

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ABSTRACT: A nucleonic measuring instrument wherein a housing contains a radiation source and has an aperture controlled by a shutter which is spring loaded to a closed position for confining and shielding the radiation and is movable by a motor to an open position for releasing the radiation, the motor being supplied with power through a heat-sensitive element so that it is deenergized and the shutter closes in response to a predetermined high ambient temperature such as may be caused by a fire, and a spring steel shutter lock is retained in a retracted position by a barrier of meltable metal which is adapted to melt and release the spring lock at a still higher ambient temperature for locking the shutter in its closed position.

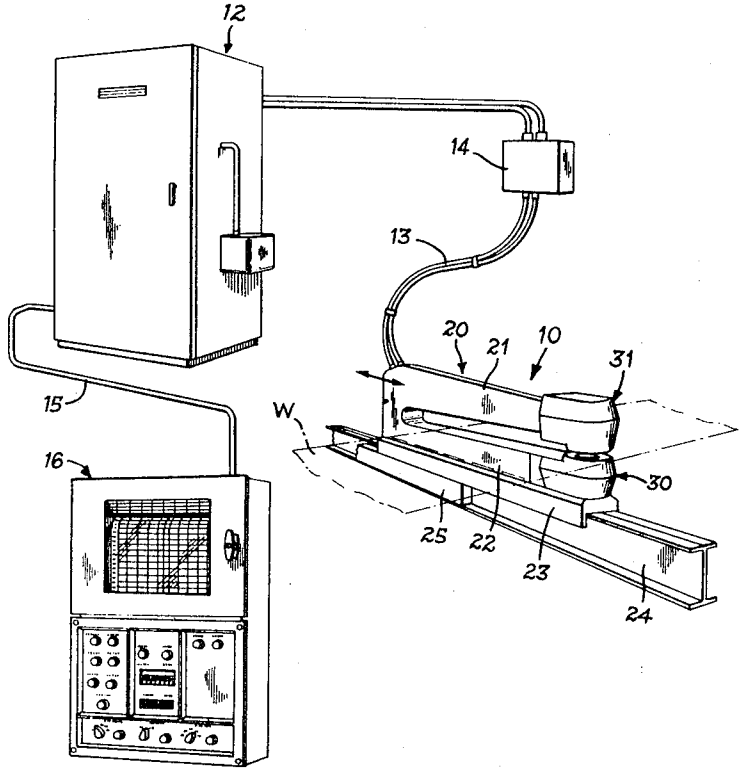


FIG-1

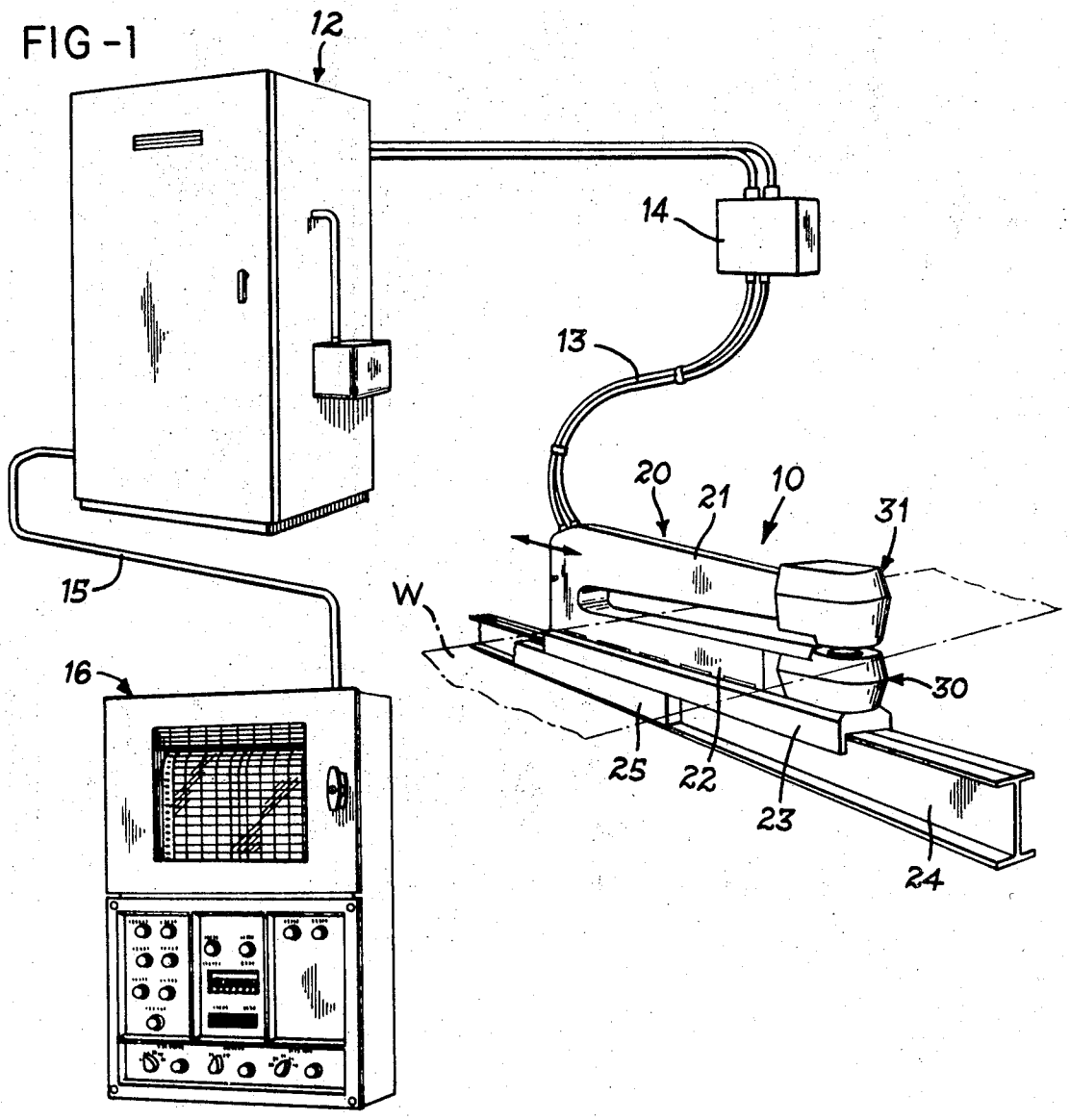
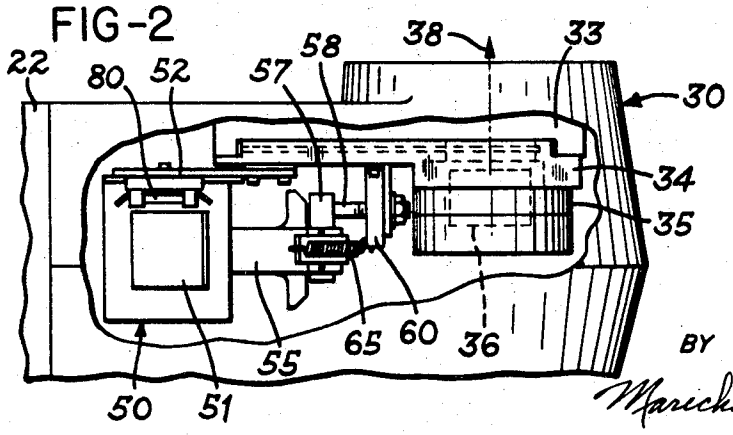


FIG-2



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FIG-3

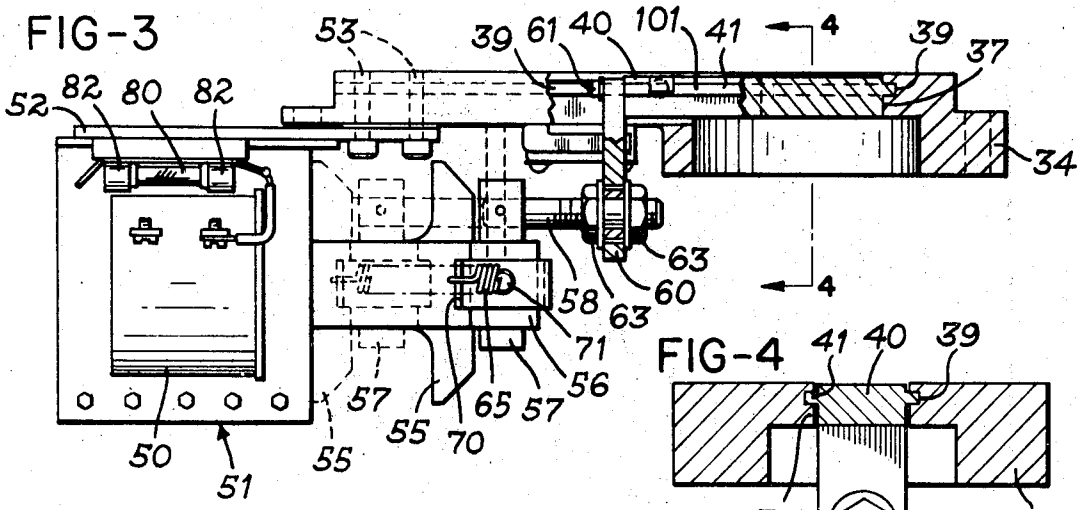


FIG-4

FIG-5

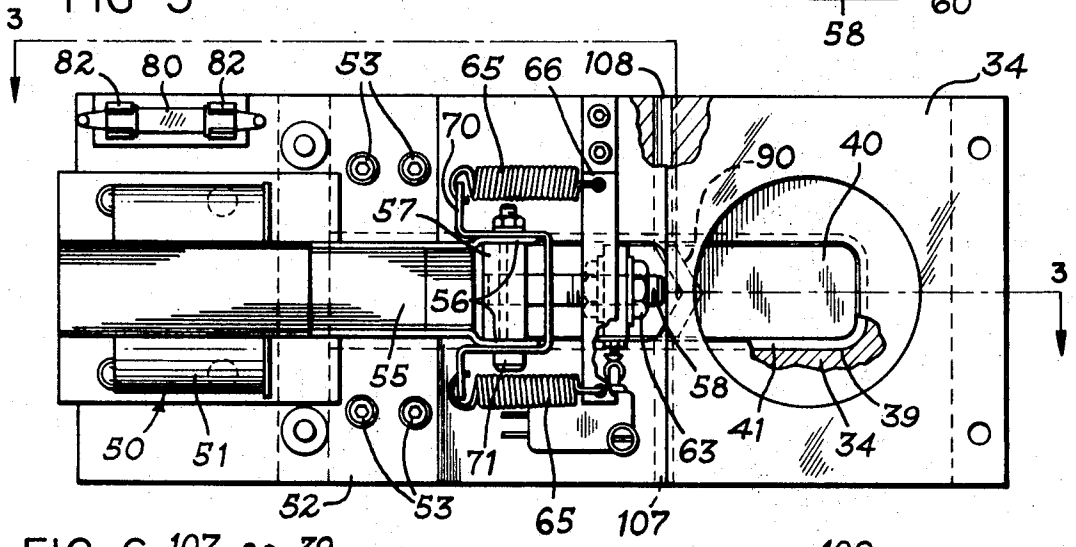


FIG-6

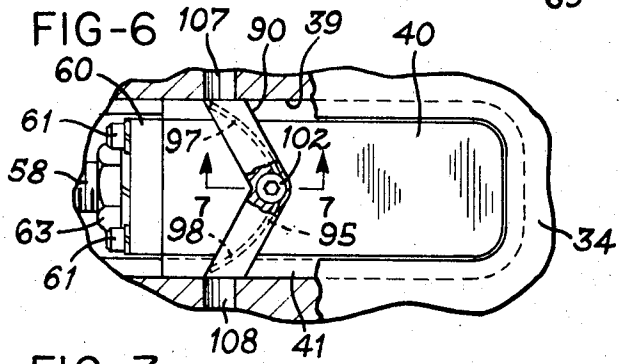


FIG-8

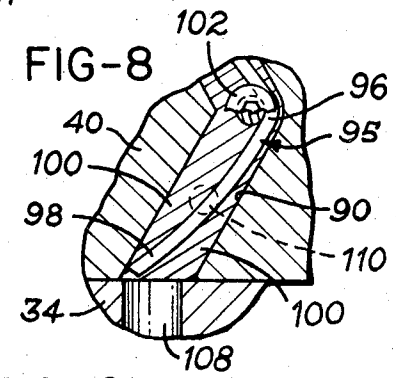


FIG-7

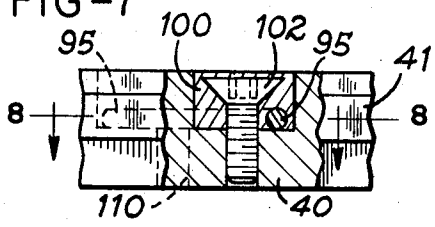
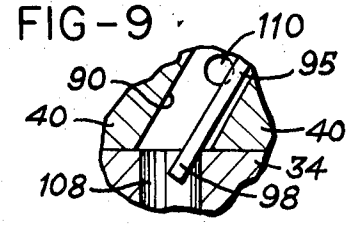


FIG-9



NUCLEONIC MEASURING APPARATUS WITH AUTOMATIC FIRE SAFETY RADIATION SOURCE SHUTTER CLOSING AND LOCKING MEANS COMPRISING A SPRING RETAINED BY A FUSIBLE BARRIER WHICH MELTS AT HIGH TEMPERATURES

RELATED INVENTIONS

The present invention relates to the inventions disclosed in copending applications Ser. No. 634,363 of Bernard C. Holben and Richard E. Bach and Ser. No. 634,366 of Richard E. Bach, both assigned to the assignee of the present invention and filed on even date herewith.

BACKGROUND OF THE INVENTION

Nucleonic measuring gauges have been provided with source housings having apertures controlled by shutters which are operated by an electric solenoid or by an air motor, or the like, for retracting and permitting the release of the radiation from a suitable nucleonic source within the housing. Examples of such shutters are shown in the U.S. Pats. of Holben No. 2,858,450 of 1958 and Lehman No. 2,932,744 of 1960, each assigned to the assignee of this invention. These shutters are normally made of heat-resistant material and also act as an effective block or shield for the rays emanating from the source, so that when the shutter is closed, the source capsule is effectively sealed within its housing and no substantial radiation emanates through the aperture.

Normally, the shutter mechanisms are "fail-safe" so that upon deenergization of the operating motor, the shutter automatically returns to the closed position such as by the use of retraction springs or the like. In the event of a disaster or conflagration, it is important to maintain the integrity of the source housing and to confine all radiation within the housing. This is accomplished by assuring that the shutter returns to the closed position under such conditions and remains there.

SUMMARY OF THE INVENTION

The present invention relates to nucleonic gauging and measuring apparatus, and more particularly, to such apparatus in which a movable shutter is positioned in relation to the exit aperture for a nucleonic source, and to apparatus for closing and locking the shutter in the event that certain predetermined temperature limits are exceeded.

The invention employs motor means, such as an electric solenoid, for moving the shutter between a closed position where it effectively shields radiation from the source of radioactive material and an open position where the aperture is uncovered. Normally, during the operation of the gauge, the shutter is maintained in its open position with respect to the aperture, by continuously energizing the solenoid. However, it is within the scope of this invention to use other means, such as an air-operated motor shown in the Holben and Lehman patents mentioned above. Such shutter apparatus includes means responsive to the occurrence of a first predetermined temperature for causing the shutter to close and seal the source capsule within its housing and to render it relatively harmless in the event of fire or the like. This may include a temperature-responsive element, such as a fuse, to interrupt the power to the solenoid so that the shutter is returned to its closed position by the shutter retraction springs.

The present invention is, in some respects, an improvement over that shown and claimed in the copending application of Bach. It is directed to improved shutter apparatus for locking the shutter in the closed position upon the occurrence of some predetermined abnormally high temperature after the shutter has moved to its closed position. Specifically, it provides a spring which is normally held in a stressed condition by a meltable barrier of metal, and which is released upon the occurrence of a specific temperature or range of temperatures by the melting of the barrier, and moves into locked relation with the shutter.

The apparatus of this invention has advantages of simplicity of design and reliability of operation. The spring member itself

is used or employed as the device which locks the shutter in its closed position or which prevents movement of the shutter to its open position. Thus, even though the spring may subsequently lose its temper, it nevertheless is operative to form a reliable lock or latch.

A specific embodiment is shown in which the shutter-locking device is carried within the shutter itself, in the form of a generally V-shaped spring recessed in a correspondingly shaped groove or opening formed in the shutter. The opposite ends of the spring are normally held in a retracted position by solder material within the shutter opening or groove. When a sufficiently high temperature is reached, the solder melts, and the spring is then free to move outwardly of the shutter so that its opposite ends come in engagement with the shutter guide, effectively locking the shutter in the closed position.

It is accordingly an important object of this invention to provide locking apparatus for a movable shutter in a nucleonic gauge in which a spring member is held in a normally stressed condition by an imposed barrier of removable material, such as solder, and which is released by the melting of the material to a position where a portion of the spring forms an integral lock for assuring that the shutter remains in its closed position, safely sealing and containing the radiation source within its housing.

A specific object of this invention is the provision of a shutter-locking device as outlined above, in which a spring member is carried within the shutter itself and which is normally retained within the confines or dimensions of the shutter, and which is released upon the attainment of an abnormally high temperature so that an integral end of the spring moves outwardly of the shutter and into locking engagement with the shutter guide.

These and other objects and advantages of the present invention will be apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a nucleonic thickness gauging system including a shutter assembly constructed in accordance with this invention;

FIG. **2** is an elevational view of the radiation source head with the head being partially broken away;

FIG. **3** is an elevational view, partially broken away, of the shutter assembly and its operating mechanism;

FIG. **4** is a transverse section through the shutter and shutter guide taken generally along the line **4–4** of FIG. **5**;

FIG. **5** is a bottom view, partially broken away, of the apparatus of FIG. **3**;

FIG. **6** is a fragmentary view, partially broken away, of the shutter-locking mechanism;

FIG. **7** is an enlarged vertical fragmentary section through the shutter-locking mechanism taken generally along the line **7–7** of FIG. **6**;

FIG. **8** is a fragmentary section through the shutter-locking mechanism taken generally along the line **8–8** of FIG. **7**; and

FIG. **9** is a fragmentary view of a portion of the apparatus of FIG. **8** after the metal barrier has been removed, showing the shutter-locking spring in its actuated position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a nucleonic thickness measuring gauge **10** is connected to an electronic equipment cabinet **12** through flexible cables **13** and an intermediate disconnect box **14**. A conduit **15** leads from the cabinet **12** to a combined recorder and remote control unit **16** located at an operator's station.

The thickness measuring gauge **10** may be of any suitable type utilizing radioactive material as the source, and may be constructed as shown in Chope U.S. Pats. No. 2,790,945 of 1957 and No. 2,829,268 of 1958, both assigned to the same assignee as this invention. Furthermore, it is within the scope of this invention, to employ a backscatter gauge as shown in the above-mentioned Holben patent.

As shown in FIG. 1, the gauge 10 includes a C-shaped frame 20 having an upper leg 21 and a lower leg 22 supported by a carriage 23 mounted for traversing movement on a supporting rail 24. A housing 25 is mounted on the rail 24 and encloses a motor which is connected to move the frame 20 in directions as indicated by the arrow 26.

A radiation source head 30 is mounted on the lower leg 22 of the frame 20 and a detector head 31 is mounted on the upper leg 21 directly above the head 30. The heads 30 and 31 cooperate to form a gap or space through which a traveling web W of material is directed. Referring to FIG. 2, the source head 30 includes a member 33 supporting a plate 34 which forms a cover for a cylindrical-shaped housing 35 containing a radiation source 36. The plate 34 has a U-shaped opening or aperture 37 (FIG. 3) through which the radiation is directed upwardly towards the detector head 31 as indicated generally by the arrow 38.

The source 36 is preferably of the penetrative radiation type wherein a source of beta, gamma, bremsstrahlung or other type radiation is produced to irradiate the material to be measured. The radiation detector in the detector head 31 may be a scintillation detector or an ionization chamber which is effective to determine the amount of radiation passing through the web W of material. The choice of radiation depends on the character and the density of the material being measured. That is, a useful detector response results from the use of beta or bremsstrahlung radiation for lightweight materials but there would be substantially no absorption of a more penetrating radiation such as gamma. On the other hand, it is desirable to use a gamma source in measuring relatively dense material. Typical examples of beta emitters are strontium–90 and krypton–85, while americium–241 and cesium–137 are suitable gamma emitters.

Referring to FIGS. 3—5, a milled groove 39 is formed within the plate 34 around the aperture 37 and forms a guideway for supporting a shutter 40 having an outwardly projecting rib or flange 41 which projects into the groove 39. Thus the shutter 40 is slidably supported for movement between a closed position, as shown in full lines, and an open position where the shutter is retracted to the left in FIGS. 3 and 4 to open the aperture 37. In the closed position, the flange 41 on the forward end of the shutter 40 is received within the corresponding portion of the groove 39 so that the cooperation between the interfitting flange 41 and groove 39 form an effective seal between the shutter 40 and the plate 34.

The shutter 40 is made of suitable material which resists exceedingly high temperatures such as would occur in a fire and also forms an effective shield to block radiation from the source 36. Suitable materials for the shutter are defined in the Holben and Lehman patents mentioned above.

Means for moving the shutter 40 within the guideway 39 to open the aperture 37 include a solenoid 50 which has its operating coil 51 mounted on an extension plate 52 bolted to the under surface of the plate 34 by screws 53. The solenoid 50 has a T-shaped armature 55 having, at its forward end, a pair of flanges 56 which receive a vertically extending block 57 therebetween. The block 57 supports, at its upper end, a threaded rod 58 which extends generally in the direction of movement of the solenoid armature. An arm 60 (FIG. 3) is mounted on the shutter 40 by screws 61 and depends downwardly to receive the rod 58 projecting through a hole formed within the arm 60. A pair of lock nuts 63 are mounted on the bolt 58 on opposite sides of the arm 60 and provide means for adjustably positioning the shutter 40 in relation to the solenoid armature 55.

The shutter 40 is moved to its closed position upon the deenergization of the solenoid 50 by a pair of retraction or tension springs 65 each having one end secured to the plate 34 by a spring retainer bracket 66 (FIG. 4), The opposite ends of the spring 65 are connected to the solenoid armature 55 by means of a hat bracket 70 which is secured to the flanges 56 by a bolt 71 extending through aligned holes formed within the bracket 70, flanges 56 and block 57. Thus when the solenoid is energized, the assembly including the block 57, the shutter arm 60 and the shutter 40 move to the left (FIG. 3) causing the extension of the springs 66 and the opening of the aperture 37. When the solenoid is deenergized, the springs 66 return the shutter 40 to a position closing the aperture 37.

Means responsive to the occurrence of a predetermined high temperature for deenergizing the solenoid 50 includes a heat-sensitive or -responsive fuse 80 mounted on the plate 52 by suitable fuse clips 82 and wired in series with the coil 51. The heat-responsive fuse 80 may be the type TFX manufactured by Bussman Manufacturing Division of McGraw-Edison Company of St. Louis, Missouri, and will interrupt the flow of current to the solenoid when the ambient temperature reaches approximately 300° F. The fuse 80 is provided in the event that electrical power to the solenoid still exists at this temperature, although it can be reasonably expected that by the time this temperature has occurred, either the solenoid itself will have become inoperative or the electrical lines to the solenoid would have become disrupted or otherwise deenergized.

The invention further includes means responsive to the occurrence of a still higher temperature for locking the shutter in the closed position. Referring to FIGS. 5 and 6, it will be seen that the inwardly extending portion of the shutter adjacent the arm 60, is provided with a generally V-shaped slot or recess 90 suitably formed in the body of the shutter 40. The recess 90 may be formed by any suitable method, such as by milling, and has a depth, as shown in FIG. 7, of approximately one-half the thickness of the body of the shutter 40. The slot 90 extends transversely the full width of the shutter 40 and accordingly opens outwardly at each side edge of the shutter.

Means for locking the shutter in the closed position upon the occurrence of a predetermined maximum temperature includes a steel wire spring 95 which is also formed with a generally V-shaped configuration. The spring 95 is received within the recess 90, and is formed of such a length that when the spring is semifolded in a stressed condition, its apex 96 lies substantially against the apex of the groove 90, and its opposite end 97 lies substantially against the apex of the groove 90, and its opposite ends 97 and 98 are positioned within the dimensions of the shutter and substantially at or near the opposite side of the groove just inwardly of the open ends of the recess 90.

The remaining space within the recess 90 is filled with a meltable barrier material 100. As an example, the material 100 may be formed of a solder composition including approximately 95 percent tin, 3.5 percent silver and 1 percent antimony so that it has a eutectic melting temperature at approximately 430° F. However, any metal alloy material may be used which has sufficient resistance against cold flow to retain its shape and prevent creeping of the spring 95 over extended periods of use at temperatures below the eutectic temperature, and which melts at a predetermined or predictable temperature to release the spring 95.

To assure the retention of the locking spring in the recess 90, it may be held by a capscrew 99 with its head being positioned in overlying relation to the spring apex 96. The screw 102 functions to hold the wire spring in place during the pouring and solidification of the solder material 100 and further assures that the spring remains in the recess and retains its relative position with respect to the shutter after the solder has melted.

The transverse length of the spring 96, in its operated or extended position, is greater than the width of the shutter 40. Accordingly, an integral portion of the spring ends 97 and 98 extend through the open ends of the recess 90 substantially as shown in FIG. 9. Thus, for the purpose of providing a positive lock, the shutter guide plate 34 may be provided with a pair of opposite, transversely oriented openings 107 and 108. These openings are generally in alignment with the open ends of the slot 90 in the closed position of the shutter, and provide an open area into which the respective spring ends 97 and 98 may move following the melting of the barrier material 100, as shown in FIG. 9. A weep hole 110 may be provided for draining off the molten material 100 to assure complete freedom of movement of the spring ends into the shutter-locking position.

Once the ends of the spring **90** are thus received and engaged within the openings **107** and **108**, the shutter is positively located in its closed position, and any force which tends to open the shutter only serves to engage further the cooperating locking elements comprising the spring ends **97, 98** and the openings **107, 108** within the guide walls. While the shutter may retract a small distance before these parts become lockingly engaged, this movement is not sufficient to expose any portion of the aperture which is closed by the shutter. In other words, the length of the flange **41** and the depth of cooperating recess **39**, at the forward end of the shutter are sufficient to assure that the shutter remains closed.

While the groove **90** is shown in FIGS. **6—9** as being open at the top, it is of course within the scope of this invention otherwise to provide a suitable groove or opening within the shutter **40** in which the lock spring may be placed. This can be accomplished by forming an undercut groove, in which case the retainer screw **102** can be eliminated. Further, the shutter may be formed in two pieces, that is, may be formed as a sandwichlike construction including a lower portion defining a spring-receiving recess and an upper cover plate portion for the recess. In that case, the retaining screw may also be eliminated.

It is within the scope of this invention to form the lock spring **95** of other material than round wire steel stock. Thus, a leaf or coil spring may be used which is held in a stressed and retracted condition by means of a eutectic metal barrier, and which moves to an operative position to block or otherwise lock the shutter in its closed position.

It is also within the scope of this invention to employ any suitable motor for the opening and closing of the shutter **40**. Preferably, a single-acting motor is used, such as the solenoid disclosed, and it is also within the scope of this invention to employ an air-operated motor, such as a piston motor. If an air motor is used, it will be deenergized when the air supply line to the motor ruptures or breaks with heat. A short section of plastic tubing can conveniently be incorporated in the air line as an equivalent of the fuse **80** used in this embodiment.

The operation of this invention is largely self evident from the preceding description. In the event of a rise in ambient temperature above the normal operating temperature, such as would occur during a fire, the operating power supplying the coil of the solenoid **50** will be interrupted, if not from other causes, then by the blowing of the heat-responsive fuse **80** at its operating temperature of approximately 300° F. The shutter **40** will then be closed by the springs **66**. Thereafter, if the temperature should continue to rise to the eutectic range of the material **100**, the locking spring **95** is released in the manner described above to move outwardly into locking engagement with the walls of the shutter guide. Thereafter, even though the temperature may rise further, and even though the gauge may be subject to violent forces, the shutter will remain locked in the closed position.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

We claim:

1. A nucleonic radiation measuring instrument comprising a housing enclosing a source of nuclear radiation and having an aperture for releasing radiation from said housing for measurement purposes, a shutter for said aperture, means supporting and guiding said shutter for movement between an open position to release radiation from said aperture and a closed position effectively confining the radiation within said housing, bias means urging said shutter to said closed position, motor means for moving said shutter from said closed position to said open position, means responsive to the occurrence of a first predetermined high ambient temperature for deenergizing said motor means so that said bias means moves said shutter from said open position to said closed position, lock means associated with said shutter formed of spring material and having an end portion movable between a first position under which said spring material is stressed permitting unrestricted movement of said shutter between its said positions and a moved position upon the releasing of said spring material in which said shutter is locked in its said closed position, and thermal responsive barrier means retaining said end portion in said first position and being responsive to a predetermined ambient temperature higher than said first temperature for releasing said end portion for movement into its said moved position.

2. The instrument of claim **1** wherein said lock means comprises a spring member having a pair or opposite ends which are retained by said barrier means in a stressed condition permitting unrestricted movement of said shutter between its said positions and which are released in response to the removal of said barrier means for movement into said moved position preventing opening movement of said shutter.

3. The instrument of claim **1** in which said barrier means comprises a eutectic alloy having a predetermined melting point which melts to release said spring member.

4. The instrument of claim **3** further comprising means in said shutter defining an opening adjacent said shutter guide means, and wherein said lock means comprises a spring wire positioned in said shutter opening and movable therethrough upon the melting of said material into locking engagement with said shutter guide means.

5. The instrument of claim **3** wherein said lock means comprises a generally V-shaped spring having opposite end portions, means in said shutter defining a transverse, generally V-shaped recess, said barrier means retaining said spring in said recess in a semifolding stressed condition with the opposite end portions thereof retracted in said opening within the dimensions of said shutter, said end portions being movable upon the said removal of said barrier means outwardly of the transverse dimensions of said shutter and into locking engagement with said shutter guide means.

6. The instrument of claim **5** further comprising means in said guide means defining openings positioned approximately in alignment with the terminal ends of said recess when said shutter is in its closed position to accept the said opposite end portions of said V-shaped spring with the release of said spring by the melting of said barrier means.

7. A nucleonic radiation energy measuring instrument having a source of nuclear energy and incorporating a temperature responsive safety lock in which a shutter member is mounted on a guide member for movement between a retracted position defining an opening for radiation measurement purposes and a closed position effectively confining radiation from said source, the improvement in shutter-locking mechanisms comprising means defining a locking spring mounted on one of said shutter and guide members having an integral portion thereof movable between a retracted position permitting movement of said shutter member between its said positions, and an operative position in which said portion is in locking engagement with the other of said shutter and guide members with said portion being normally urged to said operative position, and metal barrier means having a predetermined melting temperature retaining said spring in its said retracted position and flowable upon the attainment of said temperature to release said spring for movement of said integral portion thereof into its said operative position.