Jan. 15, 1963 M. G. LEONARD ET AL 3,073,993

COMPLETELY PROTECTED TRANSFORMER

Filed Nov. 12, 1958 3 Sheets-Sheet 1

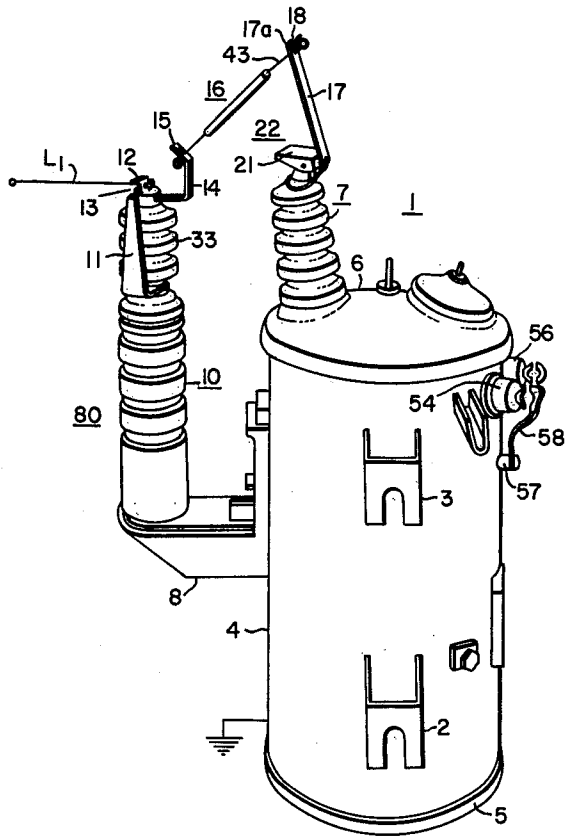


Fig. 1.

Fig. 7.

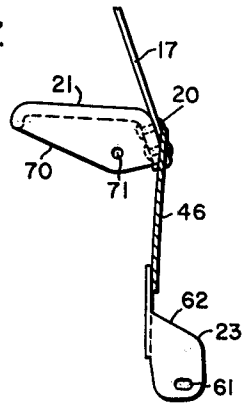
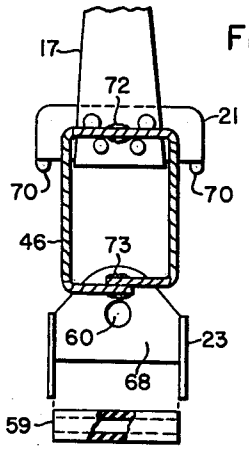


Fig. 8.



WITNESSES

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COMPLETELY PROTECTED TRANSFORMER

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3 Sheets-Sheet 2

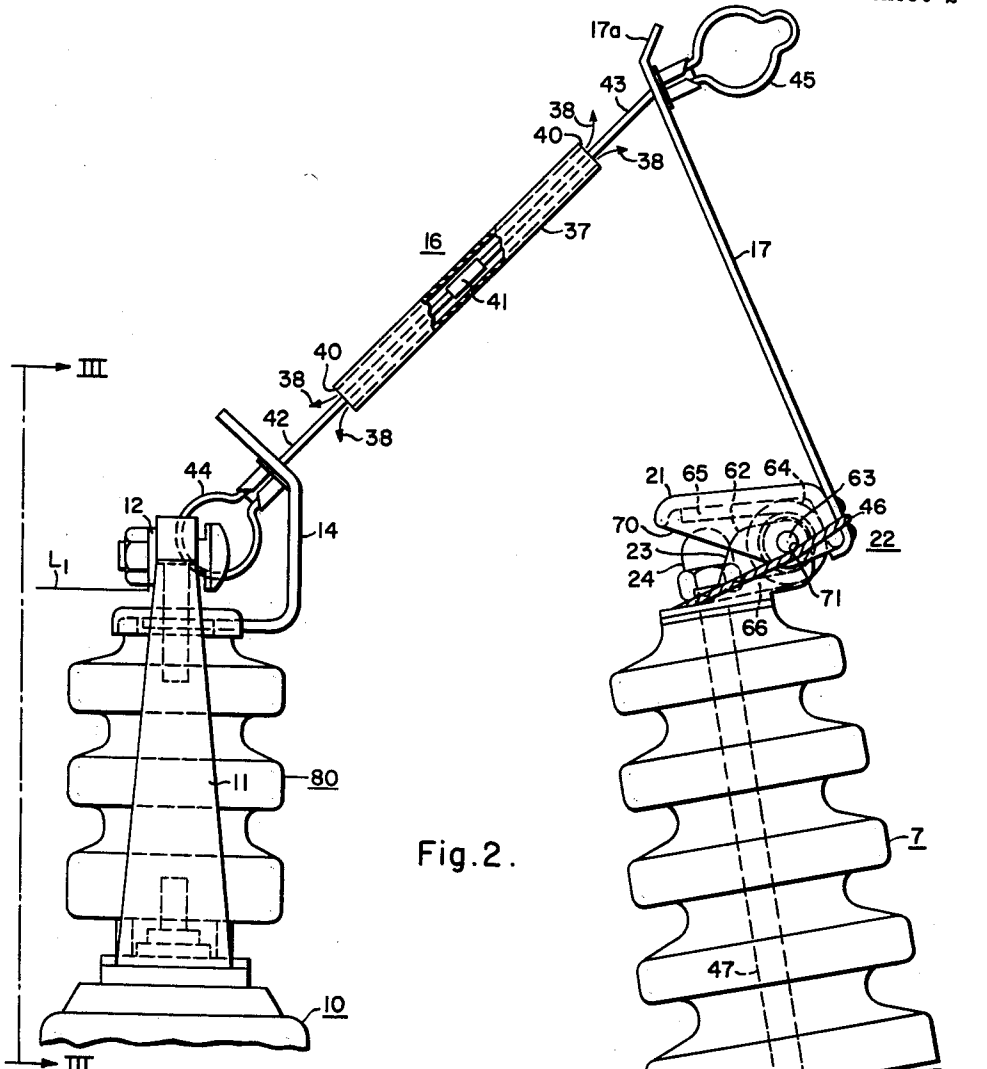

Fig.2.

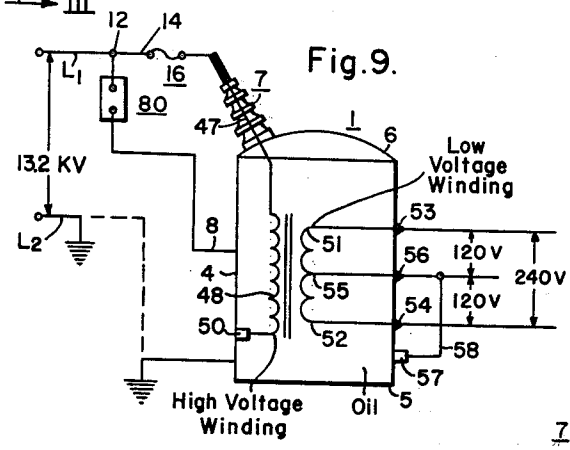

Fig.9.

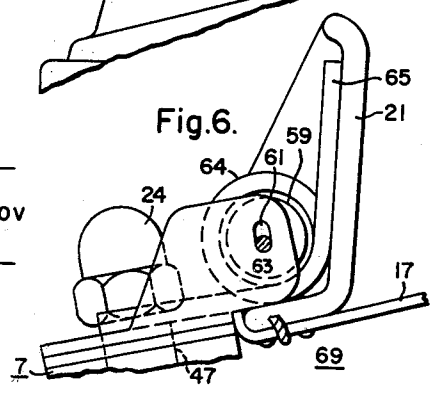

Fig.6.

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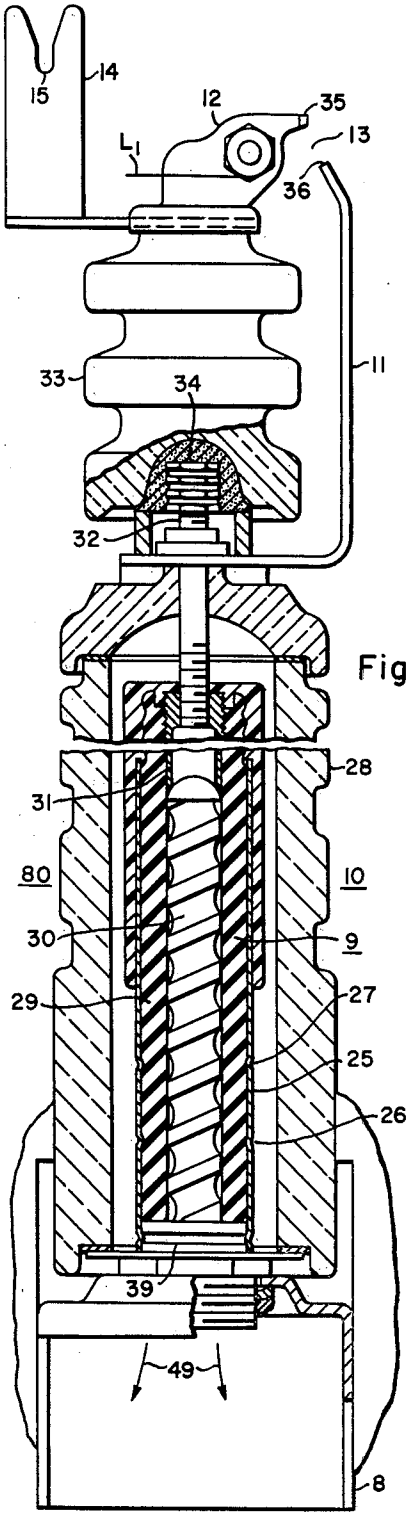
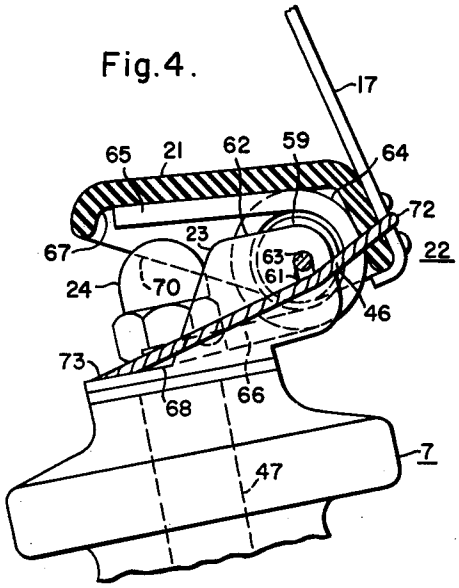


Fig.3.

Fig.4.



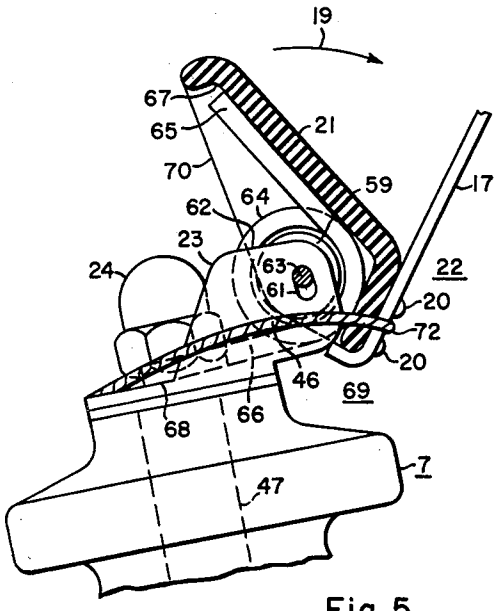


Fig.5.

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3,073,993

COMPLETELY PROTECTED TRANSFORMER

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8 Claims. (Cl. 317—15)

This invention relates to transformers having protecting means associated therewith to protect the transformers from lightning surges and also from fault currents and overload conditions, and more particularly to such transformers, wherein such protective equipment is disposed externally of the transformer casing and immediately adjacent thereto.

A general object of the present invention is to provide a transformer which has auxiliary equipment associated therewith in a novel manner to completely protect the transformer from lightning surges, and, in addition, to protect the transformer from fault current and overload conditions.

Another object of the present invention is to associate a fuse device with a transformer for the protection thereof such that much higher short-circuit currents can be interrupted by the fusible device than has been possible heretofore.

A further object of the invention is to provide a nonbouncing fuse support arm on the high-voltage terminal of a transformer, so that during blowing of the fuse, the fuse support arm will not bounce back and reenter the area of hot conducting arc gases causing thereby restriking of the extinguished arc.

Another object of the present invention is to provide a completely protected transformer in which the auxiliary equipment may be assembled at the factory so as to eliminate the necessity of mounting the auxiliary equipment, as separate items, adjacent to the transformer in the field.

Still another object of the invention is to provide an improved mounting arrangement for a lightning arrester associated with a transformer, such that the lightning arrester interrupting device serves, in addition, as a support for a fuse holder element, which supports one end of a fusible device employed to protect the transformer.

Yet a further object of the invention is to provide a spring-biased hinge assembly disposed at the outer end of the high-voltage bushing of a transformer, such that the hinge assembly assists in the interruption of a fusible device disposed in series with the high-voltage transformer winding.

Another object of the invention is to associate an energy-absorbing friction brake in connection with a spring-biased hinge assembly disposed at the outer end of the high-voltage bushing of a transformer and carrying a rigid fuse support arm thereon, the construction being such that during blowing of the fuse, the tip of the rigid fuse support arm is prevented from reentering the area of hot conducting gases and causing a restrike of the extinguished arc.

Another object is to so position and locate a fusible device and a lightning arrester with respect to a transformer, and mounted thereon, such that a completely protected transformer results having as few mounting items as possible.

Yet a further object of the present invention is to so associate a fusible device relative to a transformer, which it protects, such that during a refusing operation by a workman, the blowing of the fuse will eject the exhaust gases from the fusible device in a direction away from the workman.

Still a further object of the present invention is to provide an improved, completely protected, distribution transformer adapted for use on solidly grounded, common neutral distribution systems, where it is not desirable to mount the protective devices on a cross-arm.

The present invention results in a completely assembled transformer, which may be assembled at the factory and eliminates the necessity of the customer purchasing, stocking and mounting the fuse arrester package. It also reduces the blowings of sectionalized fuses due to higher short-circuit clearing ability. In addition, reliability of the transformer equipment is increased, since a weatherproof hood or shield is provided over a spring and hinge assembly, which facilitates fuse rupture, and the several parts are so provided as to prevent bouncing of the fuse support arm.

Another important feature of the present invention is the fact that the refusing operation by linemen is facilitated and accomplished with perfect safety.

In accordance with the present invention a lightning arrester is mounted upon the casing of a transformer and not only supports a line terminal for the transformer but, in addition, supports one end of a fusible device for protecting the transformer from overload. In the particular embodiment described, the other end of the fusible device is supported by a rotatable fuse-holder assembly mounted upon the external end of the high-voltage terminal bushing associated with the transformer. Novel biasing and shock-absorbing means are incorporated in the rotatable fuse-holder assembly to effect fast fuse rupture and prevention of rebound of the fuse-holder arm.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which:

FIGURE 1 is a perspective view of a distribution transformer employed on a solidly grounded, common neutral distribution system and embodying features of the present invention, the fusible device being illustrated in its intact, unblown condition;

FIG. 2 is a considerably enlarged, fragmentary, view showing the several parts of the transformer installation of FIG. 1 on a larger scale, again the fusible device being illustrated in its intact, unblown condition;

FIG. 3 is an end elevational view, partially in vertical section, and partly broken away taken substantially along the line III—III of FIG. 2, with the fusible device omitted, showing the several elements more fully;

FIG. 4 is a fragmentary, enlarged, partially sectional view showing the upper end of the high-voltage bushing of the transformer, with the rotatable hinge assembly in the position wherein the fusible element is intact and unblown;

FIG. 5 is a view similar to that of FIG. 4, but showing the movement of the hinge assembly at the upper end of the transformer high-voltage bushing during blowing of the series fusible device;

FIG. 6 is a fragmentary view, similar to FIGS. 4 and 5 but showing the hinge assembly in its fully open position;

FIGS. 7 and 8 are detailed, fragmentary views in side elevation, and end elevation, of the sleet hood and sleet hood supporting bracket, illustrating the flexible cable interconnecting these two elements; and

FIG. 9 is a diagrammatic view illustrating the several elements and the internal windings of the transformer for a particular voltage rating.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral 1 generally designates a completely protected transformer, adaptable for pole or cross-arm mounting by mounting brackets 2, 3 in a manner well known by those skilled in the art. For purposes of illustration, and not by way of limitation, the

transformer 1 is a distribution transformer adapted for use on solidly grounded, common neutral distribution systems, and for purposes of illustration, as indicated in FIG. 9, has a high-voltage primary winding adapted for use on, say, a 13.2 kv. solidly grounded distribution system. The low-voltage secondary windings permit the utilization of either 120 volts or 240 volts, as desired for the particular example illustrated.

Referring again to FIG. 1, it will be noted that the distribution transformer 1 includes a tank casing 4 having a base 5 and a cover 6, through which extends a high-voltage bushing, generally designated by the reference numeral 7.

Extending laterally from the tank wall 4 is a mounting bracket 8 formed of strong material, such as steel, which supports in an upright position, as shown, a lightning arrester, generally designated by the reference numeral 80. The internal construction of the lightning arrester interrupting device 10 of the arrester 80 is more fully shown in FIG. 3 of the drawings, to which reference will be made hereinafter. A gap strap 11 is secured to the upper end of the lightning arrester interrupting device 10, as shown in FIGS. 1 and 3, and cooperates with a high-voltage terminal 12 to form an external series spark gap 13, more clearly shown in FIG. 3 of the drawings.

Extending laterally from the high-voltage terminal 12 is a fuse holder support arm 14 having a notch 15 at its upper end to accommodate one end of a fusible device, generally designated by the reference numeral 16. As shown in FIG. 1, the right-hand end of the fusible device 16 is supported by an upstanding, relatively rigid, support arm 17 having a notch 18 (FIG. 1) provided at its upper end. The upper fuse support arm 17 is riveted by rivets 20 (FIG. 5) to a sleet hood or weather shield 21, having a configuration more clearly shown in FIGS. 7 and 8 of the drawings, and formed preferably of an insulating material. It has been found that one such insulating material, which is preferable, and has the requisite strength, is polyester glass-reinforced material.

The sleet hood or weather shield 21 is rotatable and forms a part of a rotatable hinge assembly, generally designated by the reference numeral 22, and comprising a shield support bracket 23, which is fixedly secured to the upper end of a terminal stud 47, which passes downwardly interiorly through the high-voltage bushing 7 and has a cap nut 24 threadedly secured to the upper end thereof.

The lightning arrester interrupting device 10, as shown in FIG. 3, includes a conducting ground shield 25, which is crimped, as at 26 and 27, about an internally disposed tubular arcing chamber structure 9 briefly described hereinafter. Reference may be had to United States Patent 2,677,072, issued April 27, 1954, to Eugene J. De Val, and assigned to the Westinghouse Electric Corporation, for details relating to the internal construction and operation of the lightning arrester interrupting device 10. For the purpose of illustrating the present invention, it is not believed necessary to go into a minute description of the internal parts of the lightning arrester 80, since reference may be had to the aforesaid patent, and the general use and operation of lightning arresters are generally well known by those skilled in the art.

As set forth in the aforesaid Patent 2,677,072, the arcing chamber structure 9 is provided by a gas-evolving fiber sleeve, to which the ground metallic shield 25 is crimped and reinforced. A spiral grooved fiber filler rod 30 is disposed within the outer fiber sleeve 29, and exerts a current-limiting action during sparkover of the lightning arrester 80. The gases evolved are ejected through perforations, not shown, in lower ground electrode 39, as indicated by arrows 49. The initial sparkover is between upper electrode 31 and ground electrode 39 in a straight path, but the power follow current is forced by the evolved gases to take a longer helical path about the spiral-groove filler rod 30. Current limiting action takes place with the power follow current quickly interrupted.

It will be noted that an external casing 28, preferably formed of a suitable weatherproof material, such as porcelain, is provided about the internal expulsion-type lightning arrester interrupting device 10 to protect it from the weather, and the external spark gap 13 is employed in series with the upper electrode 31 of the expulsion-type lightning arrester interrupting device 10 in a manner well known by those skilled in the art.

Surmounted upon an extension 32 of the upper electrode 31 of the lightning arrester interrupting device 10 is a post insulator 33 composed of a suitable material, such as porcelain. Cavities 34 are provided at the upper and lower ends of the post insulator 33, and by the use of mineral lead, or other suitable materials, are adapted to rigidly secure the extension 32 of upper electrode 31 in place as well as a stud portion, not shown, of the upper line terminal 12.

The upper cavity 34 of the post insulator 33 thus fixedly supports the high-voltage line terminal 12 in an insulated relation relative to the upper electrode 31 of lightning arrester interrupting device 10. As shown more clearly in FIG. 3, the high-voltage terminal 12 has an offstanding boss portion 35, which cooperates with the upper tip 36 of the gap strap 11 to form the external series gap 13 for the arrester.

From the foregoing it will be apparent that the lightning arrester generally designated by the reference numeral 80 and comprising interrupting device 10 and series gap 13 provided by insulator post 33, is supported by bracket means 8 from the casing 4 of transformer 1.

The present invention, as regards its broader aspects, is not limited to any particular type of fusible device 16. Particular advantage may be derived, however, by employing a fusible device 16, which is so arranged that upon blowing, the gases are expelled out both ends of the fuse casing 37 away from a lineman who may be attempting a refusing operation. As shown in FIG. 2, preferably the gases are directed in the direction of the arrows 38 out of both ends 40 of the fuse tube 37. Both ends of the fuse tube 37 are blown open by arc gases and such gases are ejected from both ends 40 of the fuse tube 37. The fusible element 41 may be secured to fuse cables 42, 43 in any well known manner, the ends of the fusible cables 42, 43, terminating in eyelets 44, 45, which are adaptable for hook-stick manipulation by a workman.

With reference to FIGS. 1 and 9, it will be observed that the high-voltage line L_1 is attached to the high-voltage terminal 12. The circuit then extends through the laterally extending fuse holder support arm 14, fusible device 16, relatively rigid fuse holder support arm 17, flexible cable 46, shield support bracket 23, cap nut 24, terminal stud 47, high-voltage winding 48, to a grounded terminal 50 disposed interiorly of the tank 4. The ends 51, 52 of the low-voltage secondary winding are connected to low-voltage terminals 53, 54, and a center tap connection 55 may be connected to an intervening grounded terminal 56. As well known by those skilled in the art, either 240 volts may be obtained across the low-voltage terminals 53, 54 or 120 volts may be obtained between the grounded terminal 56 and either low-voltage terminal 53 or 54. A ground terminal 57 preferably has a strap connection 58 to the low-voltage terminal 56. As indicated in FIG. 9, the high-voltage line L_1 is associated with the solidly grounded line L_2, which extends through the ground to the grounded terminal 50, as indicated. Thus energization of the high-voltage primary winding 48 from, say, a 13.2 kv. solidly grounded distribution system results in, for example, a secondary output voltage of either 120 volts or 240 volts. The foregoing voltage ratings are given only by way of example, and are not intended to constitute a limitation upon the present invention. It will be noted that the fusible device 16 and the lightning arrester 80 are dia-

grammatically associated with the high-voltage bushing 7 associated with the transformer 1.

With reference to FIGS. 4–8, it will be observed that the shield support bracket 23 has a hole 60 provided therein, through which extends the terminal stud 47. The cap nut 24 threaded upon the terminal stud 47 serves to fixedly support the bracket 23 in place at the upper end of high-voltage bushing 7. In addition, the hinge bracket 23 has slots 61 provided in leg portions 62 thereof, through which extends a hinge pin 63, as shown more clearly in FIGS. 4 and 5 of the drawings. Encircling the hinge pin 63 is an insulating guide sleeve 69 (FIG. 8) and a torsion spring 64, the ends 65, 66 of which respectively engage the underneath surface 67 of sleet hood 21 and the top surface of the base portion 68 of hinge bracket 23. The guide sleeve 59, as shown in FIG. 8, fixes the torsion spring 64 in a proper position. Also the tubing 59 insures proper operation of the hinged assembly. Although the guide tube 59 is formed of insulating material, it could be formed of metal. As will be obvious, the torsion spring 64 tends to bias the sleet hood 21 in a clockwise direction about the hinge pin 63. As illustrated in FIG. 6, the sleet hood 21 has side wall portions 70, each being provided with a pivot hole 71. The hinge pin 63 extends through the pivot holes 71, in the manner shown in FIGS. 4 and 5. The flexible cable 46 is brazed as at 72 to the relatively rigid support arm 17, which is made of a suitable conducting material, such as Phosphor bronze. The flexible lead 46 is also brazed, as at 73, to the base portion 68 of pivot bracket 23, as shown in FIG. 7.

Since the sleet hood 21 is preferably formed of an insulating material, the series current passing through the support arm 17 is unable to reach the pivot pin 63. Moreover, the flexible cable 46 ensures a direct passage of the series current from upper relatively rigid fuse-support arm 17, through flexible cable 46 directly to base portion 68 of pivot bracket 23, and hence directly to terminal stud 47. As a result, the hinge pin 63 and torsion spring 64 are not subjected to carrying current, with consequent heating, and hence having their characteristics changed. The series current completely bypasses the hinge pin 63 and torsion spring 64.

During normal operation of the transformer 1, that is, when no lightning surge exists, and no overload or fault current exists, the fusible device 16 remains intact and unblown, as illustrated in FIGS. 1, 2 and 4 of the drawings. Should a lightning surge occur, the lightning arrester 80 will function in its normal manner to carry the surge current directly to ground and to interrupt any power follow current. The aforesaid Patent 2,677,072, describes the interrupting operation of the expulsion-type lightning arrester 80. It is obvious, however, that any type of lightning arrester may be employed, not merely an expulsion-type lightning arrester, as illustrated by way of example.

Should, during the operation of the transformer 1, an overload or a fault-current condition exist, the series current will be so increased that rupture of the fusible element 41 will occur. This will eject the gases out of the open ends 40 of the fuse tube 37, as illustrated by the arrows 38 in FIG. 2. Assisting in the extinction of the arc drawn within fuse tube 37 is the clockwise rotative movement of relatively rigid support arm 17, as caused by the reaction of torsion spring 64. Thus, as illustrated in FIG. 5, the torsion spring 64 effects clockwise movement of sleet hood 21 and support arm 17 affixed thereto in the direction of arrow 19 to rapidly withdraw fuse cables 43 and 42 from the open ends 40 of fuse tube 37 and so facilitate arc extinction therein. Due to the rigidity of support arm 17, and the energy-absorbing friction stop, hereinafter described, there is no rebound of the arm 17, and, consequently, the current, which can be interrupted, is increased.

An important feature of the present invention is the ability of the protective equipment to interrupt much higher short-circuit currents than previous designs.

One reason for the increased arc interrupting ability is the rigid fuse support arm 17 and the hinge assembly 22, which incorporates an energy-absorbing friction stop, generally designated by the reference numeral 69. This friction stop 69 absorbs most of the kinetic energy of the moving portion of the assembly 22, thereby preventing the tip 17a of the fuse support arm 17 from reentering the area of hot conducting arc gases. Thus, no arc restrikes occur and the circuit is cleared. Prior-art designs are inadequate in this respect, and so fail at smaller amounts of current than the design of the present invention.

The principle of operation of the friction stop 69 is as follows: The moving hinge assembly 22 as it rotates clockwise brings the inside back surface of the sleet hood 21 against the lower right surfaces of the support arms 62. The pin 63 rides in the slots of the support arm 62 and is biased upward by the action of the unwound torsion spring 64. This makes the two surfaces described above rub tightly against each other during the last part of the opening travel, serving as a brake. Note FIG. 6 in this connection.

To effect a refusing operation, a lineman places the prong of the hook-stick in the eyelet 44 and positions the fuse cable 43 in the notch 18 of support arm 17. The lineman then pulls eyelet 44 in a single movement upward and away from the transformer 1 so that it engages the notch 15 provided in support arm 14. The horizontal mounting of the fusible device 16 directs the hot gases and parts, which are expelled from the fuse, outward and not downward toward the lineman, who might be on the pole below the transformer 1.

From the foregoing description of the invention, it will be apparent that there is provided a novel and simple mounting of the fusible device 16 and lightning arrester 80 relative to the transformer 1, eliminating many mounting parts customarily employed in the separate mounting of such protective devices. In addition, the sleet hood 21 protects the torsion spring 64 from the weather, and ensures a bypassing of the series current around the torsion spring 64. The post insulator 33 has three functions: (1) to provide the external series gap 13 to the lightning arrester interrupting device 10, (2) to support the line end of the fuse by the support arm 14, and (3) to provide a point for the mounting of the high-voltage terminal 12. The hinge 23 and the springs 64 are completely protected from overheating or welding or subsequent damage as the result of high currents. The insulating cap 21 insulates the hinge pin 63 from the high-voltage current, and the flexible cable 46 ensures a direct passage of the series current from the fuse support arm 17 down to the stud 47 disposed within the high-voltage bushing 7, bypassing the spring 64. The stored energy in the torsion spring 64 is always available to assist in melting of the fuse element 41 whenever an overload or fault occurs, and rapid separating motion is thereby achieved. The energy-absorbing stop 69 prevents rebound of the tip 17a of fuse support arm 17 back into the region of conducting gases, so arc restrikes cannot occur.

The combination of elements described hereinbefore results in the particular advantage of enabling factory assembly as original equipment. This results in considerable economy and precise adjustment. Also the described construction employs the hinged support arm 17 for attainment of maximum travel. The non-current carrying torsion spring 64 ensures reliable operation at all times. Moreover, the use of the torsion spring 64 and the relatively rigid arm 17 in conjunction with the energy-absorbing stop 69 minimizes the amount of support-arm rebound upon operation of the fusible device 16. The horizontal mounting of the fusible element 16 directs hot gases and expels parts outwardly and not

downwardly toward a lineman, who may be attempting a refusing operation.

Although there has been disclosed and described a specific structure, it is to be clearly understood that the same was merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art, without departing from the spirit and scope of the invention.

We claim as our invention:

1. A transformer having a grounded casing, a high-voltage terminal bushing extending out of said grounded transformer casing and carrying a line terminal at the outer end thereof, a rotatable fuse holder arm supported at the outer end of said high-voltage bushing, a bracket extending laterally of said grounded transformer casing and supporting upright a lightning arrester, a second line terminal supported by said lightning arrester, a fuse holder arm supported by said lightning arrester, a fusible device connected between said two fuse holder arms, means biasing said rotatable fuse holder arm, and a weather shield rotatable with said rotatable fuse holder arm to protect said biasing means from the weather.

2. A transformer having a grounded casing, a high-voltage terminal bushing extending out of said grounded transformer casing and carrying a line terminal at the outer end thereof, a rotatable fuse holder arm supported at the outer end of said high-voltage bushing, a bracket extending laterally of said grounded transformer casing and supporting uprightly a lightning arrester, a second line terminal supported by said lightning arrester, a fuse holder arm supported by said lightning arrester, a fusible device connected between said two fuse holder arms, means biasing said rotatable fuse holder arm, and an insulating weather shield rotatable with said rotatable fuse holder arm to protect said biasing means from the weather.

3. A fusible device including a relatively stationary support bracket having a hinge portion associated therewith, a rotatable assembly pivotally mounted to said hinge portion including a weather shield and a fuse support arm, an opening biasing spring at least partially enclosed by said weather shield and biasing said rotatable assembly in an opening direction around said hinge portion, a fuse link having a fuse-link cable, said fuse-link cable being tensioned by the outer free end of said fuse support arm, and energy-absorbing stop means including a frictional engagement between said rotatable assembly and said relatively stationary support bracket to prevent rebound of the outer free end of said fuse support arm back into the region of conducting gases during blowing of said fuse link.

4. A fusible device including a relatively stationary support bracket having a pair of spaced hinge portions associated therewith, a rotatable assembly pivotally mounted to said hinge portions including a weather shield and a fuse support arm, an opening biasing torsion spring at least partially enclosed by said weather shield and biasing said rotatable assembly in an opening direction around said hinge portion, a fuse link having a fuse-link cable, said fuse-link cable being tensioned by the outer free end of said fuse support arm, and energy-absorbing stop means including a frictional engagement between said rotatable assembly and said relatively stationary support bracket to prevent rebound of the outer free end of said fuse support arm back into the region of conducting gases during blowing of said fuse link.

5. The combination in protective equipment of a terminal bushing having a terminal stud extending therethrough, a relatively stationary support bracket secured to the end of said terminal stud, said support bracket having a hinge portion associated therewith, a rotatable assembly pivotally mounted to said hinge portion including a weather shield and a fuse support arm, an opening biasing spring at least partially enclosed by said weather shield and biasing said rotatable assembly in an opening direction around said hinge portion, a fuse link having a fuse-link cable, said fuse-link cable being tensioned by the outer free end of said fuse support arm, and energy-absorbing stop means including a frictional engagement between said rotatable assembly and said relatively stationary support bracket to prevent rebound of the outer free end of said fuse support arm back into the region of conducting gases during blowing of said fuse link.

6. A transformer including a grounded tank, a high-voltage terminal bushing extending out of said grounded tank and having a first line terminal at the outer end thereof, a lightning arrester including an upstanding interrupting device and series gap means, said series gap means including an insulating support mounted upon said lightning arrester interrupting device, said insulating support supporting a second line terminal and also a fuse holder arm, bracket means extending laterally from said grounded tank and supporting said interrupting device, a second rotatable fuse holder arm disposed at the outer end of said high-voltage terminal bushing, means biasing said second rotatable fuse holder arm, a rotatable weather shield secured to and movable with said second rotatable fuse-holder arm, and a fusible device maintained in tension between said first and second fuse holder arms.

7. In a transformer having a grounded casing and a cover which supports a high-voltage terminal bushing, said transformer having a lightning arrester mounted thereon and a rotatable hinge assembly supported by the outer end of said high-voltage terminal bushing, a fuse-holder arm carried by said rotatable hinge assembly, said transformer having a fusible device supported by the free end of said fuse-holder arm and said lightning arrester, the combination therewith of pivot means, spring means encircling said pivot means for biasing said rotatable hinge assembly, and an insulating weather shield secured to said fuse-holder arm and journaled upon said pivot means, whereby said insulating weather shield assists in protecting said spring means from the weather.

8. In a transformer having a grounded casing and a cover which supports a high-voltage terminal bushing, said transformer having a lightning arrester mounted thereon and a rotatable hinge assembly supported by the outer end of said high-voltage terminal bushing, a fuse-holder arm carried by said rotatable hinge assembly and positioned generally vertically, said transformer having a fusible device supported by the free end of said fuse-holder arm and said lightning arrester in a generally horizontal position, the combination therewith of a support bracket having apertured side flange portions, a pivot pin extending through the apertured side flange portions, a torsion spring surrounding said pivot pin, a delayed-action friction stop for preventing rebound of said fuse-holder arm and including frictional rotating portions of the rotatable hinge assembly bearing with frictional engagement upon said side flange portions only at the end of the opening travel of the fuse-holder arm, whereby initial fast opening movement of the fuse-holder arm is obtained with a subsequent energy-absorbing stop to prevent rebound of the ruptured fuse terminal into the ionized arcing region.

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