March 31, 1970 M. G. LEONARD 3,504,319

ELECTRICAL TRANSFORMER

Filed Oct. 25, 1968 2 Sheets-Sheet 1

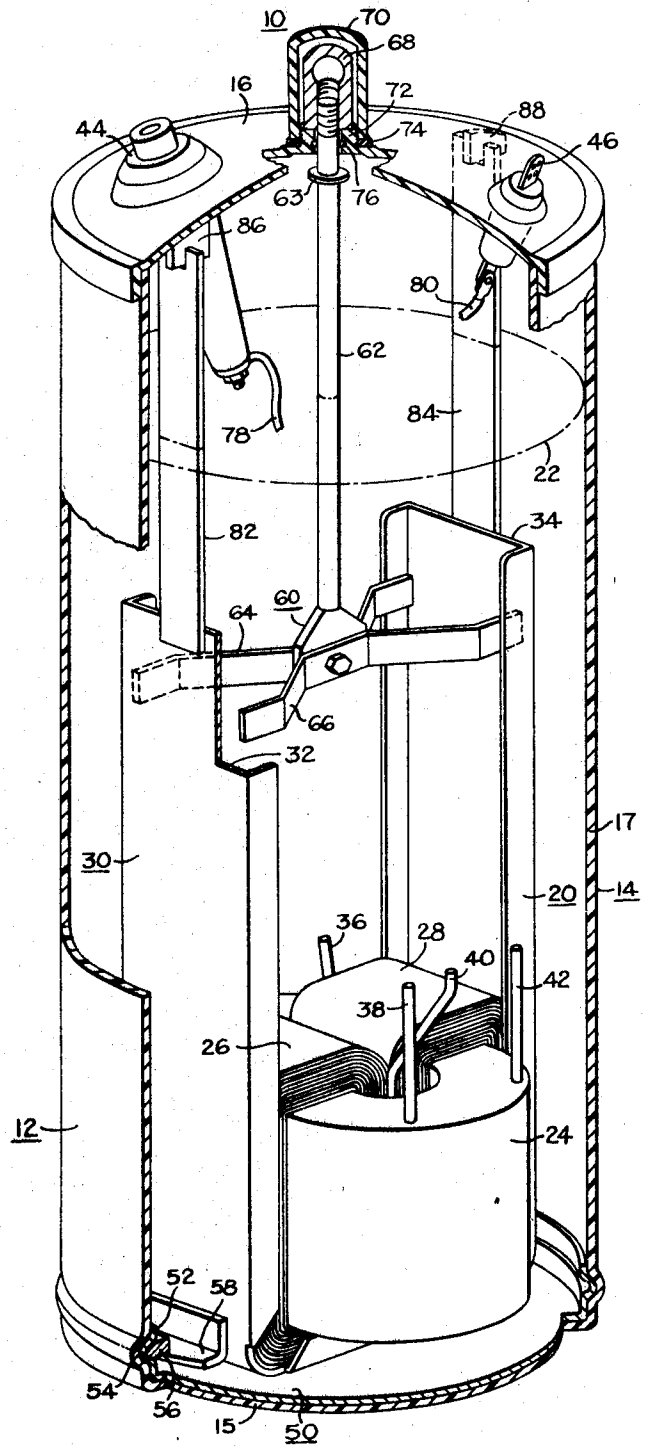


FIG. 1.

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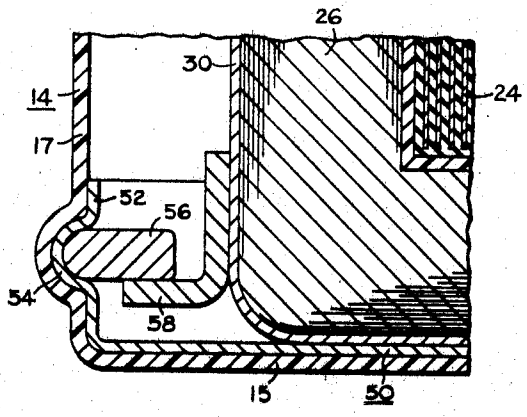


FIG. 2.

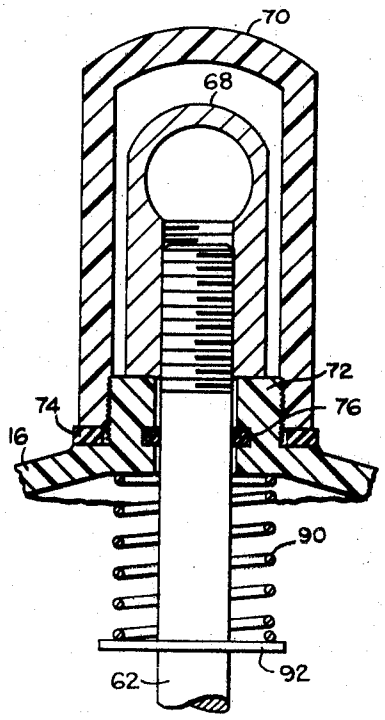
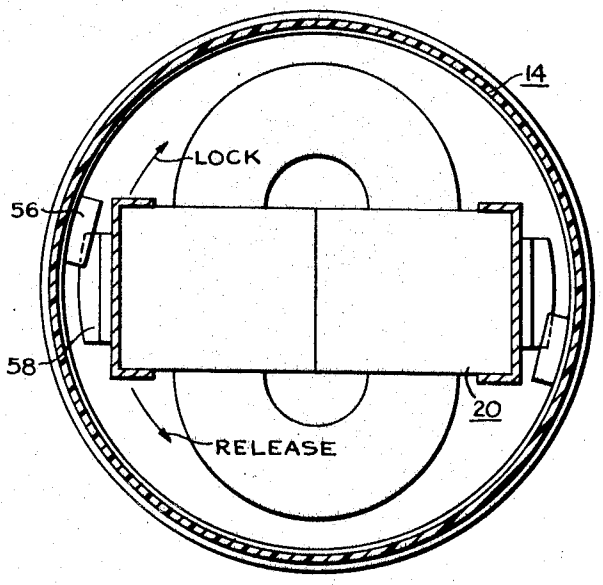


FIG. 5.

FIG. 3.



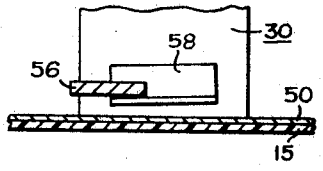


FIG. 4.

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ELECTRICAL TRANSFORMER

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U.S. Cl. 336—68 12 Claims

ABSTRACT OF THE DISCLOSURE

An electrical transformer having a magnetic core-winding assembly disposed within a non-metallic casing, which includes a tank and cover. The bottom portion of the tank includes a metallic liner which reinforces the tank, and which also secures the magnetic core-winding assembly within the tank. Lifting means is mechanically connected to the magnetic core-winding assembly, which extends through a seal in the cover. The seal allows relative motion between the lifting means and the cover, enabling the transformer to be lifted without creating stress concentrations in the casing.

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates in general to electrical transformers, and more particularly to submersible transformers adapted for use in underground electrical distribution systems.

Description of the prior art

Transformers used in underground electrical distribution systems are often subjected to an extremely corrosive environment. The vaults in which the transformers are mounted may be very damp, and they are often completely or partially flooded. The transformer may be at least partially submerged in water for extensive periods of time. The environment surrounding a transformer in an underground electrical distribution system may be so corrosive that even the stainless steels are subject to attack. Even if such steel could be made absolutely corrosion proof against all corrosive chemicals found in soil-water, it would still have the disadvantage of higher cost.

Efforts to solve the corrosion problem through organic or plastic coatings disposed on the steel transformer tanks have not been successful, as the coating must be applied without flaws, and the coated transformer must be shipped and installed without experiencing a single chip or scratch in the coating. Constructing the entire transformer casing of plastic has also many disadvantages, as the plastic bottom of the tank is subjected to abuse during shipping and installing, which may bend the bottom inwardly, or flex the corner at the edge between the bottom and side wall, causing the plastic to crack. Further, the manufacturing and handling of the transformer is complicated by the problem of securing the magnetic core-winding assembly to the plastic tank, and by the fact that the plastic tank may be unduly stressed while the transformer is being lifted.

SUMMARY OF THE INVENTION

Briefly, the present invention is a new and improved sealed, submersible transformer, having a tank and cover formed of plastic, providing a completely non-corrosive external surface. A metallic plate member, preferably steel, is permanently attached to the inside bottom of the tank, which provides the function of reinforcing the tank where it receives the most abuse, and it provides means for securing the magnetic core-winding-assembly within the tank. Lifting means is provided for lifting the transformer without creating stress concentrations in the tank or cover, which includes a shaft disposed through the cover which is secured to the end frame which maintains the integrity of the magnetic-winding assembly. The shaft has a lifting "eye" at its upper end, and means is provided to seal the entry of the shaft through the cover, without restricting relative movement between the shaft and cover. Thus, the transformer may be lifted without unduly stressing the cover or tank.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages of the invention will become more apparent when considered in view of the following detailed description and drawings, in which:

FIGURE 1 is a perspective view, partially cut away, of a transformer constructed according to the teachings of the invention;

FIG. 2 is a fragmentary view, partially in section, of new and improved locking means for securing a magnetic core-winding assembly within a plastic tank;

FIG. 3 is a functional plan view of the transformer shown in FIG. 1, illustrating the locking means shown in FIG. 2;

FIG. 4 is a fragmentary elevational view of the transformer shown in FIG. 1, without the tank, which also illustrates the locking means shown in FIG. 2; and

FIG. 5 is a fragmentary view, partially in section, of a cover and lifting shaft seal arrangement constructed according to an embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, and FIG. 1 in particular, there is shown a perspective view, partially cut away, of a new and improved submersible transformer **10**, constructed according to the teachings of the invention. Transformer **10** includes a sealed casing **12** having a tank **14** and a cover **16**. The tank **14** includes a bottom portion **15** and connecting side wall portion **17**. The tank **14** and cover **16** are formed of non-metallic material, such as a reinforced glass polyester resin, or a filament wound glass fiber impregnated with a resin such as an epoxy resin. The resins may be filled or unfilled, as desired. For example, it may be desirable to fill the resin of which the cover **16** is molded with non-tracking means, such as finely divided hydrated alumina. This would allow the electrical insulating bushings disposed through the cover to be reduced in size, as the insulation obtained in the cover would have substantially the same dielectric strength as the bushings. The casing **12**, being formed of a non-metallic material, resists corrosion, and thus may be disposed in subterranean vaults and connected in underground electrical distribution systems, without regard to the corrosive conditions inherent in these applications.

The magnetic core-winding assembly **20** is disposed within the tank **14**, and tank **14** is filled to a predetermined level **22** with a liquid dielectric, such as oil. The magnetic core-winding assembly includes high and low voltage windings, shown generally at **24**, which are disposed in inductive relation with magnetic core members **26** and **28**. The integrity of the magnetic core members **26** and **28**, and their associated electrical winding assembly **24**, is maintained by a metallic end frame structure **30**, which wraps tightly around the magnetic core members **26** and **28**, and which includes upwardly extending portions **32** and **34**, which form a superstructure for mounting associated apparatus, such as a tap changer, a block mounted high voltage fuse, and a secondary breaker. These accessories are not shown, in order to more clearly illustrate the teachings of the invention.

The winding assembly **24** includes high and low voltage leads, such as high voltage lead **36** and low voltage leads

38, 40 and 42, which are connected to suitable high and low voltage insulating bushings, either directly via suitable electrical conductors, or through the accessories utilized by a specific application, such as the hereinbefore mentioned tap changer, fusible link, and circuit breaker. A single high voltage bushing 44 and a single low voltage bushing 46 are shown in FIG. 1, in order to simplify the drawing. As illustrated in FIG. 1, cover mounting of the electrical bushings is preferred since the external connections to the bushings are more accessible when the transformer is disposed in an underground vault, and cover mounting also facilitates the making of the connections from the bushings to the electrical apparatus, as will be hereinafter explained.

The bottom portion 15 of the tank 14 is reinforced with a metallic liner 50, which is fixed to the tank 14 in intimate contact with the plastic bottom 15, and which includes an annular upwardly extending portion 52 which reinforces the junction of the side wall portion 17 of the tank 14 with the tank bottom 15. The upwardly extending portion 52 may include a circumferential projection or bead 54, which, when the tank 14 is molded about the metallic liner 50 will secure the liner firmly within the tank. The liner 50, however, may be secured in the desired position by other suitable arrangements. For example, portion 52 may have straight sides, and it may be secured in the desired position by molding an inwardly extending circumferential projection on the inner surface of the tank wall, disposed immediately adjacent the upwardly extending edge of portion 52.

While the tank wall 17 and the tank bottom 15 are shown as being a continuous integral structure, it will be understood that the tank bottom 15, along with a short section of the tank side wall, may be molded separately, about the liner 50, and the remaining portion of the side wall may be formed while overlapping and joining the portion of the side wall formed by the molded bottom; or, the remaining portion of the side wall may be a separate tubular structure which is joined to the tank bottom with an oil resistant adhesive.

The metallic liner 50 backs up the plastic tank 14 where it will receive the most abuse during manufacturing, shipping and installation. The metallic liner 50 also serves the function of anchoring the magnetic core-winding assembly 20 within the tank 14. For example, by forming the liner 50 of steel, brackets or locking lugs, such as lug 56, may be welded to the liner, prior to the step of applying the liner to the plastic bottom 15. The lug 56, may be located in the depression in the upwardly extending portion 52, which is inherently formed when the circumferential projection or bead 54 is formed. The lug 56 extends inwardly from the inner tank wall and is circumferentially spaced from a similarly disposed lug, such that they cooperate with locking projections connected to opposite sides of the end frame 30, such as locking projection 58. The locking projections 58 may be welded, or otherwise suitably attached to the end frame structure 30.

FIG. 2 is an enlarged fragmentary view illustrating the above described arrangement for securing the magnetic core-winding assembly 20 within the tank 14, and FIGS. 3 and 4 are plan and elevational views, respectively, of this arrangement. The magnetic core-winding assembly 20 is placed in the tank 14 with a predetermined orientation, such that its locking projections 58 are circumferentially spaced from the locking lugs or projections 56 secured to the metallic liner 50. Then, by rotating the magnetic core-winding assembly 90° the projections 58 will slide under the projections 56, which is best illustrated in FIG. 3. The projections 58 may be inclined slightly from the horizontal, such that upon rotating the magnetic core-winding assembly 20, the projections 58 will easily slide under the projecting lugs 56, but which will become wedged tightly against the lugs after further rotational movement, to provide the desired locking cooperation between them. This wedging action by inclining projection 58 is shown in FIG. 4. Or, instead of welding separate discrete lugs to the metallic liner 50, the metallic liner 50 may be formed such that it has two oppositely spaced inward projections, which are integral with the upwardly extending portion 52. These inward projections of the metallic liner 50 may be inclined slightly from the horizontal, or the projection 58 may be tilted as hereinbefore described. These integral projections thus serve the same purpose as the discrete lugs 56.

Transformer 10 includes lifting means 60, which provides the function of enabling the transformer 10 to be lifted without unduly stressing the tank 14 or the cover 16. Lifting means 60 includes a shaft member 62 which has one end mechanically connected to the upward extensions 32 and 34 of the end frame structure 30, via structural members 64 and 66, and which proceeds through an opening in the cover 16, terminating in a lifting eye 68. Thus, the major portion of the weight is carried by shaft member 62. The remaining portion of the weight is carried by the lead 54, which distributes this weight uniformly about the circumference of the tank. Structural members 64 and 66 may be bent to form a spider-like arrangement, the ends of which are welded to the upstanding extensions 32 and 34 of the end frame structure 30, and which extend inwardly to form a centralized location for attaching the shaft member 62 to the structural members 64 and 66.

Since the lifting eye 68 and shaft member 62 may be metallic, they should be protected from the corrosive subterranean environment by a non-metallic cap member 70, which forms a sealed enclosure about the lifting eye 70. For example, the cover 16 may have a threaded projection 72 which surrounds the opening for shaft member 62, with a gasket member 74 being disposed about the projection 72. The inside of the cap member 70 is threaded, such that it will threadedly engage the projection 72 and compress the gasket member 74 to provide the desired seal. If the shaft member 62 and lifting lug 68 are formed of non-metallic materials, or non-corrosive metals, the cap member 70 may be eliminated.

In addition to sealing the cap member 70, the opening in the cover 16 through which the shaft member 62 passes, should also be sealed. This cover seal, however, should not restrict the movement of the shaft member 62 relative to the cover 16, such as movements caused by mechanical load during lifting, or due to thermal changes, in order to prevent stressing the cover 16 and the tank 14. A "floating" seal is formed, according to the teachings of the invention, by providing a groove in the portion of the cover 16 which defines the opening for receiving the shaft member 62. An O-ring 76 is disposed in the groove, which is sized to be compressed slightly by the shaft 62 and provide a shaft seal without restricting axial movement of the shaft relative to the cover 16.

The cover 16 may be disposed on shaft 62 before the magnetic core-winding assembly 20 is disposed in the casing. Thus, the electrical leads from the electrical bushings, such as leads 78 and 80, may be easily connected to the electrical windings, via any desired accessories. The magnetic core-winding assembly 20 may then be placed in the tank 14, before the liquid dielectric is disposed therein, which enables the locking projections on the magnetic core end frame structure 30 to be properly oriented to the locking lugs 56 which project outwardly from the tank liner 50. The magnetic core-winding assembly may then be lifted slightly, to enable a hose to add the liquid dielectric to the tank 14. An adhesive may then be applied to the tank and cover portions which will overlap when the cover is in assembled relation with the tank, and the magnetic core-winding assembly along with the cover, may be lowered until the magnetic core-winding assembly is resting on the metallic insert 50. Then, the magnetic core-winding assembly may be rotated, while holding the tank 14, to engage the locking projections, as hereinbefore described, to firmly se-

cure the magnetic core-winding assembly within the tank **14**. To aid in rotating the magnetic core-winding assembly, upstanding members **82** and **84** may be welded, or otherwise suitably fastened to the upper extension **32** and **34**, respectively, of the end frame structure **30**, which have slots formed therein which cooperate with depending projections **86** and **88**, respectively, on the cover **16**. Thus, by rotating the cover **16**, the upstanding members **82** and **84** are engaged by the depending projections **86** and **88**, which rotate the magnetic core-winding assembly into its locked operating position, and the cover will maintain the proper orientation with respect to the magnetic core-winding assembly **20**. Another method of rotating the magnetic core-winding assembly **20** to lock it in the tank, would be to grip the outer end of shaft **62** with a suitable tool, and turn the shaft. The projections on the cover would not be required in this instance.

In order to prevent the cover **16** from sliding down the shaft **62** while the electrical leads from the bushings are being connected, it may be supported on the shaft **62** with a fixed stop **63**, as shown in FIG. 1. Or, a stop may be provided which enables the position of the cover to be adjusted during assembly, by utilizing a resilient stop and constructing the lifting eye such that it serves as an adjustment nut. An embodiment of the invention including an adjustable cover is shown in FIG. 5, which is an enlarged fragmentary view of the cover **16** and shaft **62** of transformer **10** shown in FIG. 1, modified to remove the fixed stop **63** and to include an adjustable support for the cover **16**.

Specifically, resilient means such as a coil spring **90**, is disposed about the shaft member **62**, against a member **92** which is fixed to the shaft **62** and which serves as a stop for the spring **90**. In assembling the transformer **10**, the cover **16** is disposed on the shaft **62** with the upper end of the spring **90** being in contact with the cover and supporting it. The lifting eye **68** is then threaded part way on the shaft, and the leads from the bushings may then be connected to the apparatus without interference from the cover. The whole assembly may then be lowered into the tank **14**, and the adjustment nut **68** advanced until the cover is properly seated on the tank. The whole assembly may then be lifted slightly just enough to allow entry of the oil filling hose. After the liquid dielectric has been added to the tank, adhesive means is applied to the areas of the cover and tank which will overlap, and the assembly may then be lowered, with the cover again being in its properly engaged position on the tank. The inside assembly may then be turned 90° by turning the cover to engage the locking projections, or by turning the shaft, as hereinbefore described, and the adhesive is allowed to cure, which completes the transformer.

In summary, there has been disclosed a new and improved submersible transformer which has no exposed metallic parts subject to corrosion, with all of the exposed surfaces of the transformer being formed of a high strength plastic, such as reinforced polyester or epoxy resins. Further, the disadvantages of plastic tanks has been removed, by internally reinforcing a plastic tank with metallic members which back-up the plastic tank at locations subject to impart or puncture loads, relieve the plastic tank of high stress concentrations when the transformer is lifted, receive both the plastic tank ond metallic inner assembly of stresses caused by differential expansion, and which limits the region of relative movement of metal and plastic to a single sealed projection, which may be protected and doubly sealed by a plastic cap.

The plastic configurations of the tank and cover are easily fabricated, and the absence of stress concentrations into the cover and tank allows fairly thin wall sections to be utilized, such as ⅛ of an inch. Thus, the casing for the transformer may be easily constructed with production line techniques, providing a low cost submersible transformer which is completely corrosion resistant. Further, the plastic cover enables smaller insulating bushings to be utilized, since they do not have to be sized to prevent flashover to the cover.

Since numerous changes may be made in the above described apparatus and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative, and not in a limiting sense.

I claim as my invention:

1. A transformer comprising:

a casing, including a non-metallic tank having side wall and bottom portions, and a non-metallic cover for said tank,

metallic reinforcing means disposed within and fixed to said tank, said reinforcing means having the first portion disposed to reinforce the bottom portion of said tank, and a second portion which includes locking means,

a magnetic core-winding assembly disposed within said tank, said magnetic core-winding assembly including locking means disposed to cooperate with the locking means of said reinforcing means, in response to relative rotational motion between them, to secure said magnetic core-winding assembly within said tank,

lifting means for lifting said transformer without creating stress concentrations in said casing, said lifting means being connected to said magnetic core-winding assembly, and including a shaft member which extends outside said casing through an opening therein.

means providing a seal between said shaft and casing which allows relative motion between them, without stressing the casing,

and bushing means disposed through sealed openings in said casing, having electrical conductors connected to the windings of said magnetic core winding assembly.

2. The transformer of claim **1** wherein the first portion of the metallic reinforcing means is in contact with the bottom portion of the tank and substantially coextensive therewith, and the second portion includes an upstanding tubular projection which extends from the first portion, in contact with the side wall portion of the tank, with the locking means associated with the second portion including projections which extend inwardly from the tubular projection.

3. The transformer of claim **2** wherein the locking projections associated with the second portion of the reinforcing means are welded to the tubular projection.

4. The transformer of claim **2** wherein the inwardly extending locking projections are an integral portion of the tubular projection.

5. The transformer of claim **1** wherein the cover has depending projections which extend inwardly therefrom within the casing, and the end frames have upstanding projections which cooperate with said depending projections, to enable the magnetic core-winding assembly to be rotated by rotating the cover, when locking and unlocking the magnetic core-winding assembly in the tank.

6. The transformer of claim **1** wherein the shaft portion of the lifting means extends through the cover of the casing, with the end of the shaft external to the casing being threaded, and including resilient means disposed within the casing which urges the cover towards the threaded end of the shaft, and an adjustment nut disposed on the threaded end of the shaft which overcomes the urging of said resilient means to position the cover at a predetermined location.

7. The transformer of claim **6** wherein the adjustment nut includes a portion having an opening therein, adapted to cooperate with external means for lifting the transformer.

8. The transformer of claim 6 including a non-metallic housing disposed over the adjustment nut, means securing the non-metallic housing to the cover, and gasket means disposed to provide a seal between the housing and the cover.

9. The transformer of claim 1 including liquid dielectric means disposed within the tank, to a predetermined level.

10. The transformer of claim 1 wherein the cover is secured to the tank with adhesive means.

11. The transformer of claim 1 including an end frame which maintains the integrity of the magnetic core-winding assembly, and the locking means associated with the magnetic core-winding assembly is fixed to said end frame.

12. The transformer of claim 1 wherein the locking means associated with the second portion of the reinforcing means, and the locking means associated with the magnetic core-winding assembly, each include projections which cooperate to secure the magnetic core-winding assembly in the casing, upon relative rotational motion between them.

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U.S. Cl. X.R.

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