Sept. 12, 1950 E. G. CAMERON ET AL 2,521,687

ELECTROFORMING APPARATUS

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Fig. 1

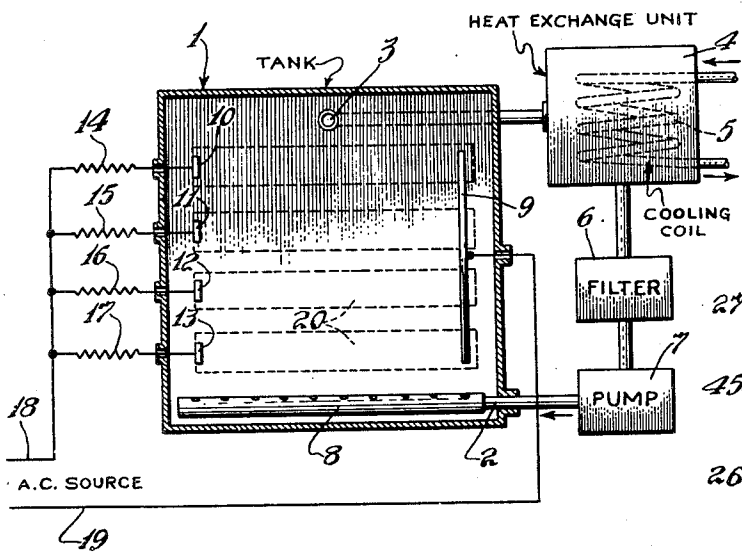


Fig. 4

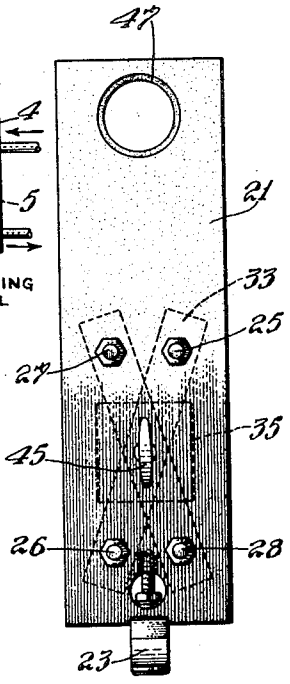
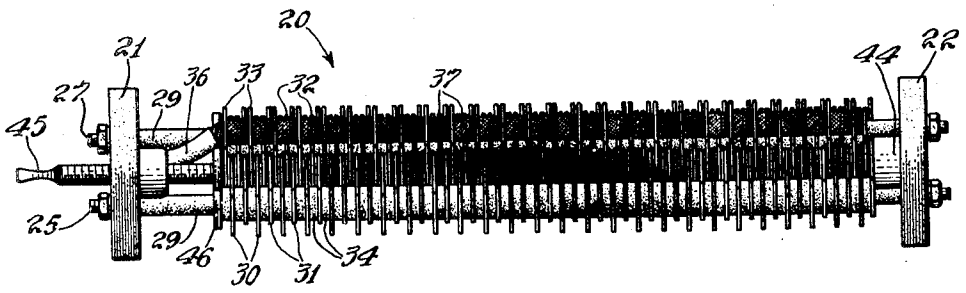


Fig. 2



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Fig. 3

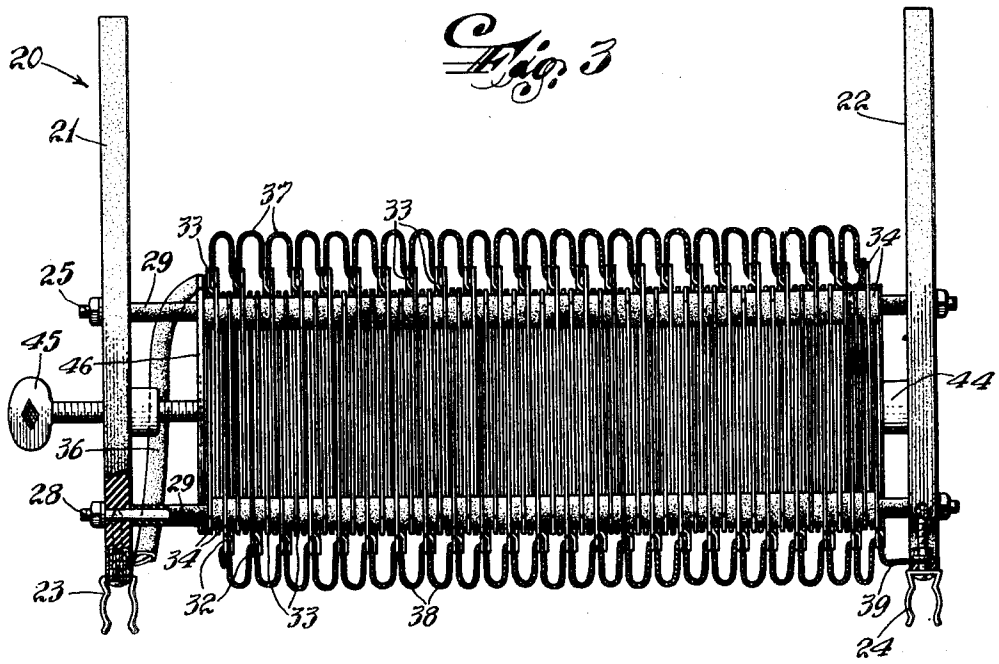


Fig. 5

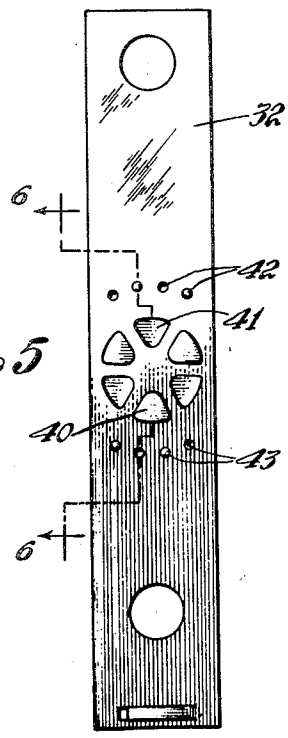
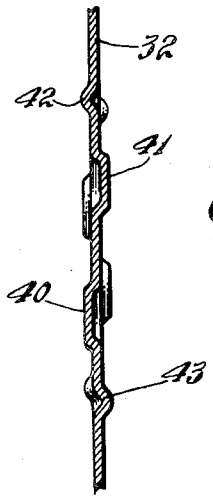


Fig. 6



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Patented Sept. 12, 1950 2,521,687

UNITED STATES PATENT OFFICE

2,521,687

ELECTROFORMING APPARATUS

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Application July 23, 1947, Serial No. 762,974

7 Claims. (Cl. 175—366)

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This invention relates to the art of electroforming electrical elements such as rectifiers and photocells of the plate type and more particularly to apparatus to facilitate the electroforming operation.

The invention has particular application to the electroforming of dry-plate or metallic rectifiers, such as selenium rectifiers, customarily composed of electrode plates of steel or aluminum, which may or may not be plated with nickel or the like, to which is adherently applied a coating of semi-conductive material, such as selenium, and over which is applied a counterelectrode of a suitable alloy, such as Woods metal. Such rectifier elements are commonly electroformed before used, so as to be operable with maximum efficiency, by applying to them a voltage to send the current through the rectifier element in the direction opposite to the direction of normal forward current flow. By application of the voltage in the relation referred to, rectifying properties are produced which are believed due to the formation of a "barrier layer" at the selenium surface underlying the counterelectrode layer.

One of the objects of this invention is to provide apparatus for electroforming a plurality of rectifier elements in a cooling medium, such as oil for example.

Another object of the invention is to provide a device in which a plurality of rectifier elements may be quickly assembled for support during the electroforming operation and which can be quickly removed therefrom when the electroforming operation has been completed.

In accordance with one feature of the invention, a tank is provided with electrical terminals to which devices supporting one or more rectifier elements may be connected for submersion in a cooling medium such as oil contained in the tank. Associated with the tank is a heat exchange unit, a filter and a pump, whereby the medium may be circulated for cleaning and temperature control. Also associated with the tank in connection with certain of the electrical terminals are ballast resistors having a characteristic such that, as the resistance of the rectifier elements increases during electroforming, the resistance of the ballast decreases proportionally. This provides for automatic voltage regulation during electroforming.

A further feature of the invention is the construction of the device which supports rectifier elements for submersion in the cooling medium. The device includes a plurality of conductor strips arranged in overlapping relation between which

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rectifier elements may be easily and quickly positioned, the device being provided with means for clamping the rectifier elements thus positioned between the strips. Alternate strips are preferably connected in circuit whereby the rectifier elements may be disposed in pairs in opposite direction such as "back-to-back" for application of alternating current.

Another feature of the invention is the shaping of the conductor strips with areas projecting from the plane thereof for engagement with the rectifier elements, whereby spaces are provided between each strip and the adjacent rectifier for circulation of the cooling medium. In addition to the circulating feature, the strips act not only as spacer elements but as additional heat conducting fins for the rectifiers.

The above and other objects and features of the invention will be more fully understood by reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatical view in plan of apparatus according to this invention;

Fig. 2 is a plan view of one of the devices for supporting a plurality of rectifier elements;

Fig. 3 is a view in side elevation of the device shown in Fig. 2;

Fig. 4 is a view in end elevation of the device;

Fig. 5 is a plan view of one of the connector strips of the device; and

Fig. 6 is a view in section taken along lines 6—6 of Fig. 5.

Referring to Fig. 1 of the drawings, the apparatus there shown comprises a tank 1 provided with an input connection 2 and an output connection 3 for the circulation of a cooling medium of insulating quality, such for example as transformer oil. The outlet connection 3 delivers the oil to a heat exchange unit 4 for temperature control and the dissipation of heat generated by the rectifier elements during the electroforming operation. The unit 4 is provided with a cooling coil 5 through which a cooling fluid, such as water, is circulated. The oil is passed from the heat exchange unit 4 through a filter 6 to remove foreign particles and is then delivered by pump 7 through inlet connection 2 to a distributor pipe 8.

The tank is further provided with a terminal 9 at the bottom of the tank at one side thereof and a series of small terminals 10, 11, 12 and 13 at the opposite side of the tank. Terminals 10 to 13 are connected to ballast resistors 14, 15, 16 and 17, respectively and thence to one side 18 of a source of alternating current, the other

side 19 of which is connected to the terminal 9. Connected across the terminal 9 and each of the series of terminals 10 to 13 are rectifier supporting devices 20, as indicated in broken lines in Fig. 1. By supporting a large number of rectifier elements in each device and providing a number of such devices submerged in the tank, it is possible to electroform a large number of rectifier elements simultaneously.

In Figs. 2, 3 and 4, one of the rectifier supporting devices is shown in detail. The device comprises two end plates 21 and 22 which are provided with spring clamps 23 and 24 at the lower ends thereof for clamping engagement, respectively, with terminal 9 and one of the terminals 10 to 13. The two end plates are connected together by two pairs of tie rods 25, 26 and 27, 28, the tie rods being arranged at the corners of a rectangle with each pair comprising the tie rods disposed at the corners cross-wise of the rectangle, each tie rod being provided with an insulating sleeve 29. Supported on the insulated sleeves of each pair of tie rods 25, 26 are two groups of conductor strips 30 and 31, the strips of the two groups being arranged alternately as shown in Fig. 2. Two groups of conductor strips 32 and 33 are similarly supported on the insulating sleeves of rods 27 and 28. The strips on each rod are separated by insulating washers 34. The strips on one pair of tie rods are alternated with the strips on the other pair of tie rods in criss-cross relation, as indicated in Fig. 4. This criss-cross relationship is particularly desirable since it facilitates greatly the assembling of rectifier elements between adjacent strips. The rectifier elements are placed one between each adjacent pair of strips in a location such as indicated in broken lines 35, Fig. 4, the rectifier elements being disposed in pairs and "back-to-back" for application of alternating current.

The electrical circuit is connected only to the strips on one of the pairs of tie rods. For example, the electric circuit is connected by lead 36 from the spring clamp 23 to the first strip 33, as viewed in Fig. 3. All of the strips 33 are connected together by flexible conductor cable 37. The strips 32 are similarly connected together by a flexible cable 38 adjacent the opposite tie rod 28, the strips 32 being connected by lead 39 to the spring clamp 24. It will be observed that disposed between the strips 32 and 33 is a strip 30 or 31, as the case may be. The strips 30 and 31 may be regarded as neutral, the rectifiers being interposed between a live strip 32 or 33 and one of the neutral strips 30 or 31 so that the current passing through the rectifiers passes from one of the live strips through a rectifier to a neutral strip and then from a neutral strip through the next rectifier to the live strip on the other side of the circuit. While the rectifier may be positioned so as to face a given direction for application of direct current, we prefer to place the rectifiers so that they face in opposite directions for application of alternating current.

While the strips 30, 31, 32 and 33 may be different, that is certain of them may be plane and others provided with projections, we prefer to make them identical. Each strip, for example, is especially formed so as to provide projecting areas from the plane of the strip for contact with the adjacent rectifier element. The projections are disposed in three groups, the center group of projections 40, 41 are trapezoidal in shape and are pressed alternately in opposite directions with respect to the plane of the strip, as shown in Figs. 5 and 6. The second and third groups are in the form of detents 42 and 43 located above and below the center projections 40, 41, alternate detents being disposed in opposite directions as indicated in Fig. 6. The projections 40, 41 provide for both heat and electrical conduction and also furnish spaces between the strip and the adjacent rectifiers for the circulation of the cooling liquid. The detents 42 and 43 assist in the proper positioning of the rectifiers, the detents being slightly lower than the projections 40 and 41.

The end plate 22 is provided with an abutment 44 while end plate 21 is provided with a thumb screw 45 in alignment with the abutment, so that when screw 45 is adjusted to engage an end plate 46 carried on tie rods 25 and 26 the conductor strips and the rectifier elements disposed therebetween may be clamped together. The device 20 when loaded with rectifier elements between the conductor strips and clamped so that they cannot be dislodged, is ready for the electroforming tank. The end plates are provided with handles or openings 47 for easy manipulation, the operator being thereby able to immerse the main portion of the device including the conductor strips in the oil bath with the conductor clamps 23 and 24 engaging terminal 9 and one of the individual terminals, such as terminal 10. Thus submerged, the electroforming operation may proceed, the ballast resistor 14 connected in series therewith providing a relatively high resistance during the initial period of the electroforming operation. As the electroforming proceeds thereby developing in the rectifier a high resistance to reverse current flow, thus reducing the current in ballast 14, the resistance of the ballast 14 in turn decreases thereby producing an increase in the voltage across the rectifiers. A suitable ballast for this purpose may comprise one or more incandescent lamps, the resistance of which decreases with decrease in current.

When the rectifiers have been sufficiently electroformed, the device 20 may be lifted from the tank. By retracting the thumb screw 45, the clamping pressure on the rectifiers and conductor strips is released, and the rectifier elements may then be easily dislodged. Before the rectifiers are removed from the device any indication of shorts may be checked by applying the terminals of a meter across adjacent strips, that is, a live strip such as strips 32 and 33 and a neutral strip such as 30 and 31. The rectifiers may be similarly graded while they are in the device 20.

While one embodiment of the invention has been disclosed, it will be clear to those skilled in the art that many variations and modifications of the tank arrangement and the rectifier supporting device 20 are possible without departing from the invention. For example, the electrical terminals for the tank may be differently arranged and a different electrical connection may be provided for the device 20. Also, the arrangement and shape of the conductor strips and the projections thereon may be considerably varied without departing from the intended purpose thereof. It is to be understood, therefore, that the present disclosure is to be regarded as illustrative of the invention only and not as a limitation of the scope thereof.

We claim:

1. An apparatus for electroforming rectifiers comprising a tank of insulating liquid, spaced electric terminals in said tank, and a device to support rectifier elements for immersion in said

tank, said device comprising a pair of end plates, tie rods connecting said end plates, a plurality of conductor strips carried by said tie rods, means to apply clamping pressure to said strips to clamp rectifier elements therebetween, a pair of connectors carried by said end plates for connection with said terminals, and means connecting one of said connectors to certain of said strips and the other connector to certain other of said strips.

2. Apparatus according to claim 1, wherein each of said strips has areas projecting outwardly from the plane of the strip for engagement with rectifier elements disposed between adjacent strips whereby spaces are provided between said strips and the rectifier elements for circulation of said liquid.

3. Apparatus according to claim 1, further including a liquid cooling chamber, a filter and means for causing circulation of said insulating liquid through said tank, said chamber and said filter.

4. Apparatus according to claim 1, further including a plurality of such devices to support rectifier elements for immersion in said tank, each such device having one individual terminal and a ballast connected thereto, said ballast having the characteristic as the resistance of the rectifier elements increases the resistance of the ballast decreases.

5. In apparatus for electroforming selenium rectifier elements, a support for a plurality of said elements comprising a plurality of parallel rods, a plurality of sets of conductor strips extending transversely from respective ones of said rods, the strips of different sets being interleaved with one another, whereby a plurality of rectifier elements may be inserted between respective pairs of said strips so that each element is in contact with two strips belonging to different sets, a source of current, conductor means connecting the strips of certain of said sets in parallel to said source, and circuit means including said source, said conductor means and said strips for passing a forming current through the elements thus inserted.

6. In apparatus for electroforming selenium rectifier elements, a support according to claim 5, further comprising clamping means for clamping said strips and rectifier elements together after said elements have been inserted.

7. In apparatus for electroforming selenium rectifier elements, a support according to claim 6 comprising a pair of end plates secured to said rods at opposite ends thereof, said clamping means comprising a movable plate slidably mounted on said rods between one of said end plates and the nearest strip, and screw means for displacing said movable plate relative to said one end plate.

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