The present invention relates to a variable load bank for heavy electric currents. It is particularly designed for absorbing large amounts of electrical energy and dissipating it in the form of heat conducted to water. The device is highly useful for testing generating equipment and for analogous purposes where heavy electric currents are generated at substantial voltages and where the power output must be consumed immediately to afford the appropriate test conditions.

According to the present invention, it is possible to dissipate very large amounts of electric power with relatively small apparatus. The arrangement is such that the resistance of the resistor elements may be varied to absorb as much power as the user may wish to put into the load bank.

In the prior art, variable load banks have been built up of incandescent and other types of lights, as well as by use of heaters or heater elements of various types, to take care of the dissipation of very large amounts of electric power. Such devices usually become very large, bulky and expensive. By contrast, the present invention can take up a comparable load of electric power and dissipate it in a relatively very small unit. It conducts the heat dissipated from a resistor to a liquid, e.g. by the use of water or other appropriate cooling liquid.

In general terms, a stream of water is contacted with resistor elements. The water also is propelled at high velocity along and around each of the resistance elements while the current is flowing. This is done in such a manner as to strip off any gas or vapor bubbles on the resistor. It serves also to prevent the formation of steam which otherwise would prevent good wetting contact between the resistance element and the liquid, e.g. water. Failure to wet or interfere with liquid contact of course would permit the resistance element to overheat.

The preferred resistance elements are wire resistors of variable effective length which are highly resistant to corrosion, even in the presence of water at high temperatures. Preferably Nichrome is used, although other materials may be substituted. The arrangement is such that the effective length of the wire resistors, as well as their number, may be varied at will so that currents of 150 to as much as 600 amperes or more (usually direct current) may be controlled safely at voltages such as are commonly used in large-scale electric welding operations. For example, potentials of 25 to 40 volts, with currents of 150 to 600 amperes or more, can be dissipated so the apparatus can consume as much as 25 kw. This requires only a relatively small device when made according to the present invention.

Automatic motor-driven means are preferably included in the apparatus to vary the resistance as desired. Preferably this is done by incorporating a reversible motor-driven adjusting device which changes the effective length of the resistance wire or wires which are used as the resistance elements. This arrangement makes possible a step-free variation in resistance so that any desired load value may be obtained. Furthermore, it avoids the highly objectionable make and break of current flow which is commonly encountered in variable load banks as additional devices are shifted into the circuit or taken out of circuit. This permits smooth adjustment of the load to take up the current, thus making it possible to regulate the power output, for example, of a direct current generator which is being tested. There is therefore no danger of burning out variable step contact elements and the problem of breaking a direct current arc, which is serious in large current flow, is completely avoided.

One purpose of the present invention is to make it possible to study the regulation of currents of large magnitude in generators such as are used in connection with heavy electric arc welding systems, for example. In connection with the voltage control and current control, which is desirable for welding large installations such as petroleum pipelines and the like, currents of the magnitude mentioned above are frequently used. The present device has particular utility for the study, adjustment, stabilization and governing of such currents, involving such modifications as may be desirable, to the generating equipment. It will be understood, of course, that the device of the present invention can be used for many other purposes and that the uses just described are only representative or typical of those for which it is designed.

The invention will be more fully understood by reference to a detailed description of a preferred embodiment. Referring to the drawings, which form a part of this specification:

FIGURE 1 is a vertical sectional view of a simple form of a device made according to the present invention.

FIGURE 2 is a transverse sectional view taken substantially along the line 2—2 of FIGURE 1.

FIGURE 3 is a transverse sectional view taken substantially along the line 3—3 of FIGURE 1.

Referring first to FIGURE 1, a cylindrical container which is liquid proof, for example water tight, is provided as indicated at 11. This container may be a metal or non-metal vessel, open at top, but it is normally closed by means of a cover structure supported in a seat comprising an annular ring of insulating material 13, such as resin-impregnated fiber or the like. This ring is joined to the metallic body in a liquid tight seal 15. The annular member 13 has an inwardly projecting ledge 17 which overlies the top edge of the cylindrical container 11 and which also supports on its upper surface a lid or disc shaped closure element 19. The latter is formed primarily of a suitable insulating material, such as a plate of reinforced plastic material or resin-impregnated fibereboard of sufficient strength to support the mechanical elements which will be described. It also carries electrically conductive parts, as will be explained below. In the center of the closure disc 19, an opening is provided to receive a bearing or bushing member 21. This bushing is bored internally at 23 to receive a vertical rotatable shaft 25. Shaft 25 is threaded as indicated at 27 for most or at least a good portion of its length from its bottom end upwards. It is designed to be supported against gravity and for free rotation by a ball-bearing 29. This ball supported in a shallow socket formed in a transverse plate...
member 31 near the bottom of the container. The member 31 does not contact the bottom.

Plate 31 is supported from the cover member 19 by means of a plurality of rods 33 of an electrically-conductive metal, such as brass. These rods 33, of which only one is shown in FIG. 1, are secured by nuts 35 and 37 to the bottom plate 31 and by nuts 39 and 41 to the top closure disc element 19. It will thus be seen that the upper plate or closure member 19 and the bottom plate 31 plus the rods 33 comprise a cage-like structure which may be lifted bodily out of the container. Certain other elements also are supported within the body or cage as will next be described.

Near the top of the vessel but below the closure disc 19, an insulating bushing member 45 which has a flanged head 47 and a downwardly projecting annular body 49 surrounds the rotatable shaft 25. This bushing prevents the shaft 25 from contacting certain elements carried by the bushing which conduct heavy currents of electricity. The basic member of these elements is a spider or star-shaped member 51, shown also in FIGURE 2, which is formed of brass or other good electrical conducting material and which is relatively current resistant in hot water. This member 51 is mounted on an insulating disc 53, which is slightly larger in external diameter than the longest radially projecting elements of the spider 51. Disc 53 has a number of holes 55, 57, 59 etc., which permit free circulation of water up and down through it for a purpose to be described more fully below. The cut-out form of the spider also facilitates such circulation.

The disc 53, which supports the spider 51, is attached thereto by suitable means, such as screws, indicated at 61 in FIGURE 2, to prevent displacement of the electrical parts. It will be understood that the disc 53 and the spider 51 form a sort of floating structure which surrounds the insulated bushing 49 but which can move up and down at least to a limited extent within the cylindrical container 11. To hold these parts in approximately a desired position against gravity, hook members 65 are supported by springs 67, which attach to hook members 69 supported by the top disc or closure member 19. Only one such set of hooks and spring is shown, but it will be understood that several preferably are employed so that the structure 53, 51 is supported against gravity in a resilient fashion, allowing a certain amount of movement. The main purpose for this spring suspension is to apply a slight tension to a plurality of resistance wires 71, 73, of which two only are shown. These wires form the effective resistor elements of the load bank and are formed of Nichrome of suitable diameter. They are capable of taking an electric current of about 100 amperes each when kept cool by the flow of water. Thus a series of six wires can absorb a current of about 600 amperes. For larger units, more wires may be used or wires of larger individual capacity also may be substituted, these values being merely exemplary. The springs 67 keep the wires tight and prevent short circuits.

An inlet water line in the form of a hose 77 passes through an opening 79 in the cover disc member 19. This hose is attached by means of a metal connection, shown here as a coil spring 81, to the spider 51. The spring provides good resilient connection between the lower end of the hose and the spider 51.

A heavy electric cable or bus bar 85 is connected by a bolt as 81 in such manner and position as to give good electrical contact not only with the plate but with the spring 81, to which the Nichrome resistance wires are securely affixed. The latter are firmly secured for good electrical current flow to the spider 51. The electric current thus flows through the bus bar 85 and through hose 77 to a curved contact element 73 through which the wires pass. The latter is a hollow tube of good conducting metal, such as copper, which is mounted in another spider member 91. See also FIGURE 3. The curved arrangement is such that the tubes 73, which are firmly secured and connected with a low resistance weld to the spider 91, afford good sliding contact with the wires 71. As a matter of fact two wires may be drawn through each tube 73, when the spider members 91 and the tubular members 75 may be provided for each wire if desired. Three such tube members and two wires are shown in FIGURE 3, whereas only one tube and two wires are shown in FIGURE 1. In the center of the spider 91 is an insulated sleeve member 95 which fits neatly with threads about the threaded rod or shaft 25. The sleeve 95 has a flanged top 97 by which it is secured through screws 99 to the spider member 91. Obviously, by rotating the shaft 25, the spider member 91 may be raised or lowered, carrying with it the contact tubes 73. This adjustment varies the effective length of the resistance wire or wires from the spider 51 to the tube or tubes 73. Thus the effective resistivity of the wire may be varied continuously without steps to any extent reasonably desired. To drive the shaft 25 in either direction, a reversible electric motor 101 is provided which is connected to this shaft through an appropriate gear reduction drive means 103. The arrangement is such that the shaft 25 may be turned in one direction or the other to adjust the voltage drop through the wires to any desired value.

A set screw 107 is provided in plate 31 at the bottom and it supports a washer 108 on which the ball bearing 29 rests. By this means the height of the ball bearing 29 may be adjusted to lift the shaft 27 and the parts secured thereto to adesired position to permit free rotation. Ordinarily, this adjustment is needed only to compensate for wear in the parts.

Spider 91 is provided with three openings 111 which are adapted to fit the rods 33 with a close sliding fit. This affords a path for return of the electric current. A bus bar 113 is connected through a spring 115 to the upper end of one of the rods 33. The other two rods may be connected through suitable cable means to this same connection or a spider arrangement (not shown) may be used to connect the upper ends of all three rods to gather electrically. Current may be returned from the spider 91 through all three of these and through the bus bar 113 to the generator. The rods 33 are preferably formed with smooth surfaces to contact the spider 91 and thus provide a return path for the current which offers negligible resistance.

A water outlet conduit 121 is secured by a connector 123 to an outlet opening formed in the container wall 11 near its top, as indicated at the upper left of FIGURE 1. The arrangement is such that water flowing in through line 77 and projected at high velocity along the wires 71 keeps these wires cool and it is considerably heated in the process. The water is heated to an elevated temperature when the apparatus is under heavy load, but not to its boiling point. The water finds its outlet through the line 121 which is above the level required for keeping the resistance wires cool. A certain amount of water turbulence is allowed for in the system, but the arrangement is such that an essentially streamlined current of water flowing directly along the wires 71 is fed in under such pressure that it strips all bubbles of air or steam from the wires and keeps them wet over the portion thereof conducting current. If desired, the water may be put through a heat exchanger and recycled.

The ends of the contact tubes 73 are cut to a smooth point, as shown, for effective cooling with the water at the point of contact with the wires. Their curved construction is so arranged as to insure a good smooth sliding contact at all times between the wires and the tubes 73, when spider 91 is adjusted up or down, so that no arcing or pitting can develop at the contacting surfaces, the Nichrome wires are preferably used as anodes rather than as cathodes because it has been found preferable to permit moderate erosion of the wire rather than to operate so as to cause plating or deposit of foreign materials on it. If reasonably pure water is used, the wires
are quite durable and corrosion is minimized. With ordinary tap water some corrosion usually does take place after extensive use. On the other hand, if the wire were used as a cathode it would tend to pick up substantial mineral deposits on its surface from most water supplies, and the wires would not be satisfactory resistor elements for very long because they would not transmit their heat efficiently to the water.

It will be understood, of course, that suitable ammeters and voltmeters, or any desired control instruments, will be placed in the circuit 85—113 at appropriate points, not shown. Hence, the magnitude of the current, as well as the voltage applied to the line, may always be readily known.

The disc 31 which forms the bottom of the cage structure is preferably formed of a synthetic plastic of high insulating capacity, such as Plexiglas. The wires 71 are attached to this disc or block in any suitable manner, as by projecting them through and having small fasteners on their ends. The tension of one or more springs 67 at the top is sufficient to keep these wires tight and to prevent buckling as they slide through the contact tubes 73 when spider 71 is raised or lowered by operation of the motor 101 in one direction or the other. In this way there is no serious deflection of the wires from the desired path and the instrument maintains good operating characteristics.

As previously explained, the whole cage assembly, including the adjusting shaft 25 and its drive means, the resistor wires, the plates and spiders which support them, etc., can be lifted out of the container for inspection of the wires and occasional replacement which may be necessary. In view of the fact that the spider 91 is fairly thick and neatly fitted to the sliding rods 33, affording relatively large contact surfaces, normally no trouble is encountered in maintaining good contact for the return current.

It is believed that the operation of the device is clear from the above description. To summarize briefly, current is fed in through line 85 and along the resistor wires 71 which can be varied in effective length, to the contact tubes 73. The latter are supported in a relatively heavy brass spider 91. The spider slidably receives a plurality of good conductor rods 33, preferably also of brass, which carry the return current to the top plate 19 and to the return cable 113. A stream of cold water is projected through hose or tube 77 along the resistor wires to keep them cool and to strip them of steam, air bubbles, etc., so as to insure good liquid contact at all times. The water, of course, is a reasonably good electrical insulator under the conditions of operation here so that the current is essentially all conducted through the resistance wires. By operating the motor 101 in one direction or the other, the effective length of the resistance path through wire 71 can be varied as desired. Also, as pointed out above, the number of wires 71 which are actually used may be varied so that the heat dissipating capacity of the device can be varied over wide limits. In a typical operation it is quite satisfactory for taking up the heat of 100 to 600 or more amperes at voltages of 25 to 40 volts. Obviously, by minor variations in structure, larger current loads, higher voltages, etc., may be used.

It will be apparent that various modifications can be made in the device without departing from the principles of the invention. It is desired to cover such modifications as would be apparent to those skilled in the art, and it is intended by the claims which follow to cover such as far as the prior art properly permits.

What is claimed is:

1. A combination, a liquid tight container adapted to hold a cooling liquid; a non-conducting, partially threaded rod concentrically located in said container; a pair of transverse conductive spiders located within said container; means for slidably and nonconductively mounting the first of said spider elements on said rod; threaded means for non-conductively mounting the second of said spiders on the threaded portion of said rod below said first spider; said spiders normally submerged in said liquid, said first spider being relatively fixed and said second spider being relatively movable with respect to said first spider; resistance wire means; means for stretching said resistance wires in electrical contact between said spiders, conduit means for forcing a stream of said cooling liquid into said container and along said wires; outlet means for said liquid; means for connecting an electrical load to said resistance element at its juncture point with said spider; and means for conducting electrical current away from said second spider.

2. Means for dissipating heat due to heavy electric currents in a load bank comprising, in combination, a liquid tight receptacle for water; a non-conducting, partially threaded rod located within said receptacle; a pair of spaced conductive plate elements within said water; means for slidably mounting the first of said plates on said rod; means for threadedly mounting the second of said plates on said rod; electrical resistance wire means; means for tensioning said electric resistance wires between said plates, means for connecting an electrical load to said resistance wires, means for selectively moving one of said plates with respect to the other to vary the effective length of the resistance path along said wires; and means for forcing a stream of water along each wire through substantially the length of said effective path, and return means for conducting electric current away from said resistance wires.

3. Combination according to claim 2 wherein a reversible motor drives said rod whereby said second plate, threadably mounted on said rod is adjusted automatically in either direction.

4. In apparatus of the character described, the combination of a vertical liquid tight container for a column of water, a non-conducting, partially threaded rod vertically located in said container, an upper conductive plate element supported on an insulated base within said water, means for slidably supporting said base on said rod, means for conducting an electric current to said upper plate, a movable lower conductive plate also in said water and supporting a contact tube, means for movably mounting said lower plate on the threaded portion of said rod, means for stretching a wire between said plates and in contact with said contact tube, means for varying the position of the lower plate to vary the effective resistance path length of said wire, means for conducting current from the lower plate out of said container, means for applying tension to said upper insulated plate and assembly thereby to tension the wire, and means for forcing a cooling stream of water along the wire to absorb heat from the wire.

5. Combination according to claim 4 wherein said contact tube is curved so as to insure effective electrical contact between the wire and said tube.

6. In a variable load bank for dissipating the energy of heavy electrical currents, the combination which comprises an open ended elongated liquid container; a closure disk of insulating material disposed on said open end of said container thereby rendering said container liquid tight; a bearing, centrally disposed in said closure disk; a non-conducting metal shaft disposed in said container, the upper portion of said shaft passing through said bearing and being rotatable therein, said shaft having a substantial part of its lower portion threaded; a pair of conductive transverse plate elements, the first of said plate elements slidably mounted on said shaft, the said second plate elements substantially perpendicular thereto; adjustable tension means for supporting said first plate element in said container from said closure disk; an insulated internally threaded mounting member for mounting said second plate element on the threaded portion of said shaft whereby said second plate is adjustably movable with respect to said first plate; means for connecting at least one resistor element be
 tween said plate elements, means located on said second plate for slidably contacting said resistor element; means for connecting an electrical load to said resistor element, means for flowing a stream of cooling liquid along said resistor element to keep said resistor element cool and to absorb heat emitted thereby, and means for conducting electricity from said second plate element.

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