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LIQUID RHEOSTAT

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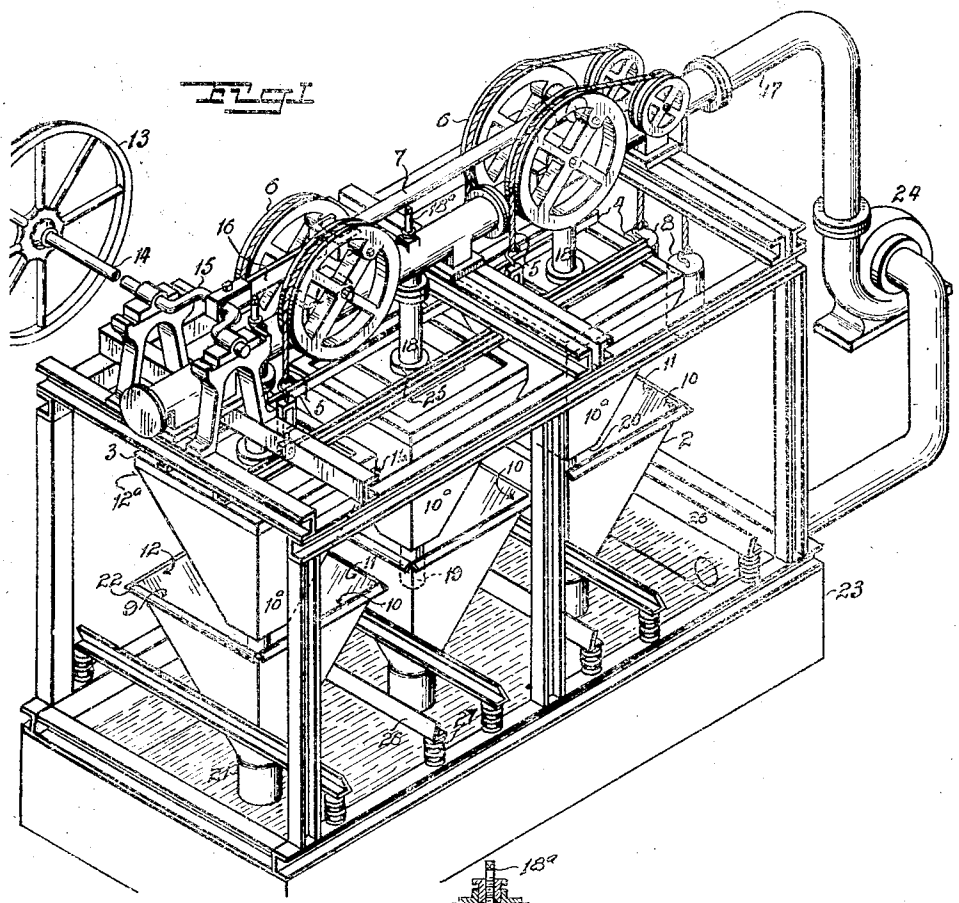


Fig. I

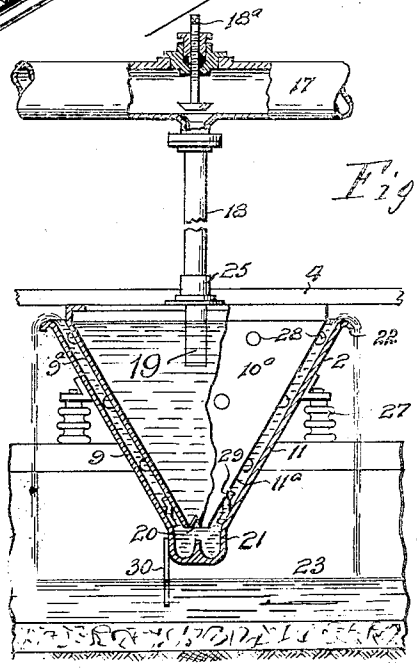


Fig. II

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## LIQUID RHEOSTAT.

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The present invention has reference to liquid rheostats and more particularly those for controlling large multi-phase motors which are frequently started and stopped.

The invention provides a liquid rheostat capable of controlling heavy currents without danger of arcing, which offers a low resistance to the full speed current whilst avoiding liability to jam in the full speed position, and which affords the advantage over the usual closed-in liquid starter, that all its parts are open to view and those parts which are likely to require adjustment or repair are out of the electrolyte.

The invention also provides for the cooling of the electrolyte in a simple and inexpensive manner.

In the accompanying drawings Fig. I is a perspective view of a starter for a large three-phase hoist motor with the electrodes separated.

Fig. II is an enlarged vertical section on a plane passing through a pair of the electrodes, showing them closed towards one another.

Rheostats of the kind in which the immersion of a series of parallel electrode-blades is varied have the disadvantage that with small immersions the cross sectional area of the liquid path becomes so reduced, without corresponding lengthening of the path, that there is danger of arcing.

The other usual kind in which the cross sectional area of the liquid path remains constant whilst its length is varied by movement of the electrodes towards and from one another requires a non-conducting or insulated container which is liable to break or otherwise become defective.

The present invention aims particularly to overcome these drawbacks by varying the length of a resistance path between parallel electrode surfaces inversely with its cross-sectional area, said path being always substantially perpendicular to the electrode surfaces.

Referring to Figs. I and II of the drawings, the numeral 2 indicates three fixed electrodes, one for each phase. These fixed electrodes are preferably also the insulated set. The other electrodes 3 of the pairs of electrodes are movable simultaneously in a defined path relatively to their fixed electrodes 2, being, in this example moved vertically by being severally fixed to a common beam structure 4 which is raised and lowered by ropes 5 clamped to and passed around pulleys 6 coupled together by a coupling rod 7. The weight of the beam 4 and the electrodes 3 is balanced by a counter-weight 8.

The electrodes of each pair provide conducting surfaces such as the pairs 9, $9^a$, 10, $10^a$ etc. which are parallel with one another and which are also substantially inclined to the direction of relative movement of the electrodes. A body of electrolyte is maintained between said pairs of surfaces. In the example under discussion the body of electrolyte is carried in the fixed electrode 2 which is constructed as a metallic container of downwardly tapering form. It is shown of pyramidal shape providing the conducting surfaces 9, 10, 11, 12; whilst the movable electrode is similarly of pyramidal shape providing the similar and parallel conducting faces $9^a$, $10^a$, $11^a$ and $12^a$.

The liquid lying between the pairs of surfaces 9, $9^a$ etc. constitutes the resisting medium and the electrode 3 is immersed to a greater or less extent in the liquid for the purpose of introducing less or more resistance into the rotor circuit of the three-phase motor.

As the result of thus inclining the conducting surfaces to the direction of movement, the pairs such as 9, $9^a$ remain parallel to one another while approaching or separating. Also by reason of their constant parallelism and of the variable immersion of the electrode 3, the current path is always substantially perpendicular to the inclined surfaces. When therefore the immersion of the movable electrode is least, as in Fig. I, the electrode area through which the current passes is the minimum, whilst the surfaces are most widely separated. On the other hand, when the electrodes are close together as in Fig. II, the cross sectional area of the liquid path is a maximum. In either case, therefore, the danger of arcing is rendered negligible.

The pulleys 6 are operated from a hand wheel 13 by means of a shaft 14 on which said hand wheel is fixed, a crank 15 in the shaft 14 and a connecting rod 16. The hoist motor being reversible and controlled as to direction by the direction in which the hand wheel 13 is turned, it is necessary that the movement of the electrodes 3 should be the

same whatever the direction of rotation of the wheel 13. The connecting rod 16 is accordingly attached to its pulley at a radius $x$ greater than the radius of the crank 15 so that a full revolution of the latter causes the pulleys to oscillate through an arc of less than 180 degrees.

Provision is made for constantly bathing the electrode surfaces with electrolyte, and when one electrode is a container as described, effective bathing is brought about by passing a stream of electrolyte into the container, so that it flows between the opposite electrode surfaces.

In the arrangement of Figs. I and II, electrolyte is supplied by means of an uninsulated main pipe 17, from which depend three branch pipes 18, each controlled by a separate valve 18a. The electrolyte is discharged through the open lower end 19 of each branch and passes through an opening 20 in the lower end of the upper electrode 3, into the lower electrode 2. The apex 21 of the electrode 2 is annularly cupped as shown to facilitate reversal of flow of the electrolyte, which passes upwards between the electrode surfaces and overflows from the lip 22.

The stream of electrolyte, issuing as a jet from the pipe 18 and passing through the open lower end of the movable electrode 3, exerts an ejector action on whatever electrolyte is contained within said electrode, tending to lower the level of the same and preventing electrolyte from spilling over the top of the movable electrode 3 which would otherwise tend to occur when said electrode is suddenly plunged into the electrolyte in the lower electrode 2 or when the electrodes are closely approached to one another. The electrolyte overflows from the lip 22 into a sump 23 as a thin sheet; and under appropriate atmospheric conditions it is thereby cooled sufficiently to render any further cooling steps unnecessary. The electrolyte collected in the sump 23 is returned to the distributing pipe 17 by the pump 24.

As mentioned above, the upper electrodes 3 are retained in their alinement with the lower electrodes 2 by gravity; but to prevent their accidentally swinging, collars 25 are provided which loosely encircle the pipes 18 so that the latter act as guides.

The alinement of the electrodes of a pair is provided for by making the bearers 26 for the lower electrodes adjustable in both horizontal directions on the insulators 27.

In order to enable the electrodes of a pair to be brought very closely together without touching, one or both of them may be fitted with studs 28 (Fig. II) of non-conducting material such as rubber. These make contact with the opposite electrode face when the electrodes are brought together, centre one electrode with the other, and also space them apart so that a very thin electrolyte sheet is left between them with consequent low resistance at full load. The inclination of the electrode surfaces is such as to avoid their wedging with one another when thus brought together.

If actual metallic contact at full speed is desired this may be effected systematically by means of spring contacts 29 on one of the electrode surfaces, which project so as to make contact with the surface of the other electrode, when the insulating studs 28 make contact.

The maintenance of the continuity of the circuit at the high resistance position, which is desirable in starters of the type in question, is effected in the example shown by the pipes 18 projecting into the electrolyte in the containers 2, and also by dippers 30 which extend from the electrodes 2 into the electrolyte in the sump 23 and offer an appropriate resistance to the current.

Whilst substantial parallelism of the opposing electrode surfaces is an essential feature of the invention strict parallelism may be departed from to meet particular conditions. For example in some circumstances it may be convenient to pass the electrolyte between the electrode surfaces comparatively slowly. As this might result in the electrolyte between the upper parts of the surfaces being considerably hotter than that between their lower parts, the plates may in such cases be somewhat diverged from one another upwardly so lengthening the current path to compensate for the greater conductivity of the heated electrolyte.

We claim:

1. A multiphase liquid rheostat comprising pairs of downwardly tapered electrodes, one electrode of each pair being imperforate and constituting an open-topped container for the electrolyte and being also fixed and insulated, the other electrode of each pair being uninsulated and presenting an imperforate external surface complementary to the internal surface of the container electrode and of approximately the same area, and being apertured at its point, means for continuously feeding electrolyte from a point distant from the internal surface of the container electrode and so that it passes through the aperture at the point of the internal electrode and upwardly between the adjacent surfaces of the electrodes, and means for simultaneously moving the uninsulated electrodes to vary their immersion in the electrolyte in the container electrodes.

2. In a multi-phase liquid rheostat, the combination of downwardly tapered electrodes forming containers for the electrolyte, said container electrodes being fixed and insulated, a plurality of corresponding uninsulated electrodes, a beam to which the uninsulated electrodes are attached, a plurality of rotatable pulleys, flexible means

supporting the beam and wound on said pulleys, and means for rotating the pulleys simultaneously whereby the beam is raised and lowered parallel with itself.

3. In a liquid rheostat, a hollow downwardly tapered electrode forming a container for the electrolyte, an electrode movable for immersion in the electrolyte in the container electrode, a pipe arranged to deliver a stream of electrolyte into the container electrode, the container electrode having an extended overflow lip such as to cause the electrolyte to fall from it in sheet form, a sump arranged below the container electrode and at such a distance that the electrolyte is substantially cooled in falling therein from the lip and a circulating pump drawing electrolyte from the sump and returning it to the delivery pipe.

4. In a multiple phase liquid rheostat, a fixed and insulated hollow electrode for each phase, adapted to contain a body of liquid and providing an overflow lip therefor, movable electrodes adapted to be inserted into the hollow electrodes, connected electrolyte supply pipes each arranged to deliver a stream of electrolyte towards a hollow electrode, the delivering ends of said pipes being within the hollow electrodes below the overflow lips thereof whereby they maintain electrical connection between the phases.

5. In a multiple phase liquid rheostat, a fixed hollow electrode for each phase, a movable electrode adapted to be inserted into the fixed electrode, a main electrolyte supply pipe, branch pipes therefrom adapted to deliver a stream of electrolyte into each hollow electrode, and means for separately controlling the flow from the main pipe to each branch pipe.

6. In a liquid rheostat, a fixed hollow electrode adapted to contain a body of liquid, an electrode movable vertically for insertion into the hollow electrode, a vertical pipe adapted to deliver a stream of electrolyte towards the hollow electrode, said pipe forming a guide for the movable electrode.

7. In a liquid rheostat, a pair of hollow electrodes of downwardly tapered form and movable relatively to one another, one being adapted for insertion into the other, means to maintain a body of electrolyte within said electrodes, the inner electrode having an opening at its lower end, and means to deliver a stream of electrolyte into the inner electrode and through said opening whereby the stream entrains electrolyte within the inner electrode.

8. In a liquid rheostat, a hollow electrode adapted to contain electrolyte, a hollow electrode movable for variable immersion in the electrolyte having an opening in its lower end, means to deliver electrolyte through said opening into the container electrode and means for facilitating reversal of the direction of flow, of the electrolyte issuing from said opening.

9. In a liquid rheostat, a hollow electrode adapted to contain electrolyte, an electrode movable for immersion in the hollow electrode, means for delivering a stream of electrolyte into the hollow electrode, the latter having an overflow for surplus electrolyte, and a sump arranged to collect electrolyte overflowing from the hollow electrode, said sump being at such a distance below the hollow electrode that the electrolyte is substantially cooled in falling from the hollow electrode to the sump.

10. In a liquid rheostat, a hollow electrode adapted to contain electrolyte, an electrode movable for immersion in the hollow electrode and means for delivering a stream of electrolyte into the hollow electrode, the latter providing an extended and open overflow lip whereby surplus electrolyte overflows from it in a form exposing a large surface to the atmosphere and is thereby cooled.

11. In a liquid rheostat, electrodes relatively movable towards and from one another and of similar tapered form respectively internally and externally, and insulatnig projections on the surface of one of them adapted to make contact with the complemental surface of the other and thereby limit the approach of the complemental surfaces to one another.

In testimony whereof we affix our signatures.

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