ed active material and thus contribute towards the hazard of "sulphating." The hazard from this cause, augmented by other causes of unequal current density hereinbefore discussed, is increased proportionately with each increase of conducting area and decreased proportionately as the conducting area is restricted.

Mechanical Structure.

In all electric storage cells as heretofore constructed, of the Faure or applied oxide type, with the exception of those employing porous media which are referred to below, the active material is supported by a metallic plate or grid, and their terms of useful life are determined by the periods which mark the disintegration and displacement of this material. Apart from mechanical jarring and vibration, which may be described as extraneous causes, these disrupting effects are produced by the normal expansion and contraction of the active material more especially on the positive plates or grids in response to the phenomena of electrochemical transmutation under charge and discharge commonly termed "breathing," which have a tendency to loosen and detach the superimposed or pocketed oxide from the supporting plates or grids and this influence is abetted by the scouring action of the electrolyte produced by circulation. This disintegrating action is continuous and progressive and is a well recognized condition in the art, as practiced to-day, as shown in the report of a stated meeting of the Railway Signal Association published in their journal issued at Bethlehem, Pa. Vol. XI. No. 3, July, 1908, page 141, where it is discussed under the caption "Sediment." The available energy of these cells primarily is directly proportionate to the quantity or weight of active material in place and in action and any loss thereof represents a corresponding loss of energy in the cell. It will therefore be noted that the life of these cells is not determined by the electrochemical exhaustion of the active material, if such be possible, nor essentially through deterioration of the supporting plates or grids but through the mechanical displacement of the material from which the energy of the cell is derived, and which, so displaced, is commonly called "sediment." When unifunctional plate cells reach the point of final exhaustion the quantity of active material present and in place in association with the positive plates or grids is less than the original quantity, and that which has been displaced is irrevocably lost. Renewal can only be effected and the term of life of the cell extended by providing fresh material in the form of new positive plates or grids.

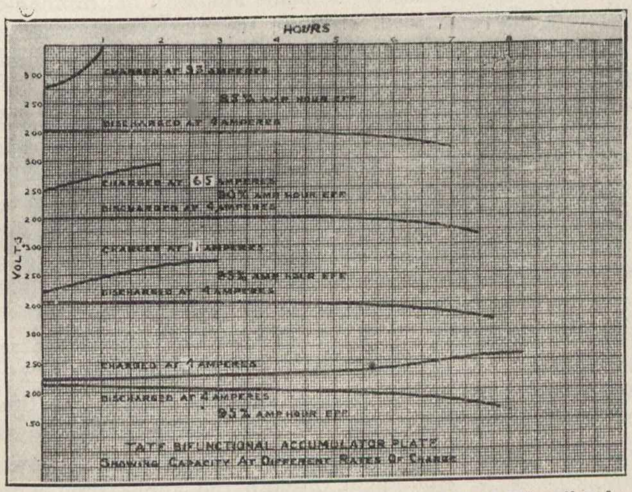

Fig. 4.—Showing Curves of Tests Made on the Tate Bifunctional Accumulator.

With regard to periods of charge and discharge which involve so-called "overloads," the relation of time to mass in the process of charging has been referred to above. Another feature which must be considered is the difference between the factors of expansion of the active material and the metallic walls which enclose and support it. These factors are wholly dissimilar, and the metal does not expand to compensate for the expansion or "breathing" of the oxide. The result of this condition is that under the influence of heavy current flow on charge or discharge the rapid or sudden expansion or contraction of the oxide has a tendency to expel it from its metallic supports or to produce the distorting phenomenon termed "buckling." This indicates one of the reasons why cells of this type can not be rapidly charged and why they are liable to serious injury through the influence of heavy discharges.

Porous media were used in electric storage cells at the inception of the art, and various kinds of diaphragms have been introduced, with the primary object of retaining the active material in place. Several of these, notably porous clay or porcelain perform this function with mechanical precision but their practical disability rests in their dependence upon capillary or molecular action in effecting the distribution or circulation of the electrolyte. They have a tendency to appreciably insulate the active material from the electrolyte through adhesive contact with the former and to filter the solution by passing the water with greater freedom than the acid.

Both of these conditions operate to curtail the useful energy of the cell; the first by rendering a part of the active material inactive, or semi-active, and the second through the production of high and deleterious acidity at the active surfaces under charge and insufficient acidity under discharge. In other words the specific gravity of the cell does not adjust itself with sufficient spontaneity to the normal and essential requirements of the active material and this condition is heavily emphasized as periods of charge and discharge are reduced. These conditions explain why porous media, originally employed in the earliest types of electric storage cells, were discarded in the subsequent practice of the art. The structural details of the Tate Bifunctional plate have been previously set forth in this paper and they will now be considered in their relation to the various conditions noted in the foregoing discussion.

Equalization of Current Density.

In the Tate plate the current finds entrance at the top and exit at the bottom, or vice versa, of a finely subdivided multiple-assembled unit provided with extremely short conductors, these being only eight inches in length, and the line of potential equalization follows, therefore, the exact horizontal centre of the plate. There can be no appreciable variation of current density either above or below this line in a vertical direction as the distance from ends to centre of the metallic conducting strips is only four inches and the drop in potential, therefore, negligible. The width of these conducting strips is seven-sixteenths of an inch. The active columns applied thereto are seven inches long, three-eights of an inch wide and about one thirty-second of an inch in depth. By thus restricting the width of the metallic conducting media and, correlatively, the active columns applied thereto, the vertical central regions, which in unifunctional plates, as hereinbefore explained, have a tendency to develop lighter current densities than other plate sections, are permanently fixed in close relation to the vertical edge areas of the media with the result that current density is again equalized, this time in a horizontal direction.

It will thus be seen that these extremely short and extremely narrow conducting strips and active columns assembled in close multiple relation achieve the equalization of current density over all the active surfaces of the unit with as great a degree of precision as it is possible to attain in the exercise of practical mechanical art. Furthermore as the