lateral edges of the conducting strips are insulated from the electrolyte by the sectional supporting frames, and as access to the vertical edge areas of the active columns is largely curtailed by the closed bearings of the intervening perforated shields, the extraneous stream lines in a working unit have been reduced to an absolute minimum and current flow confined and concentrated upon those parts (the active columns) from which useful energy is derived. Thus the probable major cause of "sulphating" (unequal current distribution) in electric storage cells as heretofore constructed has been eliminated in these bifunctional plates. The accompanying illustration, Fig. 3, shows how these conditions are maintained throughout all the ramifications of practice.

Transmutation of Active Material.

Reference has been made above to the limitation of depth of active material and to the progressive nature of transmutation involving the element of time. The accompanying curve sheet, Fig. 4, illustrates a progressive series of charges and discharges made by the writer with a Tate Bifunctional plate, about one year old, embracing forty-seven sections, or ten sections less than the present standard with the object of comparing the results of quick and slow charging. The first charge at the rate of thirty-three amperes was effected in one hour. The second at sixteen and one-half amperes in 2 hours. The third at eleven amperes in three hours and the fourth at four amperes in eight hours. All discharges were made at the same rate, four amperes. The ampere hour efficiencies shown by this test are, in the order named above, 85 per cent., 90 per cent., 93 per cent., and 95 per cent., thus demonstrating that the quick charging rate (one hour) effects curtailment of the ampere hour capacity of the unit to the extent only of about 10 per cent. Prior to this test this same unit was several times discharged on dead short circuit in an unsuccessful effort to break it down.

It would appear from this that the depth of the active material bears a direct relation to available charging periods and that the rapidity with which a Tate Bifunctional plate can be charged is due to the film-like nature of the active columns, augmented, without doubt, by the equalization of current density and concentration of current flow. It must further be noted that the active material is not enclosed by metallic walls. It rests against the faces of the conducting media, and means have been provided to effect perfect amalgamation between the metal and the applied columns during the process of "forming." The factor of metallic expansion does not have to be considered. The elasticity of the intervening perforated shields which rest against the faces of the active columns, provides amply for the expansion of the oxide in the positive sections of the plate.

The extreme shortness and narrowness of the metallic conductors in a Tate unit would in themselves reduce to an appreciable minimum the hazard of unequal metallic density but the method of preparing these strips effects a further reduction. They appear first in the form of a continuous lead ribbon half an inch wide and one-sixteenth of an inch thick, formed by forcing the metal through a die. This ribbon then enters the rolls of a specially designed automatic machine in which the conducting strips are formed ready for use, and in which that portion which carries the active columns is reduced in thickness to about .015 inch. These two processes tend to equalize metallic density and eliminate all risk of unequal current distribution through inequality of metallic resistance.

Mechanical Structure.

The Tate Bifunctional plate originally embodied porous separating media in the form of relatively thin diaphragms made of porous clay and various other porous materials. It was in testing these that the obstructive conditions relating to circulation, filtration and non-adjustment of specific gravity, were encountered and noted, and as these defects are inherent in this form of media they were discarded in favor of the perforated shields described in the first part of this article. The functions of these perforated mechanical separators are threefold. First they constitute shields or retaining walls which permanently support and conserve the active columns; second, they provide unobstructed flues or chimneys for the liberation and ascension of nascent gases and the circulation of the electrolyte; and third they aid, through their closed bearing sections, in cutting off extraneous stream lines thereby concentrating current flow along and over the path lines described by the face areas of the active columns.

The active material shows no tendency whatever to adhere to these shields so that the electrolyte, entering through the perforations, finds a relatively free passage between them and the active faces against which they rest. An exhaustive series of tests has demonstrated that the active material can not, or at least does not, subdivide in particles sufficiently fine to enter and escape through the perforations, while the scouring action of the electrolyte is expended against the exposed faces of these shields and not against the faces of the inclosed and protected active columns. Comparative curves of units equipped with porous media and with the mechanical separators just described, showing the marked improvement effected by the latter, are embraced in the illustrations accompanying Tate's United States Patent No. 926710—June 29th, 1909. This improvement is not alone due to the freer circulation of the electrolyte and the automatic adjustment of specific gravity but must be attributed in part to the elasticity of the perforated shields which permits the active material to expand freely and naturally under all conditions of current flow.

It is well understood that the total efficient energy of an electric storage cell of given size can be increased only by decreasing the internal resistance of the element. In the Tate plate the width of the exposed lateral faces of the sectional frames is only three thirty-seconds of an inch and fifty-seven of these assembled in close multiple relation constitute a standard bifunctional unit. It will thus be seen that the factor of internal resistance has been brought to the lowest point possible of attainment through the application of mechanical methods involving the sub-division and multiple grouping of all those parts which in action are electrically interrelated, and that the capacity of the unit for given weight has been raised to an absolute maximum in so far as mechanical methods are concerned. It will further be noted that in constructing plates of relatively large dimensions and capacity (Fig. 2) the individual units composing it are also assembled in multiple relation, each being independent of the other and readily detachable and replaceable in the event of injury. This is a marked advantage in the case of large installations as the seats of possible trouble through any cause are localized within spaces of about eighty square inches, representing the superficial areas of the individual units.

In view of the permanent conservation of the active material the terms of useful life of these bifunctional plates must be determined in the first instance by the time periods which will mark the deterioration of the anode conducting strips, through oxidation, to degrees that will so impair their conductivity as to render them unserviceable. This oxidation is caused by the process of charging and is progressive with relation to time. When this point of exhaustion is reached the quantity of active material present and in place in association with the anodes is greater than the original quantity for the reason that a portion of the anodes themselves has been raised to an oxide to reinforce the active material originally applied. As this condition is progressive throughout the

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