

**A HOME-MADE ALTERNATING-CURRENT RECTIFIER.**  
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The experimenter who has only alternating current at his disposal is seriously handicapped by the lack of an apparatus which will successfully convert this alternating current into unidirectional or direct current. Likewise, the owner of a gasoline automobile, having alternating current at hand, greatly feels the necessity for a rectifying apparatus suitable for charging his ignition batteries. For large currents and high efficiencies, the mercury arc rectifier is pre-eminently satisfactory; but for small currents, when the efficiency is not so important and first cost becomes a serious item, the electrolytic rectifier answers. In what follows we will first summarize the principles and essential features involved in the successful action of the electrolytic rectifier, and then give plans for the construction of a small apparatus suitable for charging storage batteries, operating electrolytic processes, and in fact supplying current for any use requiring from 3 to 5 amperes at 15 to 25 volts.

An electrolytic rectifier consists essentially of an aluminium and a conducting plate (of carbon, lead, iron, or any metal not attackable by the electrolyte) immersed in an electrolyte which is capable of acting in a certain manner on the aluminium when current passes from an external source through the cell. It is found that when a current flows from the conducting plate to the aluminium (i. e., when the aluminium is made the cathode) there is no resistance encountered beyond that of the electrolyte; but when an attempt is made to pass the current in the other direction (making the aluminium the anode) so great a resistance is met with that the current practically will not flow. This peculiar action is attributed to a very thin coating of oxide which forms on the aluminium plate. The cell has been aptly called an "electric valve," in that it allows electricity to pass freely in one direction and not in the other. Cells possessing this property are called asymmetric.

The application of this cell to the rectification of alternating currents will readily be seen. One-half of the alternating wave can be suppressed by placing the rectifier in circuit. *A* (Fig. 1) represents the sine curve of an alternating current. When the cell is put in circuit, the curve assumes the form shown at *B*. It will be seen that only half of the current is used. It is possible, however, to so connect up one or a number of cells to utilize all the current, that is, to change the sine curve to a curve as shown at *C*. Figs. 2 and 3 represent two of the methods of connection.

In Fig. 2  $\pm$  represents the alternating mains, *T* a transformer having three secondary terminals, *X* *Y* *Z*, of which one (*Z*) is attached to the middle of the secondary coil, and *A*, *A*, *C*, aluminium and carbon plates respectively in an asymmetric cell. Current passes in the direction of the arrows; it cannot pass in the opposite direction. No electricity can pass between *A* and *A*, in either direction in virtue of the oxide films on both of the plates. When *X* is negative, the current traverses the path *Z* *M* *C* *A* *X*; when *Y* is negative the path is *Z* *M* *C* *A* *Y*. The current at *M* is unidirectional. In Fig. 3  $\pm$  represents the alternating-current mains, *A* *A*, *C* an asymmetric cell as in Fig. 2, *C*, *A*, and *C*, *A*, two more cells. Current passes through the cells in the direction of the arrows. No current can flow from *A* to *A*, or from *A*, *A* to *A*. When *X* is positive, the current follows the path *X* *C*, *A*, *M* *C* *A* *Y*; when *Y* is positive, the path is *Y* *C*, *A*, *M* *C* *A*, *X*. The current at *M* is unidirectional.

Of these two methods of connection, the one shown in Fig. 2 is without doubt the best—the resistance of the electrolyte is much less, there are fewer sources of leakage, the apparatus is more compact, etc. The difficulty in its use lies in the fact that it is protected by patents. The method of connection shown in Fig. 3, devised by the author, will be used when the construction of the rectifier is taken up.

There are certain factors essential to the efficient operation of an electrolytic rectifier. First, the electrolyte to be suitable must have a low resistance, must not attack the aluminium when current is not passing through the cell, must not attack the aluminium too vigorously when current is passing through the cell, and must be composed of a stable substance. Sodium phosphate acidulated with sulphuric acid, potash alum, Rochelle salts, phosphoric acid, and in fact most of the soluble phosphates, sulphates, and tartrates, meet the requirements with more or less success. The author has had considerable satisfaction from the use of acidulated sodium phosphate solution.

The surface density at the aluminium plate must be comparatively high—not less than 1/10 of an ampere per square centimeter of surface. On account of this large amount of current traversing the electrolyte, the heating is quite excessive. Since the effi-

ciency decreases greatly as the temperature rises, an adequate means of maintaining a low temperature must be provided. Cold water, passing through glass worms in the electrolyte, is the most efficient method.

It is inadvisable to apply more than a certain voltage to a single cell. Beyond this limit the oxide film seems to break down and lose its asymmetric properties. The limit voltage for an aluminium-sodium phosphate-carbon cell is about 30 volts. Higher voltages may be rectified by connecting cells in series.

CONSTRUCTION OF A SMALL RECTIFIER.

The following are plans for a rectifier suitable for utilizing 104 to 110 volt alternating current at commercial frequencies, and for delivering direct current of 3 to 5 amperes at 15 to 25 volts. The apparatus can, however, be made to utilize any alternating-current voltage by merely changing the transformer.

It is necessary to have a transformer to step down the voltage of the alternating-current line to a value which may be handled by a single cell. Since more than 15 or 20 volts direct current is rarely needed for electrolytic work, this transformer has the further advantage of increasing the secondary current without increasing the main-line current. Thus less current is used from the supply mains for the same direct current than if full potential were employed. For want of space here, the designing of this transformer, being quite simple, is left to the builder, who, if he is not sufficiently well informed, may consult any standard textbook on alternating currents. The transformer must be constructed to deliver 5 amperes and 25 volts at the normal load. Leads must be brought out from a few of the end coils for voltage regulation. (See Fig. 6, *C*.)

The rectifying cells have hard-rubber or glass con-

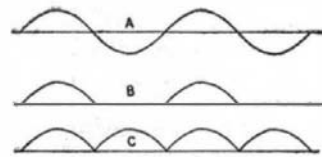


Fig. 1.

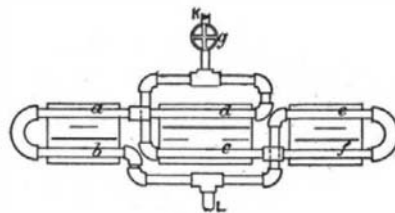


Fig. 5.

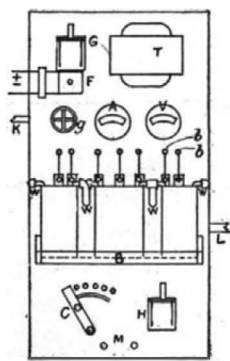


Fig. 6.

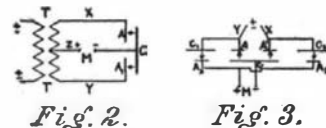


Fig. 2.

Fig. 3.

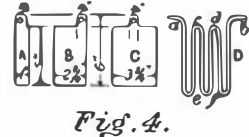


Fig. 4.

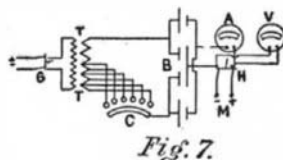


Fig. 7.

DETAILS AND CONNECTIONS OF THE ALTERNATING-CURRENT RECTIFIER.

taining jars, the middle cell with the two aluminium plates being 6 x 4 x 2 1/2 inches, and the end cells with one aluminium plate 6 x 3 x 2 1/2 inches inside measurements. The aluminium plates are cut out of 1/8-inch sheet aluminium, and are the same size and shape for all the cells. (See Fig. 4, *A*.) The carbon plates are cut from 1/4-inch carbon plate with an old hacksaw. (See Fig. 4, *B* and *C*.) Two of *B* are made for the end cells, and one of *C* for the middle cell. Both the carbon and aluminium plates are provided with binding posts as shown in the figure. The lugs of the carbon plates are dipped in melted paraffin to prevent creeping of salts. Hard-rubber tops are provided for the jars to retard evaporation of the electrolyte. The carbon and aluminium plates are suspended from this top, and held 1/2 inch apart by hard-rubber separators. The positions of the plates in each cell are shown in Fig. 5.

Six glass worms (Fig. 4, *D*) are bent from 3/8-inch (outside measurement) glass tubing with thin walls. They are of a size to fit correctly on each side of the plates in each cell (*a b c d e f*, Fig. 5). The inlets and outlets (*a* and *b*, Fig. 4, *D*) should rest on the edges of the jars, *c* and *d* should just project above the surface of the electrolyte, and *e* and *f* should nearly reach the bottoms of the jars. Fig. 5 shows the connections of the water-cooling system, *a b c d e f* representing the glass cooling worms. They are connected with each other and the water supply and waste (*K* and *L* respectively) by stout rubber tubing bound on tightly with wire. The water is supplied by 1/8-inch iron piping; the waste is 1/4-inch pipe. As the middle cell passes twice as much current as the end cells (refer to Fig. 3) it will get twice as hot. With this condition in mind, the cold water is first passed

through the middle cell and then through the end cells. The end cells may be kept cool enough by increasing the water supply at the valve *g* (Fig. 5).

If the electrolyte is of acidulated sodium phosphate, a saturated solution of the phosphate is prepared and the jars filled, with plates and cooling worms in position, to within an inch and a half of the top. After the apparatus is assembled, the sulphuric acid is added as will be shown below.

The switches are shown in the assembled apparatus (Fig. 6). *G* and *H* are ordinary 15-ampere knife switches on slate or porcelain bases. *F* shows a conventional fuse block on the alternating-current line. Three ampere fuses are quite sufficient. *C* is a point switch controlling the voltage of the transformer. Small binding posts *b b* are provided for convenient connection with the electrolytic cells; they are insulated from the panel by hard-rubber bushings and washers. At *M* are two massive binding posts; the direct current is taken off here. *A* and *V* are an ammeter and voltmeter respectively. These instruments may be omitted, though they are very useful. They must be of the hot-wire type to correctly record the pulsating current. *T* represents the transformer; *g* is the handle to the valve controlling the cooling water; *K* and *L* represent the inlet and outlet water pipes respectively; the alternating mains are shown at  $\pm$ . *W W W W* represent the connections of the cooling worms. The panel is of 1/2-inch seasoned oak, 15 x 29 inches. At *B* is a shelf of the same material.

The electrical connections are shown diagrammatically in Fig. 7.  $\pm$  represents the alternating current mains controlled by the switch *G*, *T* is a transformer, and *C* the switch controlling the voltage of its output. *B* shows the asymmetric cells connected as in Fig. 3. *A* is the ammeter connected in series with the direct-current circuit; *V* is the voltmeter connected in shunt across same. *H* is the direct-current switch, and at *M* are the binding posts where the direct current is obtained. All the wiring is done behind the panel on porcelain insulators. The piping for the water cooling is also partly behind the board.

When the panel is all connected up, the electrolyte is brought to the proper conductivity by adding sulphuric acid in each cell until the ammeter registers 5 amperes at full load. Before using the rectifier in actual work, the aluminium plates must be "formed." This is accomplished by running the rectifier with a resistance at *M* (Fig. 6) at full load for a couple of hours. In starting the apparatus, first turn on the main alternating-current switch *G* (Fig. 6); then regulate the voltage by the switch *C* to the desired value. Close the direct-current switch *H*. The current is now regulated to the proper quantity by *C*. Now turn on the water by the valve *g*, but slightly at first, then more and more as the cells grow hotter. The best efficiency is obtained when the cells are coldest and the current density is greatest. To stop the apparatus, open the direct-current switch *H*, then the alternating-current switch *G*, and lastly turn off the water. The aluminium plates will need occasional cleaning, as a hard barnacle-like substance forms on them. At certain intervals the aluminium plates will need renewing because they wear away slowly. The electrolyte will also have to be changed each time the plates are renewed.

The current obtained from such a rectifier as described above is not strictly direct-current but pulsating, unidirectional current. (See Fig. 1, *C*.) This type of current is desirable for charging storage batteries, as more time is allowed for chemical action, and therefore less "gassing" is the result. Let it be understood, however, that the wave form of the current does not hinder its application to the operation of all direct-current machinery.

**Fighting Coal Mine Fires With Chemicals.**

For fighting fire in its anthracite coal mines a new form of chemical fire engine is now being used by the Delaware, Lackawanna & Western Railroad. This engine is built on a truck which can run upon tracks throughout the mine. When an alarm of fire is sounded the engine is attached to an electric mine locomotive and rushed to the scene of trouble at high speed. Water played upon a coal fire is almost instantly converted into steam, which further disintegrates, forming a gas so suffocating that it drives away the men fighting the fire. Blue flames which shoot out when water strikes the hot coal often set ablaze pockets of gas in the ceiling. When a chemical engine plays upon burning coal the heavy gases evolved cling to the floor and smother the blaze by excluding the air. Men are not annoyed by the fumes and can stay close enough to do effective work.—Railway Engineering Review.