THE HOLWECK DEMOUNTABLE TYPE VALVE.

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Summary.

The paper briefly describes the Holweck molecular pump and, in more detail, 10- and 30-kW Holweck demountable type valves. Precautions necessary with demountable valve installations are pointed out. The chief advantages are ability to renew filaments at a cost of a few pence, and ability to carry large overloads. Some results obtained with installations employing demountable valves are given. The possibility of larger-power single units being developed is mentioned, but short-wave work may make it unnecessary to build larger units than those developed. Perfection of details with a view to complete reliability should make for increased application of this type of valve.

A demountable type of valve must of necessity be connected to a vacuum pump capable of continuously maintaining a vacuum sufficiently high for practical working purposes. F. Holweck invented a rotary molecular pump which has certain advantages tending to fit it for the commercial operation of demountable valves. This pump has already been described in various technical journals, but in order that the practical value of a demountable working unit may be ascertained it may be useful again to describe briefly its construction and method of operation.

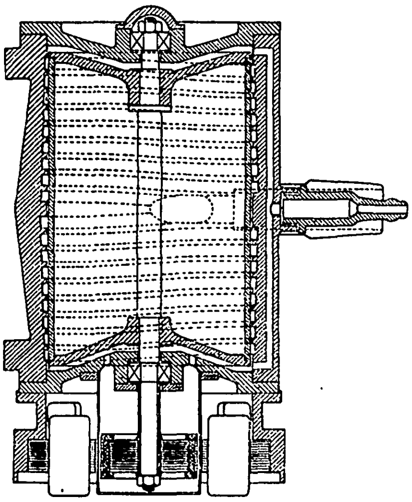

Fig. 1.

The Holweck molecular pump (Fig. 1) employs the same principle as the Gaede pump, but from a mechanical point of view it is much simpler. It consists of a smooth, light cylinder 6 inches in diameter and $8\frac{3}{4}$ inches in length, mounted on ball bearings inside, and very close to, a heavy casting upon the inside of which a 7-turn right- and left-handed spiral groove of diminishing rectangular cross-section has been cut. The cylinder is driven at a speed of 4 500 r.p.m. by means of a rotating electric field, which makes it unnecessary to bring the shafts supporting the rotating portion through the walls of the body of the pump. A small passage in the body of the pump serves as a connection to a rough vacuum pump, and a large orifice connecting the two spiral grooves serves as a connection to the vessel in which a high degree of vacuum is required. The cylinder thus revolves in the preliminary vacuum, which reduces to less than 10 watts the amount of power necessary to drive it at such a high speed. When the current is cut off, the cylinder continues to rotate for upwards of an hour. This feature is valuable when operating a valve and pump intermittently, as the pump very rapidly returns to its synchronous speed when again connected to the supply. The absence of shaft connections to the outer air obviates leaks and the possibility of lubricating oil or grease entering the interior of the pump.

The suppression of the comb as employed in the Gaede pump makes it possible to reduce to less than 1 mil the clearance between the fixed and rotary portions. This small clearance and the relatively large section of the two spiral paths make the output of the Holweck pump much greater than that of the Gaede. With a preliminary vacuum of about 1 mm of mercury it is possible to reduce the pressure in a 5-litre flask to 0·001 mm in 10 seconds. The lower limit of vacuum available is of the order of $0 \cdot 001\,\mu$ even with a preliminary pressure of 0·01 to 20 mm, which gives a ratio of preliminary pressure to final pressure of several millions, as against 200 000 with the Gaede pump. In practice it has proved itself quite capable of keeping the vacuum necessary on demountable valves with 8 000 volts on the anode.

The invention of this very practical form of pump, which does not require any mercury, liquid-air traps, etc., led to the development of the Holweck demountable valve. A cross-sectional view of such a valve assembled is shown in Fig. 2.

In practice the valve is mounted directly on top of a Holweck molecular pump, which in turn is connected to a rough vacuum pump. Several valves can be operated from one pumping system.

The valve consists of four parts as shown in Figs. 2 and 3, the parts being :—

(1) Lower glass or quartz insulating piece for connecting valve to pump.
(2) Water-cooled anode. For a 10-kW valve the dimensions of this are approximately $1\frac{3}{4}$ in. diameter, and $4\frac{3}{8}$ in. long. For a 30-kW valve the diameter is the same, but the length is 8 in.

(3) Upper glass insulating piece with grid connection.
(4) Water-cooled head carrying grid and filament. The filament in a 10-kW valve consists of about 14 in. of tungsten wire 20 mils in diameter, which, when carrying 36 amperes, gives a temperature of 2 700° abs. and a saturation current of about 6 amperes. In the 30-kW model the filament is of 32-mil tungsten wire and consists of two pieces in parallel, each $12\frac{1}{2}$ inches in length, bent in the form of a hairpin—the saturation current being about 16 amperes. The grid is of 16-mil molybdenum wound $\frac{3}{4}$ in. diameter on about $\frac{1}{8}$ in. pitch.

All joints are ground and put together with a little special vacuum grease. The Holweck pump quite readily copes with the very small leakage.

The 10-kW Holweck demountable valve employs 6 000 volts on the anode and 38 amperes at 17 volts on the filament. The filaments are changed after 200–300 hours of service, and the cost of doing this is only a few pence. An ordinary oil-type backing pump is connected to the Holweck pump upon which stands the Holweck valve. No duplicate valve is installed, as breakdowns in service are not frequent. It does not take long to change a whole new head carrying both grid and filament.

Three precautions are necessary in connection with demountable valve installations. It should not be possible to apply the high-tension supply to the anode unless :—

(*a*) An adequate supply of water is circulating through the anode and filament head.
(*b*) The preliminary vacuum pump is running.
(*c*) The molecular pump is running at synchronous speed.

Sufficient demountable valves are now in service to warrant their being seriously considered as a rival to the sealed-in variety. It is true that demountable valves require a pumping system, which can, however, be disconnected for short intervals wthout interrupting transmissions. Against this disadvantage is the very considerable advantage of being able to renew the filaments at a cost of a few pence. The ordinary life of a single valve can thus be many times that of the sealed types of glass, metal or silica valves.

Many valves of 10-kW and 30-kW input have been made and put into operation. The French Navy alone has 80 of the 10-kW size in operation. Each type is capable of considerable overload. With 5 000 volts on the anode 35 amperes were obtained in the Eiffel Tower aerial, representing 8 kW. A 30-kW model used as a rectifier handled 60 to 70 kW with 8 000 volts on the anode. Used as a three-electrode valve 70 amperes were obtained in the Eiffel Tower aerial at 7 000 volts, representing 32 kW. On a trial, one of these 30-kW valves took 100 kW.

The Malmaison station operates at 37·5 and 500 m, and is nominally rated at 10 kW. The aerial is of the Blondel type, about 45 ft. high, and has a resistance of about 100 ohms at 37·5 m. An aerial current of 6 to 7 amperes is obtained. Signals have been received in Shanghai of strength 7, and in Brazil and Argentine of strength 8 to 9.

The loading of a 30-kW valve to 100 kW points to the feasibility of making single units of 100 kW, which in turn might only be stepping stones to the building

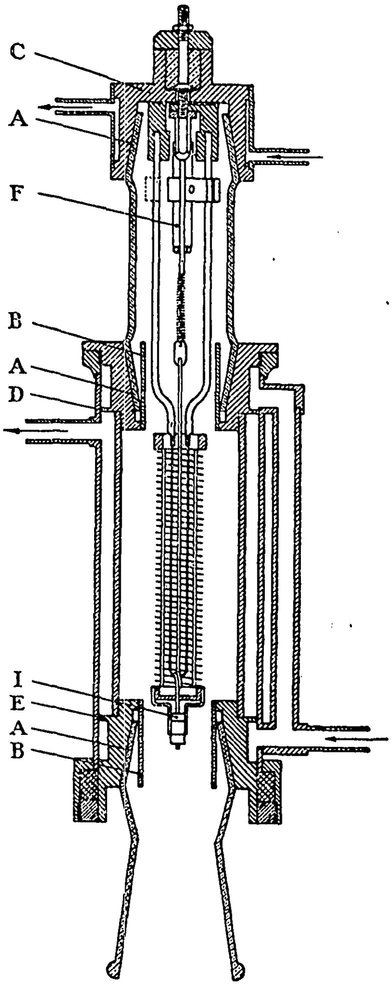

FIG. 2.

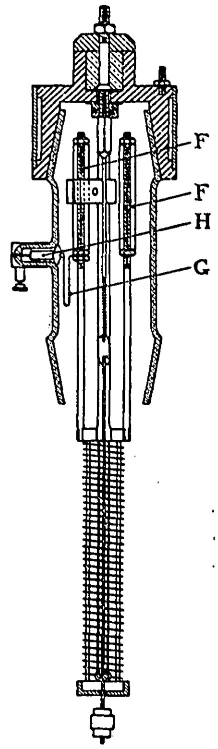

FIG. 3.

of single units capable of handling 200, 500 or 1 000 kW if necessary. But the increasing use of short waves and power inputs of 10 to 30 kW maximum may make it unnecessary to develop larger units than those which already exist. All that is required is greater refinement of details, which would no doubt be rapidly developed with increasing use.

In the author's opinion the advantages of the demountable valve greatly outweigh the disadvantages, and the valves should be employed in the future in increasing quantities.

[The discussion on this paper will be found on page 812.]