Physics. — *Methods and apparatus used in the Cryogenic Laboratory. XX. A high vacuum pump with great capacity.* By W. GAEDE and W. H. KEESOM. (Comm. N°. 195*a* from the Physical Laboratory at Leiden).

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§ 1. *Introduction.* When KAMERLINGH ONNES [1]) in 1921 obtained the lowest temperature that has hitherto been reached he disposed, to suck off the vapours which developed from the liquid helium, of an aggregate composed of 12 glass and 3 steel LANGMUIR pumps connected in parallel, which had a total exhaust capacity of about 40 L/sec. at a pressure of 0.005 mm. of mercury.

In order to diminish the temperature still more, Prof. KAMERLINGH ONNES constructed afterwards an aggregate consisting of steel LANGMUIR pumps, which had an exhaust capacity of about double the capacity of the above mentioned. Experiments with this aggregate had to be delayed till a new aggregate of mechanical pumps with greater displacement should be installed, in order to diminish as much as possible the temperature of the helium cryostat, within which, in a space isolated by vacuum, the lowest temperature had to be reached.

In the meanwhile it seemed to one of us (W. H. K.) that it might still be possible to increase considerably the capacity of the high vacuum aggregate. He wished to dispose of a pump aggregate with an exhaust capacity for helium of 400 L/sec. at a pressure of 0,001 mm., so with ten times the capacity of that of 1921. This capacity might for instance be reached by means of diffusion pumps each with an exhaust capacity of 200 L. He/sec. by connecting three of them in parallel. He applied for this to the other of us (W. G.), who thereupon designed a construction, which was performed by E. LEYBOLD's Nachf. at Köln (1926).

This pump has been tested at Leiden and answered the expectation fully. It has at a pressure of 0.001 mm. an exhaust capacity of 270 L. He/sec.

The results of this test suggested that perhaps it would be possible to reach the desired capacity with one single pump of still greater capacity. The other of us then designed a new construction with the same outer dimensions, but with properly widened diffusion slit. The new pump, also constructed by LEYBOLD's Nachf., worked indeed as required. A short description is given in the following section.

1) H. KAMERLINGH ONNES. Comm. Leiden N°. 159, 1922.

§ 2. *The diffusion pump with exhaust capacity of 400 L. He/sec.* Fig. 1 represents the new pump [1]). It is not necessary to explain the principle of the pump because GAEDE [2]) and MOLTHAN [3]) have treated this kind of pump (mercury diffusion pump) in all particulars. The really new part of the construction is the double cooling, firstly, as always, with water from the main (inlet W_1, outlet W_2), secondly by means of a liquid cooled to $-10°$ to $-20°$ C. (inlet V_1, outlet V_2, cooling spiral *Sp*). This particular cooling in the high vacuum is necessary, in order that the mean free path of the gas-molecules to be exhausted in the stream of mercury vapour, becomes large enough in comparison with the large dimensions of the diffusion pump. The conical ringslit *R* has above a diameter of 93 mm and is there 0.5 mm wide and below it is 5 mm wide [4]). An iron screen Sch_3 prevents the mercury condensed against the cooling spiral *Sp* from falling against the ringslit cap, there to partly evaporate and to emit a cloud of vapour into the high vacuum. The iron screens Sch_1 and Sch_2 protect the connection with the backing pump against falling mercury and rising mercury

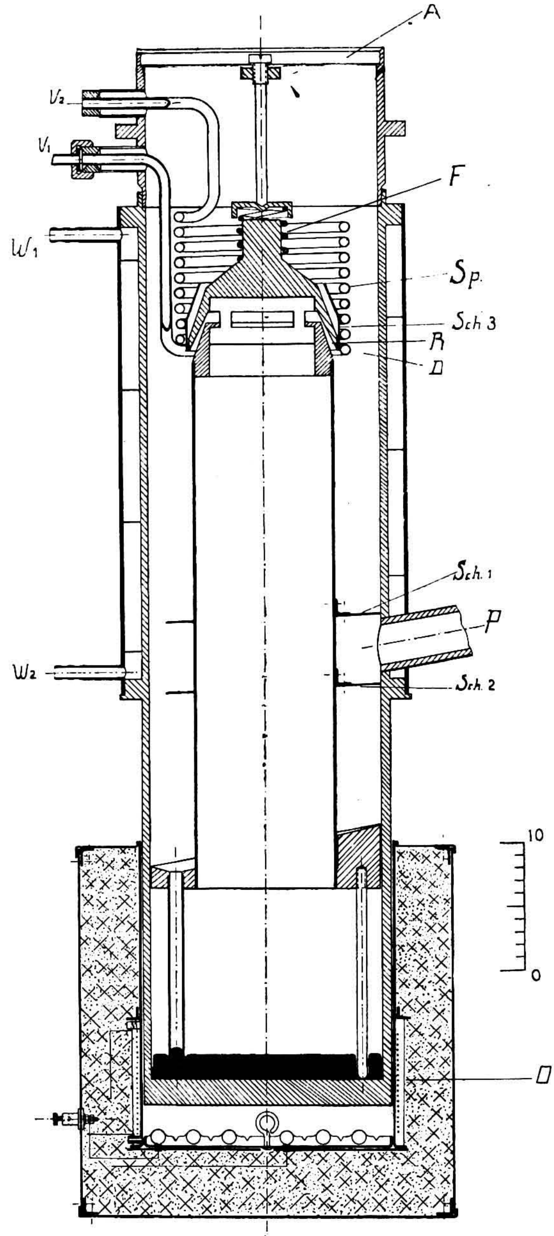

Fig. 1.

[1]) The dimensions may be deduced by means of the scale given in the figure, which gives centimeters.

[2]) W. GAEDE. Zs. f. techn. Phys. 4, 337, 1923.

[3]) W. MOLTHAN. Zs. f. techn. Phys. 7, 377 and 452, 1926.

[4]) The annular space *D* between the lowest winding of the cooling spiral *Sp* and the surrounding wall, which works as diffusion slit, has a mean diameter of about 160 mm and is about 20 mm wide.

vapour. They have a small inclination to make the condensed mercury run off. The thermal expansion of the inner part of the pump, caused by the high temperature of the mercury vapour is taken up by a steel spring *F*. At *P* the backing pump is connected. The space which is to be evacuated is connected to the pump at *A* by means of a tube with 18 cm. diameter. The pump is filled with about 7 Kg. mercury.

For the purpose of the heating an electric oven O has been constructed at Leiden. Heating may take place by two spirals of nichrome-wire; one is at the bottom and is baked in fireproof cement, resistance cold 17 Ω, the other one in the cylinder wall, resistance cold 25 Ω. This last is used at the start (15 minutes). When constant the best result is obtained by heating the bottom spiral alone, current 12.1 A (A. C. 220 V.).

§ 3. The pump was tested with air as well as with helium. For this the pump at *A* was closed with a cap (Fig. 2) in which were two holes. Through one hole the gas, which had passed a flow-meter *M* calibrated for that gas, was exhausted by the pump. The other hole served for the connection with the McLeod pressure-gauge *V*.

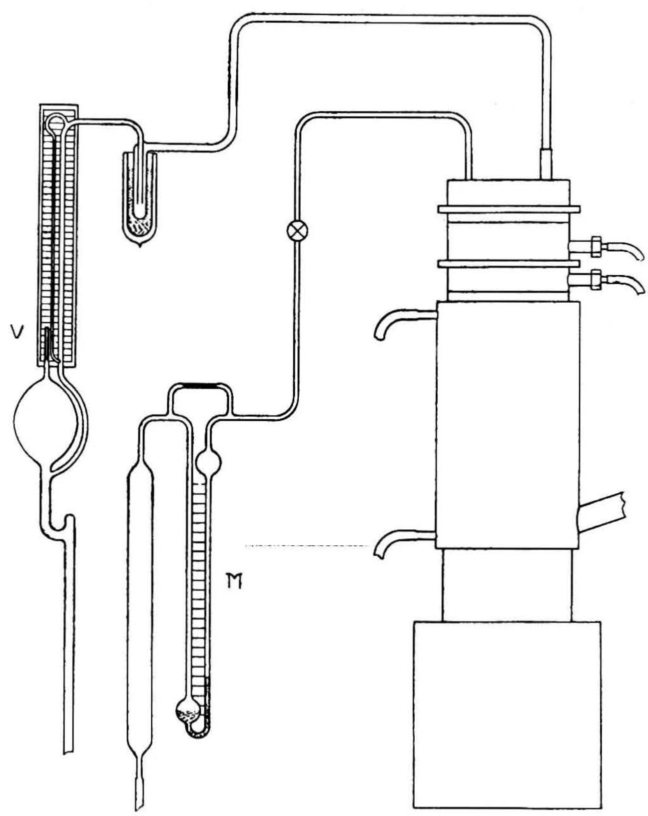

Fig. 2.

Because in these tests there was nowhere a low temperature in the space to be evacuated, it was not necessary to cool the liquid which flows through *Sp* to — 10° to — 20° C., but water was used at about 10° C.

The fore-vacuum was kept at about 0.15 mm. pressure by means of a mechanical pump with sufficient capacity.

The results are given in fig. 3. In horizontal direction is set out the pressure, measured with the McLeod, in vertical direction the displaced gas volume, measured at normal pressure. The fact that the results give straight lines, which by extrapolation pass through the origin, proves that the pump has a constant exhaust capacity to the smallest pressures at which it is tested. This exhaust capacity, that is the gas volume (measured at the pressure of the pump) which is removed per second, amounts for air to 130, for helium to 420 L/sec. With this an exhaust capacity has been obtained of fully eight times that which the 3-stage pump has at its inlet [1].

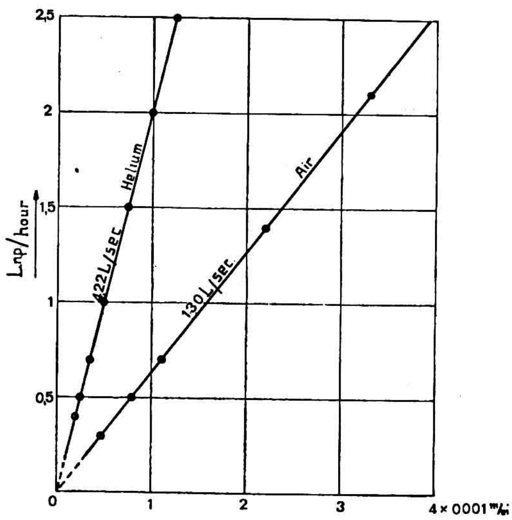

Fig. 3.

We are glad to render our thanks to G. J. FLIM, chief of the technical staff of the cryogenic laboratory at Leiden, for his intelligent aid in constructing and testing this pump, and to LEYBOLD's Nachf. for the care bestowed in executing the construction.

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[1]) W. GAEDE l.c. p. 368.