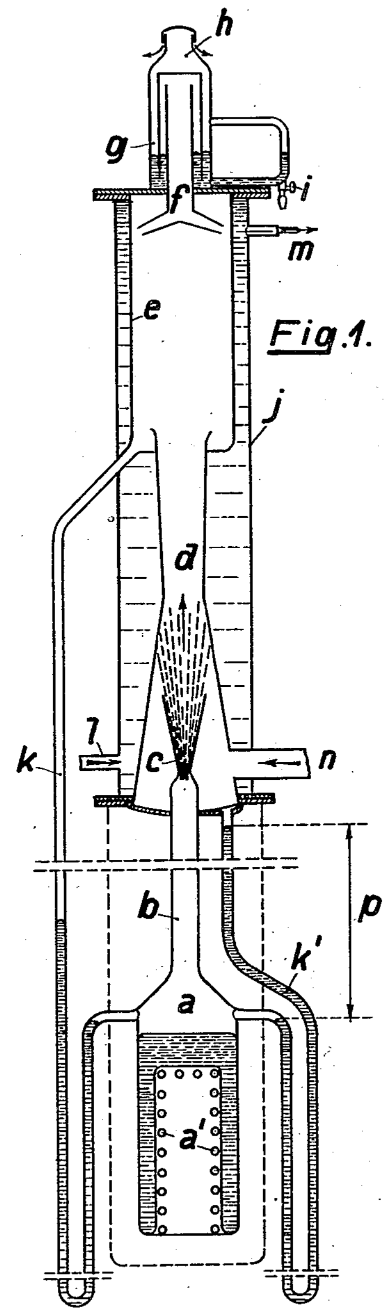
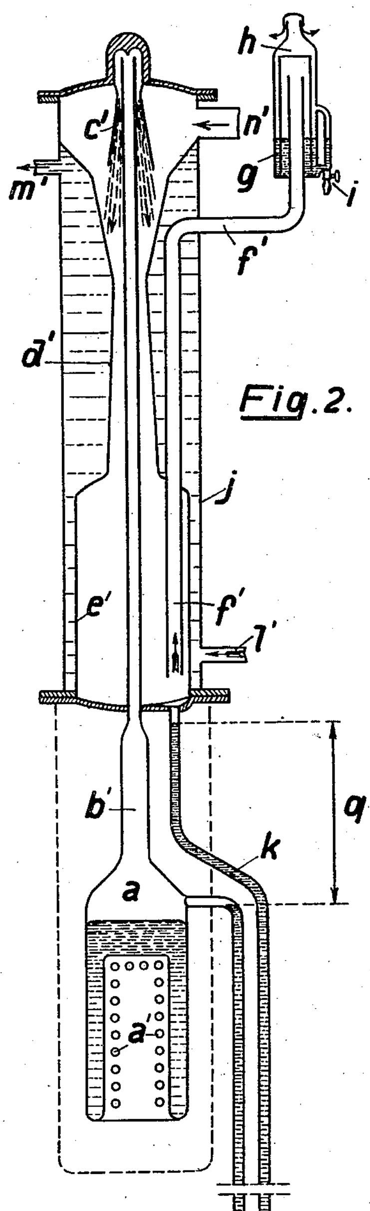
June 11, 1929. O. SEITZ 1,716,507

HIGH VACUUM APPARATUS

Filed March 24, 1926 2 Sheets-Sheet 1





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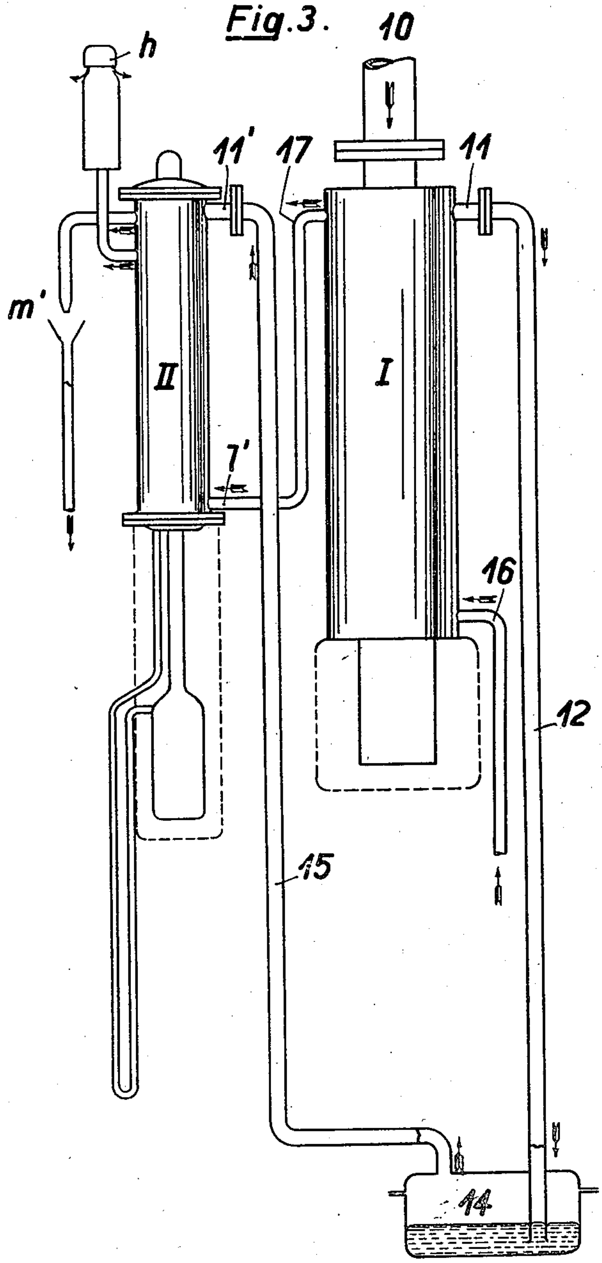
Filed March 24, 1926 2 Sheets-Sheet 2

Fig. 3.



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UNITED STATES PATENT OFFICE.

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HIGH-VACUUM APPARATUS.

Application filed March 24, 1926, Serial No. 97,071, and in Germany March 27, 1925.

This invention relates to apparatus for producing high vacua, particularly to the sort of apparatus employing a plurality of vacuum pumps in series.

The general object of the invention is the provision of apparatus requiring a minimum of moving parts and which will be certain in operation, particularly throughout extended periods, or for intermittent service.

Another object is the provision of such apparatus particularly adapted to automatic control, that is, to be automatically started and stopped in accordance with the demands of the evacuated device.

Further and other objects of the invention will be indicated or pointed out hereinafter, or will be obvious to one skilled in the art upon an understanding of the invention.

In the drawings forming a part of this specification I show in diagrammatic fashion certain forms of apparatus embodying the invention, but it is to be understood that the invention as claimed is not limited to these particular structural forms.

In the said drawings,

Fig. 1 is a sectional elevation of a vacuum pump,

Fig. 2 is a similar sectional elevation of a modified form,

Fig. 3 is an elevational view, with part in section, illustrating the associated connection of pumps in a two-stage assembly.

Referring first to the embodiment illustrated in Fig. 1, let it be understood that the character *a* designates a mercury vapour generating receptacle provided with a heating element *a'*, by which the mercury contained in the receptacle *a* may be heated to boiling for the production of mercury vapour under pressure in the receptacle. From the top of the receptacle *a* leads a restricted discharge tube *b* terminating in the ejection nozzle *c* which discharges in the contracting throat of the compression nozzle *d*. The compression nozzle *d* comprises a tubular convergent front portion or combining tube merging into the aforesaid throat, and a tubular divergent rear portion or delivery tube opening into the condensing chamber *e*. The inlet *n* for the gas that is to be pumped is at the wide front end of the combining tube, back of the opening of the ejection nozzle. The compression nozzle *d* and condensing chamber *e* are cooled by circulation about them of a cooling fluid within the jacket J. The condensing chamber *e* has an outlet at its top through the baffled tube *f* which discharges into a trap or separator at *g*, which contains a liquid capable of condensing mercury vapour and adapted to pass air outwardly to the discharge hood *h* opening to the atmosphere. The separator is provided with a suitable connection and drain cock *i* whereby mercury contained in the seal may be drawn off. From the bottom of the condensing chamber *e* a return pipe *k* leads to the receptacle *a*, and from the closed lower end of the nozzle *d* another return pipe *k'* leads to the receptacle *a*. These return pipes are of syphonic nature and afford seals preventing passage of air through the receptacle *a*. The pipe *k'* must be of sufficient length to afford an adequate head *p* to retain the pressure difference between the low vacuum pressure in nozzle *d* and the pressure in receptacle *a*.

In operation of the device the mercury vapour generated in *a* is forcibly ejected through the vapor nozzle *c* entraining with it the air in the surrounding combining tube and compressing it in the throat of the nozzle *d*, wherein it is cooled by the surrounding cooling fluid, and discharged into the condensing chamber *e* at something in excess of atmospheric pressure. In the condensing chamber *e* the greater part of the mercury vapour is condensed, and returns to receptacle *a* through pipe *k*. The compressed air leaves through pipe *f* passing through the seal of the separator *g* and passes to atmosphere through the head *h*. The cooling liquid is introduced through the pipe L and finds outlet through the pipe *m*.

In the embodiment illustrated in Fig. 2 the same elements are employed, but the direction of operation is reversed. In this form the tube *b'* is extended up to the top of the device where it discharges into the nozzle *c'* in such relationship that after discharge from *b'* the direction of the mercury vapour is reversed and it is emitted from the nozzle in the downward direction in the compression nozzle *d'*. The latter leads to the condensing chamber *e'* in which the mercury vapour is condensed and returns to receptacle a through pipe k, the compressed air finding outlet through the pipe f' to the separator g and to the atmosphere at h. This embodiment possesses the advantage over that illustrated in Fig. 1 in requiring only one siphonic return arrangement for the condensed mercury vapour, and in not requiring so long a head q in the return pipe as is necessary in the pipe k' of Fig. 1, because the pressure difference between the boiler a and the condensing chamber e is relatively low.

The pumps constructed as described above are particularly valuable because of the features which make them suitable for operation against a large pressure head, permitting their utilization in combination with mercury-vapor high-vacuum pumps, thereby elminating rotary vacuum pumps used for creating a preliminary vacuum for the high vacuum pumps.

In Fig. 3 is illustrated such two-stage arrangement in which I designates the high vacuum pump having its inlet at 10 from the evacuated chamber and its air outlet at 11, the air being conducted through the pipe 12 to the vessel 14 which contains the mercury for effecting a barometric seal between the pipe 12 and the pipe 15 leading to the air inlet 11′ of the preliminary or leading air pump II, here shown as the form illustrated in Fig. 2. In the pump I the air is raised to a pressure of some 10 or 20 mm. mercury, and, entering the leading pump II at that pressure is raised to a pressure permitting its discharge to atmosphere. Fig. 3 also shows the arrangement for circulating fluid. The fluid is introduced first to the cooling jacket of the high vacuum pump I at 16, and leaves the same at 17, whence it is conducted to the inlet 1′ of the leading pump II, from which it is discharged at m'.

With the arrangement illustrated some degree of vacuum is always maintained in the high vacuum pump I. Consequently, upon the starting of the apparatus or the energizing of the heating elements in the two pumps, the mercury in the high vacuum pump I will boil first. Accordingly, as soon as the valve controlling connection between the receivers and the high vacuum pump I is opened, which is accomplished upon the starting of the leading pump II, the high vacuum pump, which is already working, at once commences to raise the vacuum in the receivers. It is to be observed also that the only auxiliary mechanical apparatus required is the single pump for circulating the cooling fluid. This can be controlled in conjunction with the switch which controls the energization of the heating elements a'. It is contemplated that the pump I, in accordance with present practice, may be of the mercury vapour or diffusion type, although it may be of other suitable kind. The apparatus possesses distinct advantages in its freedom from mechanical complications such as necessarily are involved in pumps having moving parts which have to be actuated from external sources.

What I claim is:

1. In vacuum apparatus, the combination of a primary vapor condensation high vacuum pump and a secondary vapor condensation vacuum pump operating in series with the same, said secondary pump being arranged to maintain the primary pump under a negative pressure, and means for circulating vapor condensing cooling fluid through said pumps in series, said cooling fluid passing in the direction from the primary pump to the secondary pump.

2. Vacuum apparatus, in combination, a primary high vacuum pump of the diffusion type and a secondary pump connected to the exhaust of the primary pump, said secondary pump comprising means for producing a vapour jet arranged to compress the gas received from the primary pump to super-atmospheric pressure.

3. Vacuum apparatus comprising, in combination, a primary vacuum pump of the mercury vapour jet type, a secondary pump in series with the primary pump, said secondary pump discharging to atmosphere, and a uni-direction seal between the pumps permitting flow of gas from the primary to the secondary pump only.

4. Vacuum apparatus comprising, in combination, a primary mercury vapor high vacuum pump, a secondary mercury vapor pump in series with the primary pump for compressing the gas received from said primary pump to super-atmospheric pressure, a seal for the discharge of the secondary pump to prevent escape of mercury vapor from said pump, and a uni-direction seal between the primary and secondary pumps permitting gas flow in the direction to the secondary pump only.

5. Vacuum apparatus comprising, in combination, a primary high vacuum pump of the mercury vapour type, a secondary pump in series therewith, said secondary pump being of the mercury vapour jet type, and means for circulating a vapor-condensing cooling medium through said pumps in series.

6. Vacuum apparatus, comprising in combination, a compression nozzle having a contracted throat, a condensing chamber into which said nozzle discharges, said condensing chamber having air outlet through a mercury vapor seal, an ejector nozzle discharging through the compression nozzle towards the condensing chamber, a mercury vapour generator supplying said ejector nozzle, a conduit for return of condensate from the condensing chamber to the gen-

erator, and means for cooling the compression nozzle at said contracted throat and said condensing chamber.

7. Vacuum apparatus comprising a condensing chamber, mercury-vapour separating means communicating with said chamber and providing an air outlet therefor, a compression nozzle opening into the condensing chamber, an ejector nozzle discharging through the compression nozzle, a mercury vapor generator supplying the ejector nozzle, means for cooling the condensing chamber, a conduit for returning condensate from said chamber to the generator, and a barometric seal in said conduit.

8. A vapor jet vacuum pump comprising a boiler for generating vapor at substantially super-atmospheric pressure, a vapor discharge nozzle extending from said boiler, a compression nozzle having a converging combining tube, a throat at the narrow end of said tube, a discharge tube extending from said throat on the other side of said combining tube, said vapor discharge nozzle extending into said combining tube opening toward said throat, a condensing chamber associated with said discharge tube, a gas inlet opening into said combining tube back of said nozzle, a gas discharge opening in said condensing chamber, means for cooling the compression nozzle and the condensing chamber, and a vapor trap associated with said discharge opening for permitting escape of compressed air to the atmosphere while preventing the escape of vapor.

9. In combination, a pair of serially-connected vacuum pumps of the mercury vapor discharge type, one of said pumps constituting the primary unit and being arranged for impelling gas from a relatively high vacuum against a relatively low pressure head, the other of said pumps constituting the secondary unit and being arranged to impel the exhaust from the primary unit for discharge under atmospheric pressure conditions, a distinct mercury boiler for the primary unit, a distinct mercury boiler for the sescondary unit, means for maintaining a pressure difference between the two serially-connected pumps under absence of mercury vapor action, said means permitting gas flow in the direction from the low pressure inlet toward the atmosphere only, and means for substantially simultaneously initiating the heating of the boilers in said two pumps.

10. In vacuum apparatus, a vapour generator, a chamber disposed above and communicating with said generator and being operable to receive and effect condensation of the vapour supplied thereby, and a trap providing a vapour-condensate return from said chamber to said generator and comprising legs disposed below the normal level of the operating liquid in said generator, one of said legs being connected to said chamber, the other of said legs being connected to said generator at substantially such normal level.

In testimony whereof I have hereunto subscribed my name at Zurich, Switzerland, on the 15th day of February, A. D. 1926.

OSKAR SEITZ.