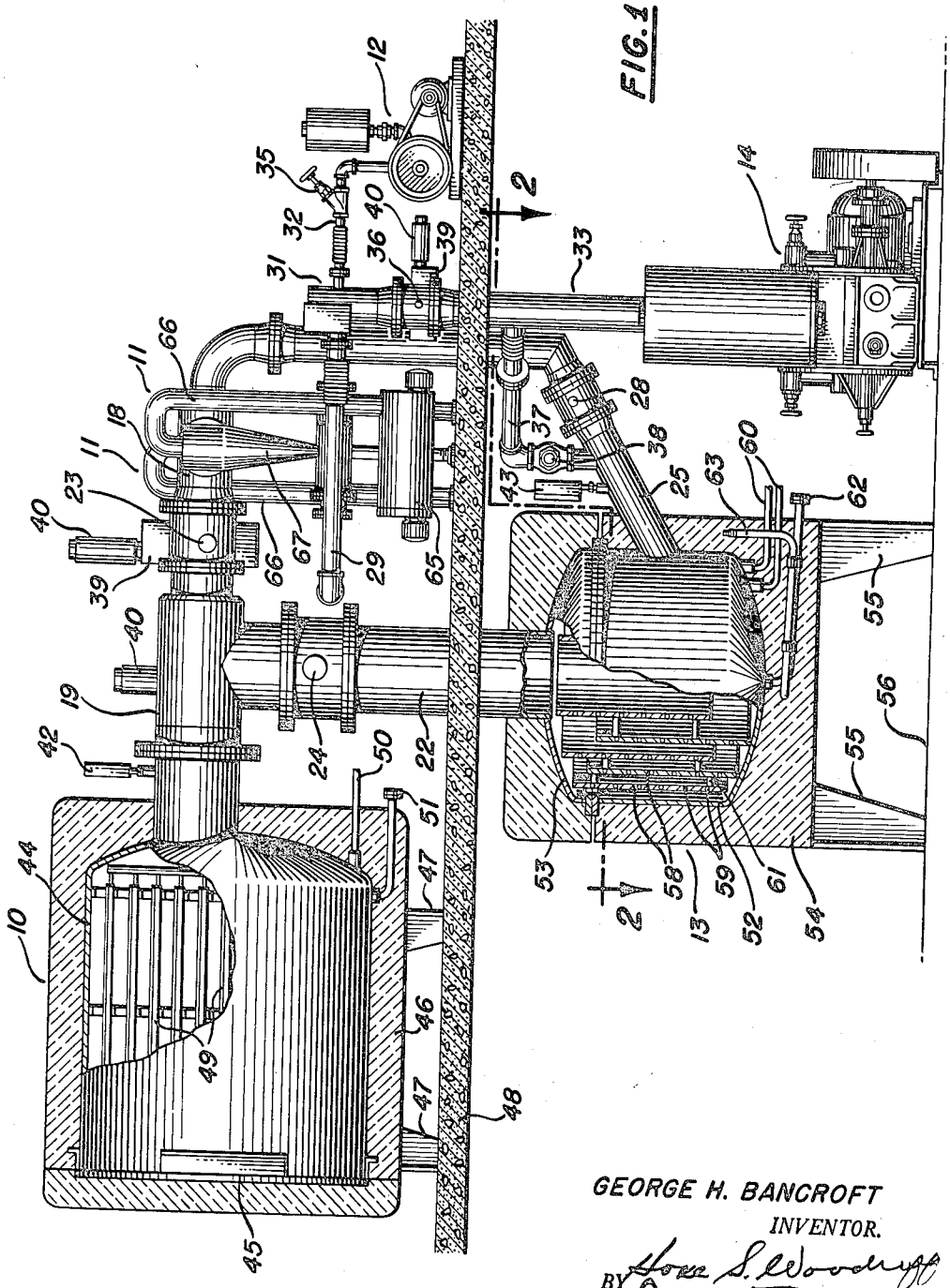
Jan. 24, 1956 G. H. BANCROFT 2,731,734

VACUUM DEHYDRATION APPARATUS

Filed June 9, 1953

2 Sheets-Sheet 1

FIG. 1



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2 Sheets-Sheet 2

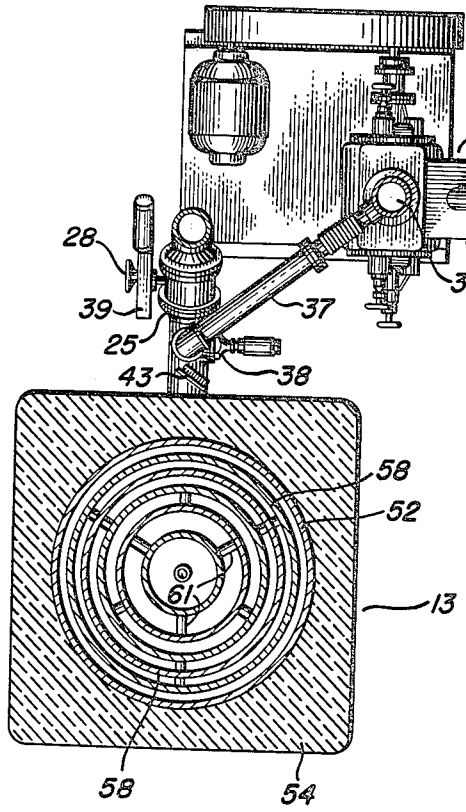


FIG. 2

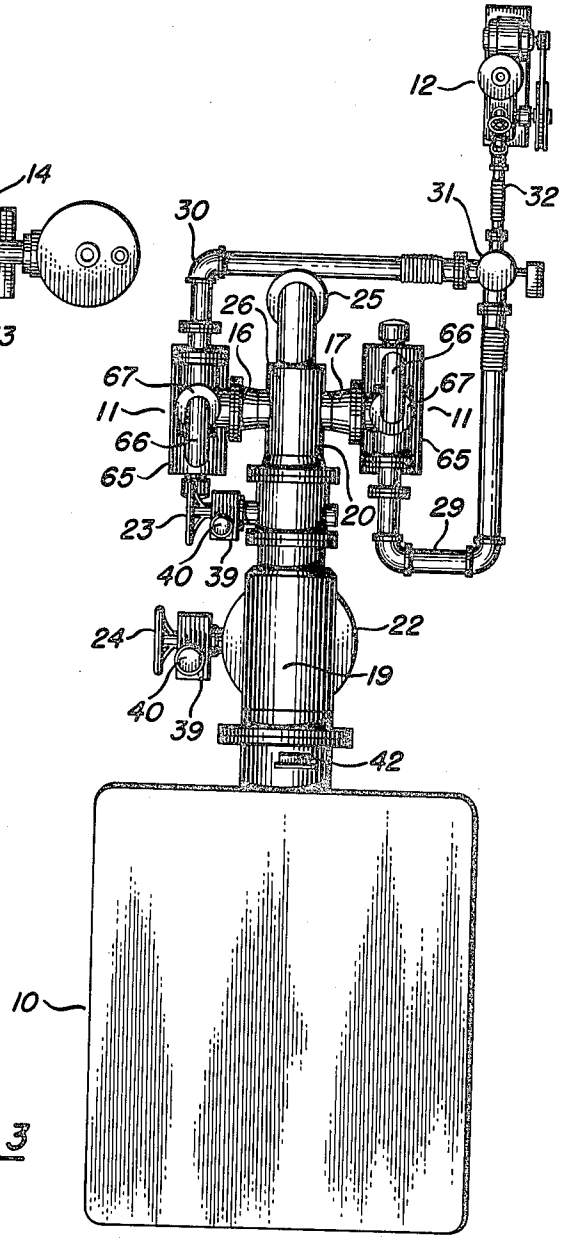


FIG. 3

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VACUUM DEHYDRATION APPARATUS

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4 Claims. (Cl. 34—76)

This invention relates to apparatus particularly adapted for dehydrating heat-labile material under vacuum.

Vacuum dehydration is used rather extensively in the processing of heat-labile materials such as serums, vaccines and the like. The process usually involves freezing the material to be dehydrated and subjecting it in the frozen state to a reduced pressure below the vapor pressure of water whereby dehydration is effected by sublimation from the frozen state.

It is an object of this invention to provide improved vacuum dehydration apparatus.

It is another object of the invention to provide improved vacuum dehydration apparatus constructed for optimum performance throughout the dehydration process.

A further object of the invention is to provide vacuum dehydration apparatus wherein the difficulties normally attendant upon the dehydration due to changes in the concentration of water vapor during the processing are largely obviated.

Another object of the invention is to provide apparatus wherein maximum pumping capacity and maximum condensing capacity are available during the evolution of the largest volume of water vapors, and wherein the efficiency of evacuation is at an optimum level during the final stages of dehydration.

Another object of the invention is to provide improved vacuum dehydration apparatus wherein the condenser is effectively employed in condensing the largest volume of vapors during the initial stages of the dehydration and is cleared of condensate during the final stages of the dehydration without impairing or interrupting the progress of the process whereby the processing cycles are accelerated.

Another object of the invention is to provide vacuum dehydration apparatus particularly adapted for optimum efficiency throughout the various stages of the processing cycle.

Another object of the invention is to provide apparatus including particular elements combined in a particular new combination of unusual utility.

Another object of the invention is to facilitate the vacuum dehydration of heat-labile materials by the provision of improved apparatus for effecting such dehydration.

Other objects will be apparent from the drawings and from the description and claims which follow.

These and other objects are attained by means of this invention as fully described hereinafter with particular reference to a preferred embodiment illustrated by the drawings.

Of the drawings:

Fig. 1 is a view in elevation, partly broken away and in section, of a complete vacuum dehydration unit constituting a preferred embodiment of the invention;

Fig. 2 is a section taken along line 2—2 of Fig. 1 and particularly illustrating the condenser and large capacity mechanical pump; and

Fig. 3 is a plan view of the apparatus shown in Fig. 1 and particularly illustrating the pumping assembly.

With particular reference to the preferred embodiment illustrated in the drawings, the apparatus embodying the invention is constructed so as to be installed at two levels such as on two floors of a processing plant. A dehydration chamber 10, a pair of ejector pumps 11, 11 and a small capacity mechanical vacuum pump 12 are mounted on the upper level, and a condenser or cold trap 13 and a large capacity mechanical vacuum pump 14 are mounted at the lower level.

Ejector pumps 11, 11 are mounted in side by side relation adjacent to chamber 10 and the intake ports of pumps 11, 11 are connected to two legs 16 and 17 of a four-way union 18. Chamber 10 is connected directly with the intake side of pumps 11, 11 by a large diameter primary conduit 19 which is connected to a third leg 20 of union 18. A large diameter branch conduit 22 connects primary conduit 19 and with inlet side of cold trap 13. Valve 23 in primary conduit 19 between branch conduit 22 and union 18 serves to close off conduit 19 and isolate chamber 10 from direct connection with pumps 11, 11. A similar valve 24 in branch conduit 22 is arranged to isolate cold trap 13 from direct communication with chamber 10.

The outlet side of cold trap 13 is connected to the intake side of pumps 11, 11 by secondary conduit 25 which is connected to the fourth leg 26 of union 18. A valve 28 in secondary conduit 25 is arranged to shut off communication between cold trap 13 and pumps 11, 11.

Pumps 11, 11 discharge through outlet conduits 29 and 30 respectively which merge at a four way fitting 31. Fitting 31 is also connected to a small discharge conduit 32 leading to the small capacity mechanical vacuum pump 12 and a large discharge conduit 33 which connects with the inlet of large capacity mechanical pump 14. A valve 35 in discharge conduit 32 serves to isolate pump 12, and a similar valve 36 in discharge conduit 33 serves to isolate pump 14 from the system. A bypass conduit 37 is connected to secondary conduit 25 between cold trap 13 and secondary conduit valve 28 and discharges into discharge conduit 33 leading to the large mechanical pump 14. Bypass conduit 37 is provided with a shut off valve 38 for breaking direct connection between cold trap 13 and pump 14.

The various valves 23, 24, 28, 36 and 38 are provided with block heaters 39, 39 and thermostats 40, 40 in order to keep the valves from becoming frozen. A Pirani gauge 42 or other suitable vacuum gauge in primary conduit 19 adjacent chamber 10, and a similar Pirani gauge 43 in secondary conduit 25 allow a continuing measure of the degree of vacuum within the system.

Dehydration chamber 10 comprises a barrel-like metal shell 44 provided with a removable end wall 45 for loading and unloading the chamber. Shell 44 and end wall 45 are encased in a heavy layer 46 of insulating material, and the entire unit is mounted on legs 47, 47 which rest on the floor of the upper level as indicated at 48. Inside chamber 10 are the usual racks 49, 49 which carry internal coils for the circulation of controlled temperature brine which is supplied through inlet line 50 and discharged through outlet line 51, both of which are connected to a suitable compressor (not shown) for refrigeration.

Cold trap 13 comprises a pot shell 52 and removable cover 53 encased in an insulating layer 54 and mounted on legs 55, 55 which rest on the floor of the lower level as indicated at 56. A plurality of concentric condenser plates 58, 58 are mounted vertically within shell 52 in staggered relation such that the inner condenser plate and each alternate plate has its upper end contiguous to cover 53 and its lower end well spaced from the bottom

of shell 52 and the remainder of plates 58, 58 are mounted with their lower ends contiguous to the bottom of shell 52 and their upper ends spaced from cover 53.

The lower end of branch conduit 22 opens through cover 53 into the space within the innermost of condenser plates 58, 58, and secondary conduit 25 opens out of the side of shell 52 outside the outermost condenser plate whereby vapors entering cold trap 13 must traverse a tortuous path around the condenser plates to reach the outlet into secondary conduit 25. Condenser plates 58, 58 are fabricated to provide internal fluid channels 59, 59 for the circulation of refrigerant through the plates, and refrigerant lines 60, 60 connect plates 58, 58 with a compressor (not shown). Spacer tubes 61, 61 maintain proper spacing between plates 58, 58 and afford communication between channels 59, 59 in adjacent plates. A drain line 62 opens out of the bottom of shell 52 and is traced with a heater line 63 to free it of ice.

Pumps 11, 11 are desirably of the ejector type employing an organic pump fluid and comprise the usual boiler 65, ejector tube stack 66, and diffuser tube 67. Pump fluid vapors generated in the boiler ascend the ejector stack and are discharged through a flared ejector nozzle into the diffuser tube adjacent the intake end of the pump. Pumps 12 and 14 are conventional mechanical vacuum pumps such as are well known in the art.

In operating the apparatus illustrated by the drawings, the material to be dehydrated is either frozen before introduction into the dehydration chamber or is placed on the racks in the chamber and frozen by circulation of refrigerated brine through the coils in the racks. During the initial rough pumping when the greatest volume of vapors is being evolved, valve 24 in branch conduit 22 and valve 38 in bypass conduit 37 are both open, and valve 23 in primary conduit 19, valve 28 in secondary conduit 25 and valve 36 in discharge conduit 33 are closed whereby the vapor path is out of the chamber through primary conduit 19, into branch conduit 22, through cold trap 13, and thence from secondary conduit 25 into bypass conduit 37 and to the large mechanical pump 14. In this initial stage of the dehydration cycle, ejector pumps 11, 11 and small mechanical pump 12 are isolated from the system. Refrigerant circulated through the plates of cold trap 13 effectively freezes out the major part of the water vapor and such minor amounts as are drawn into pump 14 do not seriously affect its operation since they are progressively purged from the pump fluid by operation of the pmup.

When the initial large volume of vapors has been drawn off and the pressure drops to a value where the ejector pumps are necessary, as for example about 3 mm. pressure, valve 28 in secondary conduit 25 and valve 36 in discharge conduit 33 are opened and valve 38 in bypass conduit 37 is closed. The vapor path is then from chamber 10 into cold trap 13 through conduits 19 and 22 and thence out secondary conduit 25 to pumps 11, 11 which discharge through outlet lines 29 and 30 into discharge conduit 33 and thence to large pump 14 which acts as a backing pump for pumps 11, 11. This arrangement is maintained until the dehydration cycle nears completion. As the volume of gases being pumped decreases, pump 14 can be cut out of the system by closing valve 36 and the smaller pump 12 used as backing pump by opening valve 35 in discharge conduit 32.

When all but a few percent of the moisture has been removed from the material being dehydrated, the cold trap 13 is isolated from the system by closing valve 24 in branch conduit 22 and the ejector pumps 11, 11 are connected directly to chamber 10 by opening valve 23 in primary conduit 19. The low moisture content of the pumped vapors does not deleteriously affect the operation of pumps 11, 11 and the pumping efficiency is increased to optimum by shortening the pumping path and thus greatly lessening the impedance in the system. The small pump 12 is of sufficient capacity to serve effectively

as a backing pump for pumps 11, 11 during such direct operation. In the usual dehydrating process, the material being dehydrated can be allowed to warm up during the final stages of the cycle whereby the vapor pressure of the moisture being removed is increased and the dehydration is facilitated.

During the final stages of the dehydration cycle when cold trap 13 is isolated from the system, it can be purged of condensate by circulating warm fluid through the condenser plates and drawing off the resulting liquid condensate from the trap through drain 62. In this way, the processing of successive batches is facilitated since the cold trap is ready for another cycle by the time the material being processed is finished.

During the processing cycle, the various block heaters 39, 39 serve to maintain the valves in operating condition. Although the various stages of the process can be run on a time cycle, it is desirable to follow the course of the dehydration and change the pumping combinations according to the pressure in the system. This is done by means of Pirani gauges 42 and 43.

Thus, the process can be carried out in the following manner. During the initial stages of the process, the volume of vapors and gases being pumped will be high and the reading on Pirani gauge 43 will approach atmospheric pressure. When the pressure on gauge 43 begins to drop and approach the limit of the range of the mechanical pump, little water vapor is getting through the cold trap and pumps 11, 11 can be cut into the system. The course of the subsequent stages can then be followed on gauge 42 adjacent the chamber. When the pressure on this gauge has dropped well within the range of the ejector pumps 11, 11 and reaches a relatively steady value, the volume of vapors being evolved is small, and the cold trap can be cut out of the system. The pressure as measured on gauge 42 will continue downward slowly until a final steady value is reached. Pumping can be continued for a predetermined interval or discontinued at this point depending upon the degree of dehydration desired, the material being dehydrated and similar variable determinants. Similarly, the various stages of the process can be varied in accordance with usual dehydration practices.

The invention thus provides apparatus particularly adapted for effecting vacuum dehydration under optimum conditions throughout the processing cycle, and capable of use in closely spaced recurring cycles of operation. The apparatus is adapted for economical operation without the sacrifice of effectiveness, and lends itself to considerable variation in processing techniques and requirements. The apparatus is particularly adapted for maximum pumping speed and efficiency throughout the wide pressure range necessary for effective dehydration and under constantly changing conditions of vapor evolution.

Although the invention has been described in considerable detail with reference to a preferred embodiment thereof as illustrated in the drawings, it will be understood that variations and modifications can be effected within the spirit and scope of the invention as illustrated in the drawings and described hereinabove and as defined in the appended claims.

I claim:

1. Vacuum dehydration apparatus comprising an evacuable dehydration chamber, high vacuum pumping means disposed adjacent to said chamber, a primary conduit connecting said chamber directly to the intake side of said high vacuum pumping means, valve means in said primary conduit between said chamber and said high vacuum pumping means, condenser means disposed adjacent to said chamber, a branch conduit opening directly from said primary conduit into said condenser means, said branch conduit being joined to said primary conduit between said chamber and said valve means, a secondary conduit opening out of said condenser means remote from said branch conduit and connecting said condenser means

with the intake side of said high vacuum pumping means, mechanical pumping means, discharge conduit means connecting said mechanical pumping means with the discharge side of said high vacuum pumping means, valve means in said discharge conduit means, bypass conduit means connecting said condenser means with said mechanical pumping means, and valve means in said bypass conduit means.

2. Vacuum dehydration apparatus comprising an evacuable dehydration chamber, high vacuum pumping means disposed laterally from said chamber, a primary conduit connecting said chamber directly with the intake side of said high vacuum pumping means, condenser means, a branch conduit connecting said primary conduit directly with the inlet of said condenser means, valve means in said primary conduit between said branch conduit and said high vacuum pumping means, valve means in said branch conduit, a secondary conduit connecting the outlet of said condenser means with the intake side of said high vacuum pumping means, a mechanical vacuum pump, a second mechanical vacuum pump of smaller capacity than said first-named mechanical vacuum pump, discharge conduit means connecting said mechanical vacuum pumps with the discharge side of said high vacuum pumping means, and valve means in said discharge conduit means for selectively isolating each of said mechanical vacuum pumps from said high vacuum pumping means.

3. Vacuum dehydration apparatus comprising an evacuable dehydration chamber, ejector pumping means disposed adjacent to said chamber, a straight primary conduit connecting said chamber directly with the intake side of said ejector pumping means, a vapor condenser, said condenser having a central intake port and an outlet port remote from said intake port and having a plurality of concentric condenser elements arranged in vertically staggered relation for causing vapors to traverse a tortuous path from said intake port to said outlet port, a branch conduit connecting said primary conduit with said intake port, valve means in said primary conduit and said branch conduit for selectively isolating said ejector pumping means and said condenser respectively from direct connection with said chamber, a secondary conduit connecting the outlet port of said condenser with the intake side of said ejector pumping means, valve means for said secondary conduit, a large capacity mechanical vacuum pump, a discharge conduit connecting said large pump with the discharge side of said ejector pumping means, a smaller capacity mechanical vacuum pump, a discharge conduit connecting said smaller pump with the discharge side of said ejector pumping means, valve means for selectively isolating each of said mechanical pumps from said

ejector pumping means, a bypass conduit for connecting said condenser directly with said large pump, and valve means for closing off said bypass conduit.

4. Vacuum dehydration apparatus comprising an evacuable dehydration chamber, high vacuum pumping means disposed adjacent to said chamber, a primary conduit connecting said chamber directly with the intake side of said high vacuum pumping means, valve means for closing off said primary conduit, a condenser positioned directly below said primary conduit, said condenser comprising an evacuable condenser chamber, a plurality of vertically disposed generally concentric tubular condenser elements, said elements being alternately staggered vertically to define a tortuous vapor path through said chamber between said elements, an intake port opening through the top of said condenser chamber into the space defined within the innermost of said condenser elements, an outlet port opening out of said condenser chamber outside the outermost of said condenser elements, means for circulating condenser fluid through said condenser elements, and means for draining condensate from said condenser chamber, a branch conduit connecting said intake port with said primary conduit on the dehydration chamber side of said valve means for said primary conduit, valve means for closing said branch conduit, a secondary conduit connecting said outlet port of said condenser with the intake side of said high vacuum pumping means, valve means for closing said secondary conduit, mechanical pumping means for backing said high vacuum pumping means, discharge conduit means connecting said mechanical pumping means with the discharge side of said high vacuum pumping means, valve means for closing said discharge conduit means and isolating said mechanical pumping means from said high vacuum pumping means, bypass conduit means for connecting said outlet port of said condenser directly with said mechanical pumping means, and valve means for closing said bypass conduit means.

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