

UNITED STATES PATENT OFFICE.

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EJECTOR METHOD AND APPARATUS.

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To all whom it may concern:

Be it known that I, ROBERT SUCZEK, a citizen of the Czechoslovak Republic, residing in the city and county of Philadelphia, State of Pennsylvania, have invented certain new and useful Improvements in Ejector Methods and Apparatus, of which the following is a specification.

My invention relates to ejector apparatus employing elastic motive fluid, as steam, for entraining and raising to higher pressure another elastic fluid, as air, gas, vapor, or a mixture of any of them.

In accordance with my invention, the ejector structure, as the diffuser, is cooled, for example, as described in my prior Patent No. 1,282,977, October 29, 1918, the cooling medium serving also for extracting heat from associated condenser structure.

In accordance with my invention, an ejector may discharge the mixture of entrained and motive fluid into a condenser, in which the condensable component is condensed and the uncondensable component cooled, and the cooling medium for the condenser is employed also for extracting heat from the mixture of motive and entrained fluids, particularly while undergoing compression, as by conversion of velocity into pressure.

In accordance with my invention, an ejector, or part thereof, may be built in or constitute part of a condenser structure; and such condenser structure may be employed for condensing the mixture of motive and entrained fluids discharged by the ejector.

Further, in accordance with my invention an ejector may discharge into an interstage condenser which in turn discharges to the suction of a second stage ejector, parts of the ejectors, as their diffusers, being cooled by the medium which cools the interstage condenser; and a further condenser into which the second stage ejector discharges may be similarly associated or related.

My invention resides in the method and apparatus hereinafter described and claimed.

For an illustration of one of the various forms my invention may take, reference is to be had to the accompanying drawing, in which:

Fig. 1 is a vertical sectional view of apparatus embodying my invention.

Fig. 2 is a plan view of the structure shown in Fig. 1 with the top removed.

Referring to the drawing, C is the shell or body of the condenser or combined condenser and ejector structure provided at opposite ends with the tube sheets *a* and *b*, through which extend a plurality of vertical tubes *c* and *c*¹, of different groups. The tube sheet *a* forms one wall of a chest or box B having the removable cover *d* and the side wall *e*. Within the box B is formed by the wall *f* the suction chamber *g*, with which communicates the suction port or intake *h* connected to a condenser, not shown, or other device or region from which air or other elastic fluid is to be withdrawn and raised to higher pressure. Carried by the cover *d* is a nozzle plate *i* carrying ejector nozzle structure, in this instance comprising a plurality of nozzles N, which extend into the suction chamber *g* and whose intakes communicate with the motive fluid or steam chamber *j*, to which steam or other motive fluid is delivered through the strainer *k* and delivered by the pipe *m* controlled by the valve *n*. Aligned with the nozzles N is the ejector diffuser D, in this instance illustrated as a converging-diverging tube. The diffuser is carried by the tube sheets *a* and *b* and discharges into the chamber *o* of the lower box or chest B¹, which has a partition *p* completely separating the chamber *o* from the chamber *q*. The first group of tubes *c* communicate with the chamber *o* at their lower ends, and at their upper ends communicate with the chamber *r* in the chest B, the chamber *r* being formed between the wall *f* of the suction chamber and the wall or partition *s*.

The chamber *r* receives the discharge from the condenser tubes *c* of the first group, and constitutes also the suction chamber of the second stage ejector whose diffuser, indicated at D¹, is carried by the tube sheets *a* and *b* and is aligned with the second stage nozzle structure N¹, communicating with the steam or motive fluid chamber *t*, with which communicates the aforesaid pipe *m*, and which receives steam through the strainer *u* delivered thereto by the main steam pipe *v*. The diffuser D¹ discharges into the chamber *q*, with which communicate at their lower ends the tubes *c*¹ of the second group of tubes, these tubes discharging into the chamber *w* in chest B, such chamber being formed between the

partition or wall *s* and the peripheral wall *e* of the chest B. At *x* is shown the discharge port communicating directly with atmosphere or with any region under any desired pressure.

Associated with each group of tubes may be one or more drainage tubes *y* having its upper end flush with the upper surface of the tube sheet *a*, whereby any liquid above the tube sheet *a* may be drained downwardly through the tube *y* and then escape into the chest B¹, each tube being provided with a suitable liquid seal structure *z*. The condenser tubes preferably project, as indicated, suitably above the tube sheet *a*, so that any liquid accumulating thereon will not interfere with upward passage through the tubes of the ejector discharge.

Communicating with the chamber *o* is the drainage pipe *a*¹, through which is drawn off any liquid or condensate received in the chamber *o*, such liquid or condensate being conducted back under vacuum to the main condenser or to any other suitable destination. Similarly, the pipe *b*¹ drains the chamber *q*, the drainage being conducted back to the main condenser or to any other suitable destination, or may be discharged at atmospheric pressure.

Between the tubes of the first and second groups is disposed the downwardly extending baffle or dividing plate *d*¹, which at its lower end is spaced above the tube sheet *b*. Communicating with the interior of the shell C is the inlet *e*¹ for the cooling medium, which may be water, condensate or any other suitable medium. This cooling medium passes between the tubes *c* of the first group and around and in contact with the diffuser D of the first stage ejector, and thence passes the lower edge of the baffle *d*¹ and thence between the tubes *c*¹ of the second group and around and in contact with the diffuser D¹ of the second stage ejector, the cooling medium then passing off through the outlet *f*¹.

The operation is as follows:

Steam or other motive fluid is delivered through the pipe *v* to the nozzle structures N and N¹ of both ejectors. The jets from the nozzles of the first stage ejector entrain the air or other elastic fluid entering at *h*, and the mixture of motive and entrained fluids is projected at high velocity into the diffuser D, where the velocity is reduced while effecting increase in pressure. The mixture of motive and entrained fluids is discharged into the chamber *o* and then passes upwardly through the tubes *c* of the first group or interstage condenser, and in these tubes the condensable component of the ejector discharge, as the steam or other condensable fluid, is condensed, the condensate running downwardly through the tubes *c* into the chamber *o*, from which it is with-

drawn through the pipe *a*¹. The uncondensed component, as the air originally entering at *h*, is discharged into the chamber *r*, which it reaches substantially free of steam or condensable fluid, and cooled. It is then acted upon by the jets from the second stage nozzle structure N¹ and projected at high velocity into the diffuser D¹, where again further compression with loss of velocity takes place. The second stage motive fluid and the air or other entrained fluid is discharged into the chamber *q*, in which the pressure may be atmospheric or substantially atmospheric, or any other suitable pressure. The mixture then passes upwardly through the tubes *c*¹ of the second group or condenser. The condensable component, as the steam from the nozzle structure of the second stage, is condensed, the condensate running down the tubes *c*¹ into the chamber *q*, from which it is withdrawn through the pipe *b*¹. The air or other uncondensable fluid is discharged into the chamber *w*, from which it passes off through the port *x*.

The cooling water or medium while the above action takes place also cools the diffusers D and D¹, and so abstracts heat from the mixtures of motive fluid and entrained fluid while undergoing compression, effecting results of the character referred to in the aforesaid Patent 1,282,977.

In accordance with my invention, therefore, the structure is such that the medium which cools the mixture of motive and entrained fluids of an ejector also cools the heat transfer structure of the condenser into which the mixture is discharged.

And by an arrangement of the character described, the structure is made compact in that the ejector structure is part of or built in the condenser structure.

It will be understood that my invention is not limited to the employment of a single cooling medium. By dividing the shell C into different compartments, a plurality of cooling media may be employed. For example, the diffuser D may be cooled by one medium and the tubes *c* by another, and similarly in the case of the diffuser D¹ and tubes *c*¹. Or the diffuser D and the tubes *c* may be cooled by one medium, and the diffuser D¹ and the tubes *c*¹ by another medium.

What I claim is:

1. The method of compressing elastic fluid, which consists in expanding an elastic motive fluid, entraining therein the elastic fluid to be compressed, compressing the mixture of motive and entrained fluids by conversion of velocity into pressure, causing transfer to a cooling medium of heat from said mixture while undergoing compression, and thereafter condensing from said mixture the condensable component thereof.

2. The method of compressing elastic fluid, which consists in expanding an elastic

motive fluid, entraining therein the elastic fluid to be compressed, compressing the mixture of motive and entrained fluids by conversion of velocity into pressure, causing transfer to a cooling medium of heat from said mixture while undergoing compression, thereafter condensing from said mixture the condensable component thereof, in a second stage expanding motive fluid, entraining therein the uncondensed component of said mixture, and compressing to higher pressure the mixture of said uncondensed fluid and said second stage motive fluid by conversion of velocity into pressure.

3. The method of compressing elastic fluid, which consists in expanding an elastic motive fluid, entraining therein the elastic fluid to be compressed, compressing the mixture of motive and entrained fluids by conversion of velocity into pressure, causing transfer to a cooling medium of heat from said mixture while undergoing compression, thereafter condensing from said mixture the condensable component thereof, in a second stage expanding motive fluid, entraining therein the uncondensed component of said mixture, compressing to higher pressure the mixture of said uncondensed fluid and said second stage motive fluid by conversion of velocity into pressure, and extracting heat from said second stage mixture while undergoing compression.

4. The method of compressing elastic fluid, which consists in expanding an elastic motive fluid, entraining therein the elastic fluid to be compressed, compressing the mixture of motive and entrained fluids by conversion of velocity into pressure, causing transfer to a cooling medium of heat from said mixture while undergoing compression, thereafter condensing from said mixture the condensable component thereof, in a second stage expanding motive fluid, entraining therein the uncondensed component of said mixture, compressing to higher pressure the mixture of said uncondensed fluid and said second stage motive fluid by conversion of velocity into pressure, extracting heat from said second stage mixture while undergoing compression, and thereafter condensing from said second stage mixture the condensable component thereof.

5. The method of compressing elastic fluid, which consists in expanding an elastic motive fluid, entraining therein the elastic fluid to be compressed, compressing the mixture of motive and entrained fluids by conversion of velocity into pressure, causing transfer to a cooling medium of heat from said mixture while undergoing compression, and thereafter condensing by said cooling medium the condensable component of said mixture.

6. The method of compressing elastic fluid, which consists in expanding an elastic

motive fluid, entraining therein the elastic fluid to be compressed, compressing the mixture of motive and entrained fluids by conversion of velocity into pressure, causing transfer to a cooling medium of heat from said mixture while undergoing compression, thereafter condensing by said cooling medium the condensable component of said mixture, compressing the uncondensable component by similar action of a motive fluid in a second stage, and extracting heat from the second stage mixture while undergoing compression.

7. The method of compressing elastic fluid, which consists in expanding an elastic motive fluid, entraining therein the elastic fluid to be compressed, compressing the mixture of motive and entrained fluids by conversion of velocity into pressure, causing transfer to a cooling medium of heat from said mixture while undergoing compression, thereafter condensing by said cooling medium the condensable component of said mixture, compressing the uncondensable component by similar action of a motive fluid in a second stage, and extracting heat by said cooling medium from the second stage mixture while undergoing compression.

8. The method of compressing elastic fluid, which consists in expanding an elastic motive fluid, entraining therein the elastic fluid to be compressed, compressing the mixture of motive and entrained fluids by conversion of velocity into pressure, causing transfer to a cooling medium of heat from said mixture while undergoing compression, thereafter condensing by said cooling medium the condensable component of said mixture, compressing the uncondensable component by similar action of a motive fluid in a second stage, extracting heat by said cooling medium from the second stage mixture while undergoing compression, and thereafter condensing by said cooling medium the condensable component of said second stage mixture.

9. The combination with an ejector, of a condenser into which said ejector discharges, a second ejector withdrawing uncondensed elastic fluid from said condenser and raising it to higher pressure and means for cooling the diffuser of said first named ejector by the cooling medium of said condenser.

10. The combination with an ejector, of a condenser into which said ejector discharges, and means for cooling said ejector and condenser with the same cooling medium.

11. The combination with an ejector comprising nozzle and diffuser structures, of a condenser into which said diffuser discharges, and means for passing the same cooling medium in heat transfer relation with said diffuser structure and with the heat transfer structure of said condenser.

12. The combination with an ejector com-

prising nozzle and diffuser structures, of a condenser comprising a plurality of tubes into which said diffuser discharges, and means for passing the same cooling medium between said tubes and in contact with said diffuser structure.

13. The combination with an ejector comprising nozzle and diffuser structures, of a shell within which said diffuser structure is disposed, condenser tubes within said shell, and means for passing cooling medium into and from said shell in contact with said tubes and said diffuser structure.

14. The combination with an ejector comprising nozzle and diffuser structures, of a shell within which said diffuser structure is disposed, condenser tubes into which said diffuser discharges disposed in said shell, and connections for passing cooling medium into and from said shell in contact with said tubes and said diffuser structure.

15. The combination with a plurality of ejectors, an interstage condenser, and means for extracting heat by the cooling medium of said condenser from the mixtures of said ejectors while undergoing compression.

16. The combination with a plurality of ejectors, an interstage condenser, means for extracting heat by the cooling medium of said condenser from the mixtures of said ejectors while undergoing compression, and a second condenser into which a second of said ejectors discharges.

17. The combination with a plurality of ejectors, an interstage condenser, means for extracting heat by the cooling medium of said condenser from the mixtures of said ejectors while undergoing compression, and a second condenser into which a second of said ejectors discharges, said cooling medium cooling said second condenser.

18. The combination with a plurality of ejectors, a condenser between two of said ejectors, a second condenser receiving discharge from a second of said ejectors, and means for cooling each of said ejectors and the condenser into which it discharges by the same cooling medium.

19. The combination with a shell, of tube sheets spaced from each other, tubes within said shell extending through said sheets, a diffuser of an ejector extending through said sheets, a chamber into which said diffuser discharges and with which said tubes communicate, a chamber with which the other ends of said tubes communicate, and an ejector suction chamber adjacent said second named chamber.

20. The combination with a shell, of spaced tube sheets, chests on opposite ends of said shell, a partition in one of said chests forming separate chambers one of which is the suction chamber of an ejector, the diffuser of the ejector extending through said sheets and communicating at its one end

with said suction chamber, a chamber in the other chest into which said diffuser discharges, and a plurality of tubes extending through said sheets and connecting said last named chamber with the second of said first named chambers.

21. The combination with a shell, of spaced tube sheets, an ejector diffuser and a plurality of condenser tubes disposed in said shell and extending through said sheets, said diffuser discharging into said tubes, a chest having one of said sheets as a wall, a partition in said chest forming the ejector suction chamber and a separate chamber into which said tubes discharge, and ejector nozzle structure carried by a wall of said chest.

22. The combination with a shell, of spaced tube sheets, an ejector diffuser and a plurality of condenser tubes disposed in said shell and extending through said sheets, said diffuser discharging into said tubes, a chest having one of said sheets as a wall, a partition in said chest forming the ejector suction chamber and a separate chamber into which said tubes discharge, and a second ejector diffuser extending through said shell and sheets, the suction chamber of the second ejector being said separate chamber into which said tubes discharge.

23. The combination with a shell, of separated tube sheets, a plurality of groups of tubes extending through said shell and said sheets, a chest on each end of said shell, an ejector for each group of tubes, the ejector diffusers extending through said shell and said sheets, one of said chests having three chambers the first of which is the suction chamber of one ejector, the second the suction chamber of a second ejector into which the first group of tubes discharges, and the third a chamber into which the second group of tubes discharges, the second chest having two chambers into one of which the diffuser of the first ejector discharges and with which the first group of tubes communicates, and the second into which the diffuser of the second ejector discharges and with which the second group of tubes communicates.

24. The combination with a shell, of tube sheets spaced from each other, tubes within said shell extending through said sheets, a diffuser of an ejector extending through said sheets and said shell, a chamber into which said diffuser discharges and with which said tubes communicate, a chamber with which the other ends of said tubes communicate, an ejector suction chamber adjacent said second named chamber, and means for passing through said shell cooling medium contacting with said tubes and said diffuser.

25. The combination with a shell, of spaced tube sheets, chests on opposite ends

of said shell, a partition in one of said chests forming separate chambers one of which is the suction chamber of an ejector, the diffuser of the ejector extending through said shell and sheets and communicating at its one end with said suction chamber, a chamber in the other chest into which said diffuser discharges, a plurality of tubes extending through said sheets and connecting said last named chamber with the second of said first named chambers, and means for passing through said shell cooling medium contacting with said tubes and said diffuser.

26. The combination with a shell, of spaced tube sheets, an ejector diffuser and a plurality of condenser tubes disposed in said shell and extending through said sheets, said diffuser discharging into said tubes, a chest having one of said sheets as a wall, a partition in said chest forming the ejector suction chamber and a separate chamber into which said tubes discharge, ejector nozzle structure carried by a wall of said chest, and means for passing through said shell cooling medium contacting with said tubes and said diffuser.

27. The combination with a shell, of spaced tube sheets, an ejector diffuser and a plurality of condenser tubes disposed in said shell and extending through said sheets, said diffuser discharging into said tubes, a chest having one of said sheets as a wall, a partition in said chest forming the ejector suction chamber and a separate chamber into which said tubes discharge, a second ejector diffuser extending through said shell and sheets, the suction chamber of the second ejector being said separate chamber into which said tubes discharge, and means for passing through said shell cooling medium contacting with said tubes and said diffusers.

28. The combination with a shell, of separated tube sheets, a plurality of groups of tubes extending through said shell and said sheets, a chest on each end of said shell, an ejector for each group of tubes, the ejector diffusers extending through said shell and said sheets, one of said chests having three chambers the first of which is the suction

chamber of one ejector, the second the suction chamber of a second ejector into which the first group of tubes discharges, and the third a chamber into which the second group of tubes discharges, the second chest having two chambers into one of which the diffuser of the first ejector discharges and with which the first group of tubes communicates, and the second into which the diffuser of the second ejector discharges and with which the second group of tubes communicates, and means for passing through said shell cooling medium contacting with said diffusers and the tubes of said groups.

29. The combination with a plurality of ejectors, of an interstage condenser, a condenser into which a later stage ejector discharges, and means for cooling said condensers and ejectors by the same cooling medium.

30. The combination with an ejector comprising nozzle structure and diffuser structure, of a plurality of tubes disposed side by side with said diffuser structure, and means for passing a cooling medium in contact with said tubes and said diffuser structure.

31. The combination with an ejector comprising nozzle structure and diffuser structure, of a plurality of tubes into which said diffuser structure discharges and disposed side by side with said diffuser structure, and means for passing a cooling medium in contact with said tubes and said diffuser structure.

32. The combination with an ejector comprising nozzle structure and diffuser structure, of a plurality of parallel tubes into which said diffuser structure discharges, the axis of said diffuser structure being substantially parallel with said tubes, and means for passing a cooling medium around said diffuser structure and said tubes.

In testimony whereof I have hereunto affixed my signature this 14th day of December, 1920.

ROBERT SUCZEK.