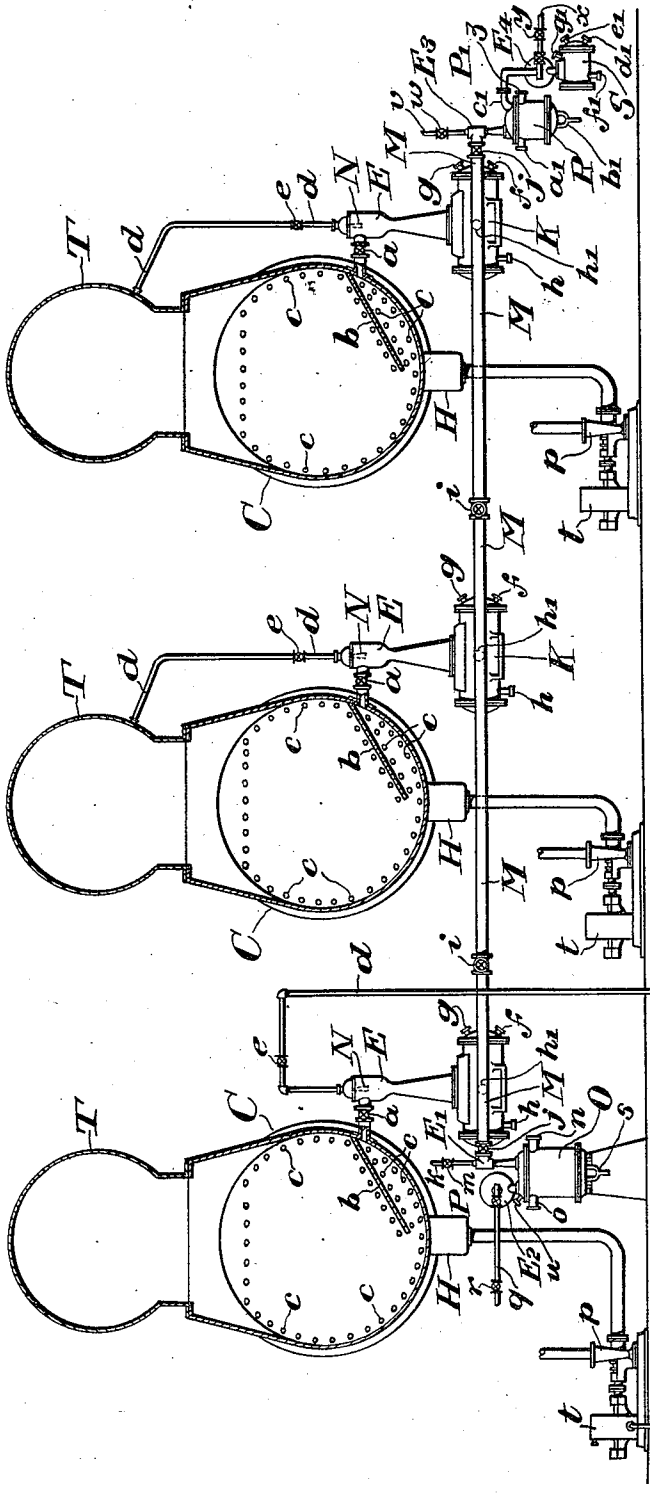
June 12, 1923. 1,458,737

R. SUCZEK

SYSTEM OF VACUUM PRODUCTION

Filed March 18, 1922



NOTE:- E^1 & E^2 are Ejectors.

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UNITED STATES PATENT OFFICE.

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SYSTEM OF VACUUM PRODUCTION.

Application filed March 18, 1922. Serial No. 544,815.

To all whom it may concern:

Be it known that I, ROBERT SUCZEK, a citizen of the United States, residing in the city and county of Philadelphia, State of Pennsylvania, have invented certain new and useful Improvements in Systems of Vacuum Production, of which the following is a specification.

My invention relates to a system for producing vacuum, and more particularly for producing or maintaining a vacuum in a plurality of vessels, as steam condensers.

In accordance with my invention, a vacuum is produced or maintained in each of a plurality of vessels, as steam condensers, vacuum pans, etc., by any suitable vacuum-producing means, as one or more pumps, or one or more ejectors, common to the vessels, and an ejector augmenter intervening between each of the vessels and the common vacuum-producing means, the augmenter ejector preferably, though not necessarily, employing as motive fluid exhaust or other low pressure steam or other elastic motive fluid.

Further in accordance with my invention, the aforesaid vacuum-producing means common to the vessels may comprise a plurality of vacuum-producing apparatus of different capacities whereby one or any number of them may be employed to accord with variations of load or demand.

My invention resides in apparatus of the character 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, which is an elevational view, partly in section, of a system or apparatus embodying my invention.

Referring to the drawing, C, C, C represent, generically, any number of vessels in each of which a vacuum is to be produced or maintained. These vessels may be steam condensers of any type, vacuum pans of any type, or any other vessel; one or more of them may be of one type and one or more of them of another type or other types.

In the example of my invention to be described, the vessels C are condensers such, for example, as used in steam power plants for condensing the steam from the engines or turbines.

In the example illustrated, the vessels C are surface condensers into which is delivered the exhaust steam from the turbines T. The steam passes between the numerous condenser tubes *c*, through which cooling water is passed, as well understood in the art. The condensate collects in the hot well H, from which it is withdrawn by the condensate-removal pump *p* driven by any suitable means, as an electric motor, or, as indicated, a steam turbine *t*.

While it is preferred, as indicated, that each condenser be provided with its condensate-removal pump, a single condensate pump may be employed with its suction connected to the several hot wells H. And while it is preferred, as indicated, that the several condensate-removal pumps *p* be driven by an individual turbine or motor *t*, it will be understood that a single motor or turbine may drive all the condensate-removal pumps *p*.

Communicating through a valve *a* with any suitable region within each condenser C, as beneath or behind the baffle *b*, is the suction chamber of an ejector augmenter E whose nozzle structure N is supplied with elastic motive fluid, as steam, and preferably exhaust or low pressure steam, from any suitable source. As indicated at the left of the figure, the exhaust steam, of substantially atmospheric pressure, or of a pressure several pounds below or above atmospheric pressure, is supplied through the pipe *d*, controlled by the valve *e*, connected with the exhaust of the turbine *t* driving the pump *p* of the associated condenser C. Or, as indicated at the middle and right of the figure, the pipe *d* may be connected with a suitable stage of the turbine T for withdrawing therefrom steam of suitable pressure, preferably of the order above indicated.

Each of the ejectors E discharges its mixture of motive fluid and air and uncondensable gases or vapors withdrawn from the condenser C into a condenser K of any suitable type. In the example illustrated, the condenser K is a surface condenser into the spaces between whose tubes the discharge passes. Through the tubes is passed cooling water entering, for example, at *f* and leaving at *g*.

The condensate or condensed motive fluid steam is drawn off through the condensate

outlet h, while the air and any uncondensed gases, vapors or motive steam is discharged at h^1 into the omnibus pipe or manifold chamber M. The manifold or pipe M is common to the ejecter augmenters E, whether or not the condensers K be employed. The valves i serve to isolate different parts or sections, or one or more parts or sections, of the manifold pipe M when suitable or desirable. P represents generically any vacuum-producing means, which may be a single vacuum pump or a plurality of vacuum pumps in series with each other. Or, as preferred and indicated, the vacuum-producing means may be an ejector E^1, or an ejector E^1 in series with another ejector E^2, the latter being indicated, by way of example, as of the type disclosed in Letters Patent of the United States No. 1,282,595; and either E or E^1 or both, may be of that radial flow type. The suction chamber of the ejector E^1 communicates through a valve j with any suitable portion, as one end, of the manifold pipe M. Motive fluid, perferably live or high pressure steam, as of from 70 pounds to 150 pounds, more or less, is delivered to the nozzle structure of the ejector E^1 through the pipe k controlled by the valve m. The ejector E^1 discharges to atmosphere or into any other suitable vessel. It may discharge as indicated into a surface condenser O, whose cooling water may enter at n and leave at o. The air or other uncondensable gas or vapor may be discharged from the condenser O to atmosphere or other suitable region, in which case the condenser serves as a so-called "after" condenser. As indicated, however, the air and other uncondensable gas or vapor from which the motive fluid steam from the ejector E^1 has been condensed is delivered to the suction of the second condenser E^2, whose nozzle structure receives motive fluid, preferably live or high pressure steam, through the pipe q controlled by the valve r. The discharge of the ejector E^2 may pass to atmosphere or any other desired region. In the example illustrated, however, it discharges into a second section of the condenser O in which the motive steam and other condensable vapors are condensed, the condensate being drawn off at s, as for example, into the hot well H or the pipe connecting the same to the pump p. The air and other uncondensable gas or vapor is then discharged to atmosphere or other suitable region at u. In the example indicated and described the condenser O is a so-called "inter and after" condenser.

By the system or apparatus described, the ejector augmenters E raise the pressure of the air and uncondensed vapors in the condensers C by several inches of mercury absolute pressure, as, for example, one to three or four inches in the case where the vessels C are steam condensers in which the absolute pressure is represented by one or two inches of mercury, more or less. The discharge pressures of the ejectors E are substantially the same, and, in any event, the pressure in the manifold pipe M is substantially the same throughout, with the result that whatever may be the varying loads upon the several vessels or condensers C, and whatever may be the variations between them as to the absolute pressures within them, the augmenter ejectors E raise the pressure of the exhausted air from different suctions pressures to substantially the same discharge pressure. The vacuum-producing means P then raises the pressure of the air and accompanying uncondensed gases or vapors to atmospheric pressure or to other suitable pressure.

In this way the exhaust steam, of otherwise small or slight value in a steam or similar plant, is employed to raise the pressure of the air extracted at different absolute pressures from the various condensers or vessels C to a common pressure from which the air and accompanying uncondensed vapors or gases are then raised by the vacuum-producing means P to suitable or desired higher pressure by employment of an amount of live or high pressure steam which is less than would be required in case the augmenters E were not employed. The over-all steam consumption for the vacuum-producing apparatus as an entirety is accordingly materially reduced.

In addition to the vacuum-producing means P, there may be employed one or more additional vacuum-producing means. As indicated at the right of the figure, an additional vacuum-producing means P^1 is employed, the same involving as before any suitable means, as pumps, ejectors, etc., and in the example illustrated ejectors E^3 and E^4, whose nozzle structures are supplied with live or high pressure steam through the pipe v and controlled by the valve w, and through the pipe x controlled by the valve y. In this case, the ejector E^3 discharges into the interstage surface condenser R, the cooling water for which enters, for example, at z and leaves at a^1; and the condensate is drawn off at b^1 and is delivered to any suitable destination, as for example, to the hot well H or the pipe connecting the same to the pump p. The air and uncondensed gas or vapor is delivered through the connection c^1 to the suction of the ejector E^4, which discharges into the after surface condenser S, the cooling water for which may enter at d^1 and leave at e^1. The condensate may be drawn off at f^1 and delivered to any suitable destination, as for example, to the hot well H or the pipe connecting the same to the pump p. The air and uncondensed gas or vapor is discharged

at g^1 to atmosphere or region at other pressure, or any other suitable region at suitable pressure.

Preferably the vacuum-producing means P and P^1 are of different sizes or capacities, whereby when one or more condensers is or are out of operation or when the load on the entire system is low, the vacuum-producing means of smaller capacity may be employed alone. When the load is greater the vacuum-producing means of greater capacity may be employed, and with still greater loads both may be simultaneously employed. By closing either of the valves *j*, the corresponding or associated vacuum-producing apparatus P or P^1 is put out of service, leaving the other to handle the entire or any suitable part of the load. Furthermore, by suitably setting the valves *i*, as by closing both, opening both, or closing either one and opening the other, the vacuum-producing apparatus, or either of them, with appropriate settings of the valves *j*, will be brought into any suitable combinations, the valves *i* and *j* effecting great flexibility in mode of operation of the system.

The cooling water for the condensers K, O, R and S, or for any one or more of them, may be the water or the make-up water fed to the boiler or boilers which deliver steam to the turbines T and *t*, or any of them; or the cooling water for the aforesaid condensers may be the condensate from one or more of the condensers C; or it may be cooling water such as supplied to the tubes *c* of the condensers C, or it may be a part of the cooling water supplied to one or more of the condensers C and traversing the auxiliary condensing apparatus either before or after it traverses the tubes *c* of one or more of the condensers C.

By the system described, notwithstanding the different pressures within or loads upon the different condensers or vessels C, vacuum-producing means, particularly ejector apparatus, common to all of them, raises the pressure of the air or other fluid to the desired pressure from a pressure to which the different augmenters E raise the pressure of the air or other fluid withdrawn from the vessels or condensers C.

By the arrangement described, the steam consumption for vacuum production is greatly economized in that the augmenters, as aforesaid, employ low pressure or exhaust steam, thereby materially diminishing the live or high pressure steam required by the vacuum-producing means P or P^1.

When any one or more of the ejector augmenters E derives its motive steam from the turbine *t* associated with the same vessel or condenser C, the augmenter may be, if desired, of such size or capacity as to be operative to produce the desired or suitable degree of compression of the air or other fluid withdrawn from the vessel C with or by the minimum amount of exhaust steam delivered by the turbine *t*, and any excess steam from the turbine *t* may be diverted, as in the manner and by means described in my prior application Ser. No. 534,310, filed February 6, 1922. Each augmenter ejector E may, however, be of such size or capacity as to employ more motive steam than the minimum supplied by the turbine *t*, in which case the absolute pressure in the manifold pipe M may or will be higher.

The ratios of compression of the augmenters E may be anything suitable or desirable, as for example, somewhat less than two to three or more, the ratio of compression of the combined ejectors E and E^2 being then approximately the quotient derived by dividing 30 by the ratio of compression of the associated augmenter E. Such quotient or ratio of compression may then be divided between the ejectors E^1 and E^2 as may be suitable or desirable. It is preferred, however, that the ratio of compression of the ejector E^1 be greater than the ratio of compression of the ejector E^2, and may be, if desired, as described and disclosed in my prior Letters Patent No. 1,283,593.

It will be understood that while I have shown two ejectors E^1 and E^2 in series, a single stage ejector may be employed in lieu of them; for example, there may be employed an ejector of the character disclosed in my prior Letters Patent No. 1,388,670.

For brevity, the terms "steam" and "air" as employed in the appended claims include, respectively, steam and other suitable elastic motive fluids, and air and other uncondensable or uncondensed gases or vapors; and the term "condenser," when referring to a main or large condenser C, includes the condenser or any other vessel in which vacuum is to be produced or maintained.

What I claim is:

1. The combination with a plurality of condensers, of vacuum-producing apparatus therefor comprising ejector apparatus for augmenting the vacua in said condensers, and vacuum-producing means common to said condensers for further raising the pressure of the fluid discharged by said ejector apparatus.

2. The combination with a plurality of condensers, of vacuum-producing apparatus therefor comprising an ejector augmenter for each of said condensers, and vacuum-producing means common to said condensers operating upon the fluids discharged by said augmenters to further raise their pressure.

3. The combination with a plurality of condensers, of vacuum-producing apparatus therefor comprising an ejector augmenter for each of said condensers, a manifold common to said augmenters into which they discharge, and means common to said con-

densers and connected to said manifold for further raising the pressure of the fluids delivered to said manifold by said augmenters.

4. The combination with a plurality of condensers, of an ejector augmenter for each of said condensers, and ejector apparatus common to said augmenters for further raising the pressure of the fluids discharged by said augmenters.

5. The combination with a plurality of condensers, of an ejector augmenter for each of said condensers, and serially connected ejectors common to said augmenters for further raising the pressure of the fluids discharged by said augmenters.

6. The combination with a plurality of condensers, of an ejector augmenter for each of said condensers, means for supplying exhaust or low pressure steam to the nozzle structures of said augmenters, and means common to said augmenters for further raising the pressure of the fluids discharged by said augmenters.

7. The combination with a plurality of condensers, of an ejector augmenter for each of said condensers, means for supplying exhaust or low pressure steam to the nozzle structures of said augmenters, ejector apparatus common to said augmenters for further raising the pressure of the fluids discharged by said augmenters, and means for supplying high pressure steam to the nozzle structure of said ejector apparatus.

8. The combination with a plurality of condensers, of an ejector augmenter for each of said condensers, means common to said augmenters for further raising the pressure of the fluids discharged by said augmenters, and heat exchange apparatus intervening between each of said augmenters and said means.

9. The combination with a plurality of condensers, of an ejector augmenter for each of said condensers, means common to said augmenters for further raising the pressure of the fluids discharged by said augmenters, and a condenser intervening between each of said augmenters and said means for condensing a condensable component of the discharge from the augmenter.

10. The combination with a plurality of condensers, of an injector augmenter for each of them, ejector apparatus common to said augmenters for further raising the pressure of the fluids discharged by said augmenters, condensing means into which said ejector apparatus discharges, and a condenser intervening between each of said augmenters and said ejector apparatus.

11. The combination with a plurality of condensers, of an ejector augmenter for each of them, a plurality of serially related ejectors common to said augmenters for further raising the pressure of the fluids discharged by said augmenters, a condenser intervening between neighboring of said ejectors, and a condenser intervening between each of said augmenters and said ejectors.

12. The combination with a plurality of condensers, of an ejector augmenter for each of them, an ejector common to said augmenters for further raising the pressure of the fluids discharged by said augmenters, a second ejector for further raising the pressure of the fluid discharged by said ejector, a condenser between said ejectors, a condenser into which said second ejector discharges, and a condenser intervening between each of said augmenters and said first named ejector.

13. The combination with a plurality of condensers, of an ejector augmenter for each of them, and a plurality of apparatus common to said augmenters and each receiving and raising the pressure of a part of the total of the fluids discharged by said augmenters.

14. The combination with a plurality of condensers, of an ejector augmenter for each of them, a manifold receiving the discharges from said augmenters, and a plurality of apparatus connected with said manifold and each receiving and raising the pressure of a part of the fluid in said manifold.

15. The combination with a plurality of condensers, of an ejector augmenter for each of them, a manifold receiving the discharges from said augmenters, a plurality of apparatus connected with said manifold and each receiving and raising the pressure of a part of the fluid in said manifold, and means for isolating from said manifold at least one of said apparatus.

16. The combination with a plurality of condensers, of an ejector augmenter for each of them, a manifold receiving the discharges from said augmenters, a plurality of apparatus connected with said manifold and each receiving and raising the pressure of a part of the fluid in said manifold, and means for isolating each of said apparatus from said manifold.

17. The combination with a plurality of condensers, of an ejector augmenter for each of them, a manifold receiving the fluids discharged by said augmenters, means for withdrawing fluid from said manifold and further raising its pressure, and means for isolating different parts of said manifold from each other.

18. The combination with a plurality of condensers, of an ejector augmenter for each of them, a manifold receiving the fluids discharged by said augmenters, means for isolating different parts of said manifold from each other, a plurality of apparatus each adapted to receive a part of the fluid

in said manifold for increasing its pressure, and means for isolating at least one of said apparatus from said manifold.

19. The combination with a plurality of condensers, of an ejector augmenter for each of them, a manifold receiving the fluids discharged by said augmenters, means for isolating different parts of said manifold from each other, a plurality of apparatus each adapted to receive a part of the fluid in said manifold for increasing its pressure, and means for isolating each of said apparatus from said manifold.

20. The combination with a condenser, of a steam-operated motor exhausting into said condenser, an ejector for producing a vacuum in said condenser, a second condenser into which low pressure steam from said motor is delivered, said low pressure steam traversing the nozzle structure of said ejector before reaching said second condenser.

21. The combination with a condenser, of a turbine exhausting into said condenser, an ejector for producing a vacuum in said condenser, a second condenser, and a connection from a low pressure stage of said turbine to said second condenser, the nozzle structure of said ejector included in said connection.

22. The combination with a plurality of condensers, of an ejector for each of said condensers, a condenser for each of said ejectors receiving the discharge therefrom, a manifold receiving the uncondensed fluid from said ejector condensers, and vacuum-producing apparatus connected with said manifold.

23. The combination with a plurality of condensers, of an ejector for each of said condensers for removing elastic fluid therefrom and raising it to higher pressure, a manifold into which the elastic fluid of increased pressure is delivered from said ejectors, and vacuum-producing apparatus connected to said manifold for further raising the pressure of said fluid.

24. The combination with a plurality of condensers, of an ejector for each of said condensers for removing elastic fluid therefrom and raising it to higher pressure, a manifold into which the elastic fluid of increased pressure is delivered from said ejectors, a plurality of apparatus connected with said manifold for further raising the pressure of said fluid, and means for isolating from said manifold at least one of said apparatus.

25. The combination with a condenser, of an ejector for producing a vacuum in said condenser, a turbine, and a connection from a low pressure stage of said turbine to the nozzle structure of said ejector.

26. The combination with a condenser, of an ejector for producing a vacuum therein, a turbine exhausting into said condenser, and a connection to the nozzle structure of said ejector from a low pressure stage of said turbine.

27. The combination with a condenser, of apparatus for producing a vacuum therein comprising plural stage ejector apparatus, a turbine, means for conveying high pressure elastic fluid to the nozzle structure of an ejector of said ejector apparatus, and a connection to the nozzle structure of an ejector in an earlier stage of said ejector apparatus from a low pressure stage of said turbine.

28. The combination with a condenser, of apparatus for producing a vacuum therein comprising plural stage ejector apparatus, a turbine exhausting into said condenser, means for conveying high pressure elastic fluid to the nozzle structure of an ejector of said ejector apparatus, and a connection to the nozzle structure of an ejector in an earlier stage of said ejector apparatus from a low pressure stage of said turbine.

29. The combination with a condenser, of apparatus for producing a vacuum therein comprising an ejector and a pair of double stage ejectors, means for delivering high pressure elastic motive fluid to the nozzle structure of at least one stage of each pair of said double stage ejectors, a turbine, and a connection to the nozzle structure of said first named ejector from a low pressure stage of said turbine.

30. The combination with a condenser, of apparatus for producing a vacuum therein comprising an ejector and a pair of double stage ejectors, means for delivering high pressure elastic motive fluid to the nozzle structure of at least one stage of each pair of said double stage ejectors, a turbine, a connection to the nozzle structure of said first-named ejector from a low pressure stage of said turbine, a condenser into which said first named ejector exhausts, and connections from said last named condenser to the suction chambers of the first stage ejectors of said double stage ejectors.

In testimony whereof I have hereunto affixed my signature this 10th day of March, 1922.

ROBERT SUCZEK.