April 30, 1957 K. EBNER 2,790,595

STEAM JET APPARATUS

Filed Sept. 20, 1950

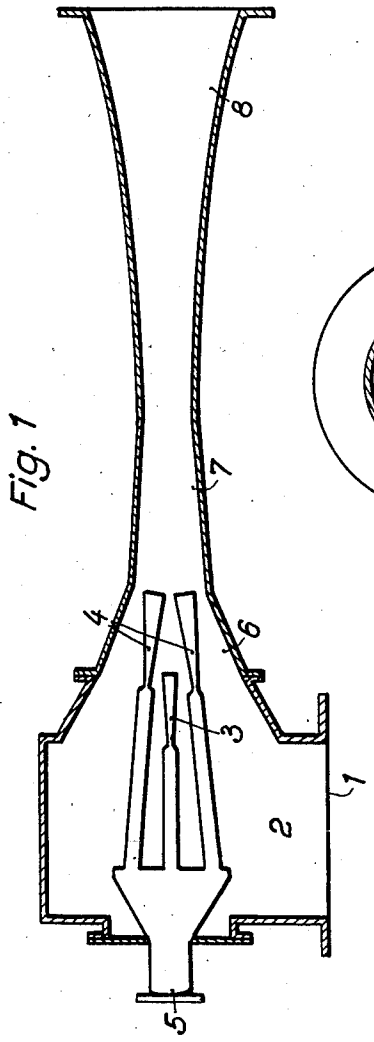

Fig. 1

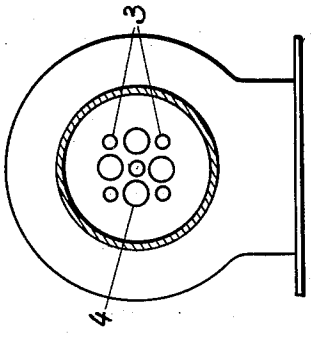

Fig. 2

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STEAM JET APPARATUS

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This invention relates to steam jet apparatus. Steam jet apparatus are known in which the nozzle for the operating medium is surrounded by a convergent diffuser for the medium to be conveyed, said latter medium being accelerated on its passage through this diffuser before it encounters the operating medium. In this case, the operating medium was expanded to a mixing pressure which was lower than the suction pressure of the medium to be conveyed. Kinetic energy was imparted to the latter in the diffuser by expansion from the suction pressure to the lowered mixing pressure as a function of the quantity pumped, the mixing pressure and the cross-section available for admission to the mixing chamber. By this means, a reduction was effected in the impact and eddy losses occurring on the meeting of the medium to be conveyed and the operating steam. The medium to be conveyed had, however, to be compressed from the lower mixing pressure to the unchanged final pressure. This required a correspondingly greater quantity of operating steam, so that some of the saving in steam effected by the diminished impact and eddy losses was lost again. For pre-accelerating the medium to be conveyed, jet apparatus have already been used, which are provided with an annular nozzle and a central nozzle situated in the axis of said annular nozzle. The annular nozzle terminates in the diffuser, and the central nozzle is carried beyond the mouth of the annular nozzle into the throat of the diffuser. The medium to be conveyed flows through the hollow space of the inlet nozzle into the mixing chamber of the diffuser.

The efficiency of this arrangement is, however, unsatisfactory because the steam issuing from the annular nozzle and passing directly along the wall of the jet apparatus is subjected there to high friction losses, and because the central nozzle terminates in the divergent compression chamber of the jet apparatus. According to other known types, a pre-acceleration is imparted to the medium to be conveyed by feeding a portion of the operating steam through separate nozzles provided in the suction chamber of the jet apparatus. The mixture of medium to be conveyed and operating steam from the nozzles employed for pre-acceleration enters the mixing chamber in front of the main nozzle at increased velocity. This arrangement has, however, the disadvantage that there is no linear flow in the suction chamber, but increased eddy formation. Increased impact losses also occur in the suction chamber, because the medium to be conveyed encounters the steam issuing from the nozzles employed for pre-acceleration, at the same high velocity difference as would have been present in the mixing chamber in front of the main nozzle had the said pre-acceleration nozzles been omitted.

In the jet apparatus according to the invention, pre-accelerating and main nozzles are likewise used.

According to the invention, the pre-accelerating nozzles open in the conically convergent part of the diffuser, so that the medium to be conveyed reaches the mouths of said nozzles with a pre-acceleration. This pre-acceleration is, however, kept within moderate limits and is higher or lower according to the suction pressure. The velocity imparted by this pre-acceleration to the medium to be conveyed should not amount to more than 50% of the velocity of sound in that medium. By means of the pre-accelerating nozzles, the velocity of the medium to be conveyed is increased further, namely by up to about half the velocity of sound, or more. For this purpose, about 10–40% of the total operating steam of the jet apparatus is required, according to the head of pressure to be overcome by the jet apparatus. The medium to be conveyed accordingly enters the mixing chamber of the main nozzle or nozzles at a high velocity and in linear flow. The impact and eddy losses in the mixing chamber in front of the main nozzle or nozzles are thereby reduced very considerably, without any substantial increase being necessary in the total compression work of said nozzles.

In order to enable the invention to be more readily understood, reference is made to the accompanying drawings which illustrate diagrammatically and by way of example, one embodiment thereof and in which:

Fig. 1 is a longitudinal section; and

Fig. 2 is an end view of the nozzle arrangement with the diffuser removed.

The medium to be conveyed enters the suction chamber **2** through the connecting piece **1**. **3** are the pre-accelerating nozzles and **4** the main nozzles. Steam is supplied to these nozzles through the conduit **5**. **6** is the pre-acceleration chamber of the diffuser, **7** the mixing chamber and **8** the compression chamber. Preferably, not one but a plurality of pre-accelerating nozzles and a plurality of main nozzles are used. The nozzles are distributed over the cross-section of the diffuser in such a manner that operating steam is admitted uniformly over the entire cross-section of the diffuser. The pre-accelerating nozzles are uniformly distributed between the main nozzles. The pre-accelerating nozzles are slightly inclined to the diffuser axis, so that the steam jets issuing from the nozzles first encounter the diffuser wall approximately in the narrowest cross-section. The provision of a plurality of nozzles has the advantage that the mixing chamber of the diffuser can be substantially shortened.

If, for example, steam is to be pumped out of a distillation column from an absolute pressure of 3 mm. of mercury to an absolute pressure of 30 mm. of mercury, the mouths of the pre-accelerating nozzles are located at a point of the diffuser at which the medium to be conveyed, which enters the jet apparatus at a velocity of about 40–50 metres per second, has a velocity of about 100 metres. This increase in velocity is conditioned by the convergent form of the diffuser. The velocity is increased to about 400 metres by the action of the pre-accelerating nozzles. This results in that the steam to be conveyed encounters at the mouths of the main nozzles, in linear flow and with a substantial pre-acceleration, the operating steam issuing from the main nozzles. The pre-acceleration is effected, without practically any steam being drawn into the jet apparatus, as the steam is expanded below the suction pressure, which would require additional work of compression by the main nozzles. In the region of the main nozzles, the difference between the velocity of the steam to be pumped and that of the operating steam of the main nozzles amounts only to about 600 to 700 metres. In the part **7** of the diffuser, which extends from the main nozzles to the narrowest cross-section of the diffuser, mixing of the operating steam of the main nozzles and the pre-accelerated steam to be pumped takes place, said mixing proceeding under compression. In the divergent part of the diffuser **8**, com-

pression is increased to the final pressure, which in this case is 30 mm. of mercury.

Since the impact loss varies according to the difference of the squares of the velocity of the medium to be conveyed and that of the operating medium, the efficiency of the jet apparatus may therefore be increased very considerably by the stepwise increased pre-acceleration, which, according to the invention, may be raised to a very high value, without incurring other disadvantages. The increase in efficiency may amount to over 50%.

What I claim is:

1. Jet apparatus for effecting the compression of an elastic fluid, which comprises a diffuser with means for admitting an elastic fluid at one end thereof, the cross-section of said diffuser converging to a portion of narrowest cross-section and then diverging, at least one acceleration jet nozzle positioned with its exit in the converging portion of said diffuser facing in the direction of the portion of narrowest cross-section, said acceleration jet further being positioned at a point where the velocity of an elastic fluid being passed through said diffuser will reach about half the velocity of sound, due to the dimensioning of said converging portion, and at least one main

jet nozzle with its exit positioned in the converging portion of said diffuser past the exit of said acceleration jet nozzle in the direction of the portion of narrowest cross-section of said diffuser, said main jet further being positioned at a point where the velocity of said elastic fluid will reach about the full velocity of sound.

2. Jet apparatus according to claim 1, including a multiple number of acceleration nozzles and main nozzles uniformly distributed over the cross-section of said diffuser.

3. Jet apparatus according to claim 2, in which all of said nozzles not positioned on the central axis of said diffuser are so positioned that the jet impinges upon the inner wall surface of the portion of narrowest cross-section of the diffuser.

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