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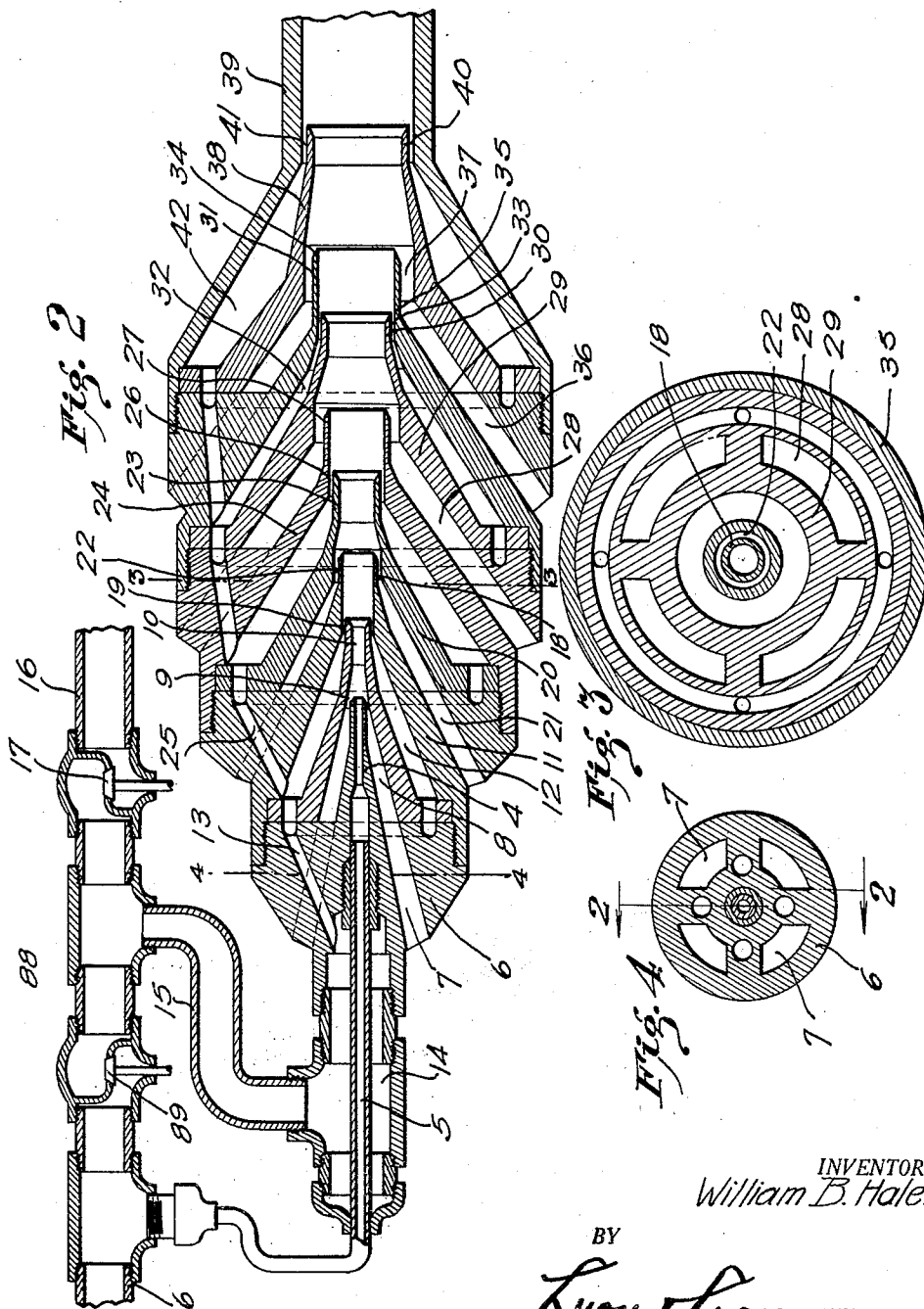
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AIR COMPRESSING APPARATUS

Filed June 8, 1929

4 Sheets-Sheet 2



INVENTOR.
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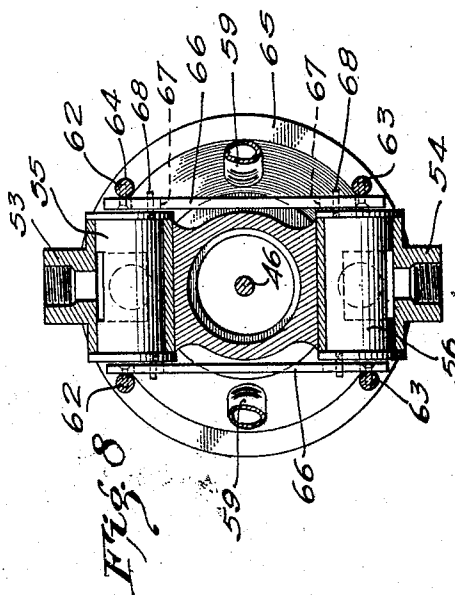
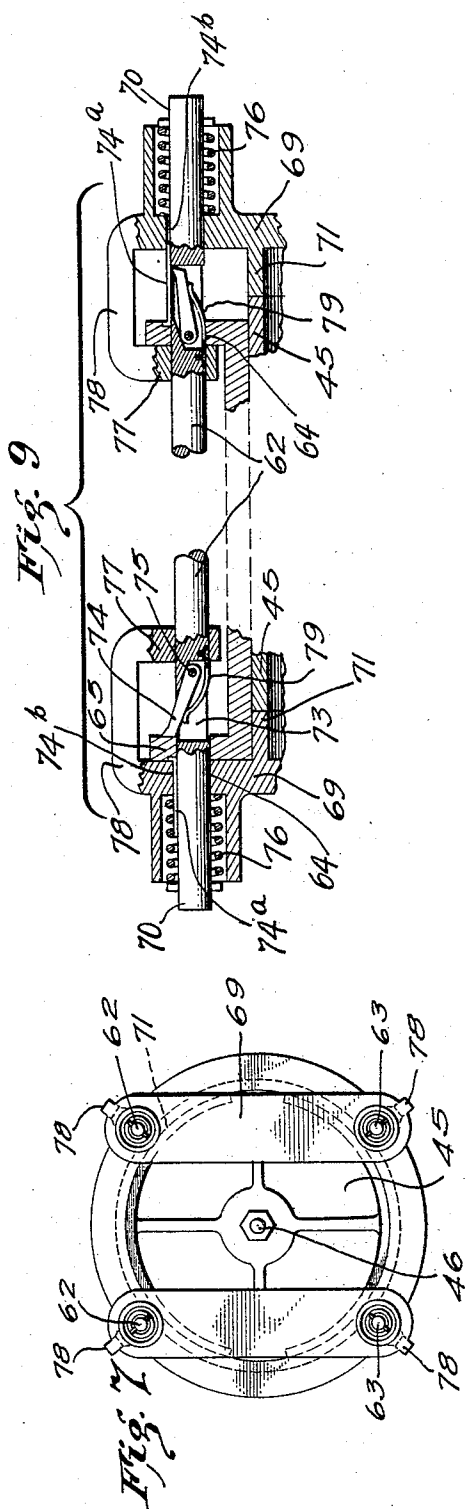
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AIR COMPRESSING APPARATUS

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This invention relates to apparatus for developing pressure in fluid such as gas or air. The general object of the invention is to provide an efficient method for compressing gas or air.

The apparatus preferably includes an injector of special construction, enabling air of different pressure to be employed to cooperate in the entraining of atmospheric air to produce a relatively large volume of low pressure air. If desired, a portion of this volume of low pressure air may be used with high pressure air, in the injector nozzle. In accomplishing this I prefer to employ a compressor in which low pressure air is used expansibly instead of permitting the same to escape when it is exhausted from the expansion cylinder. This air is forced back into the high pressure reservoir. In this way, with relatively small compressor equipment, I am enabled to augment the quantity of air in the two reservoirs of different pressures. The increased supply of compressed air may be utilized for any industrial purposes, such as the uses to which compressed air may be employed in garages or industrial plants.

The high pressure air can be most conveniently piped to points where it can be utilized in one of my nozzles to produce a large quantity of low pressure air for use in driving air actuated machinery or for charging auto tires.

A further object of the invention is to provide an injector nozzle of improved form which can be utilized to develop a relatively large quantity of air at a relatively low pressure through the medium of a relatively small quantity of compressed air at a high pressure. In the construction of the injector nozzle, one of my objects has been to provide for admission of air to flow with the current of high pressure air in such a way as to prevent turbulence and to prevent any tendency of the high pressure air to produce a back flow in the entraining nozzle.

Further objects of the invention will appear hereinafter.

The invention consists of novel parts and combination of parts to be described herein-

after, all of which contribute to produce an efficient air compressing apparatus.

In the drawings:

Figure 1 is a diagrammatic plan of the apparatus including a high pressure tank and a low pressure tank, both of which are represented as broken away.

Figure 2 is a longitudinal section through the injector constituting a feature of my invention.

Figure 3 is a cross-section taken through the injector about on the line 3—3 of Figure 2.

Figure 4 is a cross section through the injector taken about on the line 4—4 of Figure 2.

Figure 5 is a vertical section through the compressor illustrated in Figure 1, taken about on the line 5—5 of Figure 1.

Figure 6 is a horizontal section taken about on the line 6—6 of Figure 5.

Figure 7 is an end elevation of the compressor as viewed from the left end of Figure 1.

Figure 8 is a section taken on the line 8—8 of Figure 1, but upon an enlarged scale. This view particularly illustrates portions of the valve mechanism for controlling the flow of the fluid to the compressor cylinder.

Figure 9 is a longitudinal section taken on the line 9—9 of Figure 1 and further illustrating details of the valve mechanism of the compressor.

Referring more particularly to the parts, the apparatus preferably includes a high pressure reservoir 1 for containing the fluid, such as air, at the pressure, for example, of 150 pounds per square inch, and 2 represents a low pressure reservoir in which the air is held under a relatively lower pressure, for example, 40 pounds per square inch. In practicing the invention, I provide between the reservoirs an injector 3 which operates to conduct a current of high pressure air from the high pressure reservoir 1 toward the low pressure reservoir 2. As this current passes through the injector, it operates to entrain atmospheric air; as it does so, other currents of air of an intermediate pressure are admitted to flow with the high

pressure air current for operating as a screen around the same to reduce turbulence and preventing any tendency of the high pressure air to produce a back flow in the injector nozzle through the entraining ports for the atmospheric air.

While the injector preferably cooperates with two pressure reservoirs at different pressures, a high and a low, it should be understood, however, that the injector can be used simply to employ a stream of relatively high pressure air to develop a relatively large quantity of compressed air at a lower pressure.

The construction of the injector is disclosed in Figures 2 to 4. The injector is preferably constructed of sections and is formed in such a way that as the high pressure air current flows through it, the injector operates to admit entrained atmospheric air and also low pressure air.

Both the atmospheric air and the low pressure air are admitted in annular currents disposed around the flowing current of air that is being augmented in volume by the entrained air. In order to accomplish this, the injector is constructed with a high pressure inlet nozzle 4 (see Figure 2) that receives high pressure air from a tube 5 connected to a pipe 6 leading from the high pressure reservoir. This nozzle 4 is formed on a nozzle section 6 having a plurality of admission ports 7 of segmental form (see Figure 4), for admitting atmospheric air around the nozzle 4, said ports communicating with the interior of a cone 8 that seats on the forward end of the section 6 and coaxial with the nozzle 4, so that the entrained atmospheric air is admitted in an annular current at the point 9 where the two streams of air mix and pass on through a second nozzle or tip 10 formed on the cone 8.

The air flowing through the tip 10 is augmented by a supply of entrained air of a lower pressure than the high pressure air. This new supply of air is admitted through the agency of a cone 11 and it seats over the cone 8 forming an inner conical chamber 12 to which low pressure air is admitted through ports 13 leading from a low pressure housing 14 that is connected by pipes 15 and 16 with the low pressure air supply, such as the low pressure tank 2. The pipe 16 is provided with a valve 17 with the hand control means, as illustrated, to enable this valve to be opened as far as desired.

The cone 11 has a tubular tip 18 of slightly larger diameter than the tip 10, so that an annular entraining port 19 is formed around the tip 10 through which the low pressure air is admitted. Beyond this point, I provide a succession of nozzles arranged similarly to the nozzles already described, but of progressively increasing diameter to allow

for the increasing volume of the air current. By admitting the low pressure air current in an annular form, as described, it has a tendency to prevent too great a spreading effect in the inner high pressure current which it envelops and surrounds. In this way, the annular low pressure air current seems to operate as a curtain between the high pressure air current and the ports of the nozzles, tending to prevent turbulence and maintaining the inner high pressure air current along the axial line of the injector.

The tip 18 delivers the augmented air current into an entraining cone 20 with segmental admission ports 21 for admitting additional atmospheric air, said atmospheric air being admitted through an annular passage 22 formed between the tip 18 and the tubular tip 23 of the cone 20. Over the cone 20, is a nozzle or cone 24, which is connected by low pressure air passages 25 with the low pressure passages 13, already described. In this way, the low pressure air is again admitted in an annular air current at the point 26, augmenting the air current flowing through the injector. The cone 24 has a tubular tip 27 of a progressively increased diameter and this tip 27 entrains atmospheric air through admission ports 28 in a concentric cone 29 having a tubular tip 30 of progressively enlarged diameter, which in turn delivers the augmented air current through an entraining nozzle 31 supplied with low pressure air which flows through the chamber 32 and through the annular passage 33 formed between the tip 30 and the tip 34 of the next cone 35 which admits atmospheric air through ports 36 in an annular current through the annular passage 37 delivering the air into the last nozzle 38, which projects into an outlet pipe 39 of slightly larger diameter than the tubular tip 40 of the nozzle 38, so that an annular passage 41 is formed to which low pressure air is admitted from the chamber 42 connected by ports, as illustrated, with the low pressure ports 25. In this way, a current of air of relatively low pressure is developed through the connection 39 through the coaction of the high pressure air, low pressure air and atmospheric air. This delivered air current flows at a high velocity and is of considerable cross-section so that a relatively large quantity of low pressure air will be delivered through it. This connection 39 may be connected directly to machines using compressed air, but, if desired, it may be connected to the low pressure air reservoir 2 from which air can be supplied to air using machines through another pipe connection 43.

If desired to increase the supply of high pressure air in the reservoir 1, this may be accomplished by utilizing the increased amount of compressed air accumulated in the low pressure reservoir 2 by compressing the

same and forcing it into the high pressure reservoir 1. I prefer to accomplish this by means of a compressor having a plurality of expansion chambers in which the low pressure air can expand and this compressor preferably includes also a compression cylinder of smaller diameter which takes the exhaust air from the expansion cylinder.

In this way, none of the air is exhausted into the atmosphere, but when the compressor is driven, the air from the compression cylinder may be forced into the high pressure reservoir. The preferred construction for such a compressor will now be described together with the automatic valve mechanism for controlling flow of the air to the cylinders and from them to the reservoirs.

Referring to Figures 1, 5 and 6, I provide two compression cylinders 44a and 44b which are duplicates of each other, each cylinder being provided with its corresponding piston 45, said pistons being attached to a common piston rod 46 which is provided with a double piston head 47 reciprocating in a compression cylinder 48 located between the adjacent heads 49 of the expansion cylinders.

Air from the reservoir 2 is supplied by a pipe 50 to two branch pipes 51 and 52 that connect, respectively, to two valve casings 53 and 54 (see Figure 5). Within the valve casing 53 there is a rotary valve 55 and a similar rotary valve 56 in the casing 54. When the valves 55 and 56 are in the position illustrated in Figure 5, low pressure air is admitted to the expansion cylinder 44a. In the opposite position of these valves, air would be admitted to the other expansion cylinder 44b. When in the position indicated in Figure 5, the air in the cylinder 44b is being exhausted from the same through the head 49 by passing through poppet valves 57 that admit the air to the right hand end of the compression cylinder 48.

At this time, the piston rod 46 is being moved toward the left by a motor, which will be described hereinafter. While the piston rod 46 is moving toward the left, the head 47 is forcing air in front of it out through poppet valves 58 (see Figure 6) and this air passes into two manifolds 59 which are connected by branch pipes 60 to a pipe 61 that leads to the reservoir 1.

A valve actuating mechanism is provided for rotating the valves 55 and 56 from one extreme position, as shown in Figure 5, to the opposite extreme position. For this purpose, I provide four valve rods (see Figure 8) comprising an upper pair of valve rods 62 and a lower pair of valve rods 63. These valve rods are guided to slide through openings 64 in the flanges 65 at the ends of the expansion cylinders. The middle point of each valve rod carries a valve plate 66 (see Figure 6) and each valve plate has a substantially vertical slot 67 in it which receives

a pin 68 projecting outwardly from the end of the corresponding valve 55 or 56. With this arrangement, it will be evident that whenever the valve rods are moved to an extreme position, the valves 55 and 56 will be rotated to a corresponding extreme position. In order to actuate the valve rods and hold them in each of the extreme positions, I provide the outer end of each expansion cylinder with two cross-heads 69 (see Figures 5 and 7).

The cross-heads 69 are supported on the ends 70 of the valve rods and each cross-head is in the form of a long, flat plate disposed in a vertical position and provided on its inner face with an arcuate guide wing 71 that is machined to the radius of the bore of the expansion cylinder, so as to act as a guide on the inner face of the cylinder and also so as to receive movement from the cylindrical apron 72 that projects outwardly from each of the pistons 45.

Referring to Figure 9, near each end flange 65 of the expansion cylinder, each valve rod is provided with a central slot 73 in which is mounted a latch 74 supported on a cross-pin 75 in the slot. When the right hand piston 45 strikes the right hand cross-heads 69, it moves them outwardly and compresses coil springs 76 disposed around the projecting ends 70 of the rods and the force exerted by these springs shoves the valve rods 62 toward the right. When they arrive at the end of their travel, a leaf spring 79 back of each latch 74 throws the free end of the latch outwardly, as indicated at the left end of Figure 9, so that the latch will come against the right hand face of the flange 65. In this way, the latches 74 at the left end of the compressor will lock the valve rods in their extreme right hand position.

In order to effect the automatic release of the latches 74 when the pistons arrive at the end of their movement toward the left, each cross-head is provided with a releasing sleeve 77 (see Figure 9) which is connected to it by an integral arm 78. When the skirt 72 on the left hand piston 45 strikes the left hand cross-heads 69, it will move it toward the left, compressing the spring 76 at this end of the compressor and storing up energy in them to shift the valve rods to the left. As the sleeve 77 completes its sliding movement, it engages the projecting free end of its corresponding latch 75 and shoves it back into its slot 73. As soon as the latch 74 is released in this way, the spring 76 at the left end of the compressor will cause the valve rods to shift to their extreme left hand position, in which position they are latched automatically by the latches 74 at the right hand end of the compressor.

In order to prevent the latches 74 from jumping out when they should not do so, for example, in the position shown in Fig. 9, I provide a narrow guard tongue 74a of thin

metal attached to the outer face of each flange 65. This tongue may be formed of thin sheet metal and as the cross-heads slide to and fro it slides in a groove 74b in the outer portion of the cross-head where the valve-rod passes through it.

Any suitable means may be employed for actuating the piston rod 46. For this purpose I may provide the end of the rod 46 with a connecting rod attached by a cross-pin 80 (see Figure 1) between two counter-weighted cranks 81 on shaft sections 82 and 83, the latter of which is driven shaft 83 carrying a worm wheel 84 actuated by worm 85 carried on the extended shaft of an electric motor 86.

The reservoirs 1 and 2 may be provided with relief valves 87 which can be set to maintain any desired working pressure in these two reservoirs, for example, 150 pounds per square inch and 40 pounds per square inch.

Referring again to the injector 3, if desired the pipe 6 which supplies high pressure air to this nozzle may be connected by a pipe 88 to the pipe connection 16 and this pipe connection 88 may be provided with a hand controlled valve 89 which, of course, is normally closed but which may be open, if desired, to permit air to flow from the high pressure tank into the low pressure tank 2, if the valve 17 is open, or if desired, this valve 89 can be "cracked" so as to permit air to escape at this point to pass directly into the low pressure connection 15 to supply the low pressure nozzles of the injector.

I will now describe the general mode of operation of the apparatus. Air at a relatively high pressure (as compared with the low pressure air used) is permitted to flow through the high pressure nozzle 4 of the injector, and this air passes then to the tubular tip 10 of the second nozzle, thereby entraining atmospheric air. The entrained atmospheric air mixes with the high pressure air and passes on to the tip 10 beyond which it is enveloped in an annular current of low pressure air flowing through the annular passage 19.

In this way, the air passes through the series of sections of the injector nozzle, alternately receiving increments of atmospheric air and low pressure compressed air.

In this way, the volume of air passing through the injector is greatly augmented and the pressure of this current flowing through the injector is maintained or boosted by the successive admissions of low pressure air.

Generally a large volume of low pressure air is delivered through the delivery connection 39. This air may pass directly to machines utilizing the compressed air or it may be accumulated in a receiver such as the low pressure reservoir 2. From this reser-

voir 2, the low pressure air may be supplied to machines that are operated by compressed air.

If it is desired to increase the supply of high pressure air in the reservoir 1, the apparatus includes the compressor. This compressor is operated by the electric motor 86 that reciprocates the piston rod 46 and the piston heads carried by it. As the piston rod 46 moves toward the left, as viewed in Figure 5, the air which has been received in the right hand expansion cylinder through the valves 55 and 56 will be expelled through the poppet valves 57, into the right hand end of the compression cylinder 48. At the same time, air in the left end of the compression cylinder 48 will be expelled through the poppet valves 58 (see Figure 6) and passed into the manifold 59 and thence through the branch pipes 60 and the pipe 61, into the reservoir 1.

The action of the compressor at the end of the stroke toward the right is identical with that described above, except that the valves 55 and 56 would be in a reverse position from that shown in Figure 5.

The valves 55 and 56 are held in extreme position by one set of the latches 74 in the valve rods 62. These latches engage the inner faces of the flanges 65 on the ends of the expansion cylinders to hold the valve rods in their extreme positions (see Figure 9). The sleeve 77, when moved by the skirts of the pistons 45, at the ends of their strokes, automatically release these latches 74 at one end of the compressor, and the springs at that end shift the valve rods in the same direction a sufficient distance to enable the latches 74 at the other end to swing out and cooperate with the flanges at the other end of the compressor to latch the valve rods in that extreme position.

It is understood that the embodiment of the invention described herein is only one of the many embodiments this invention may take, and I do not wish to be limited in the practice of the invention, nor in the claims, to the particular embodiment set forth.

What I claim is:

1. In apparatus for raising the pressure of a fluid, the combination of a reservoir for holding the fluid at a given pressure, a reservoir for holding the fluid at a relatively lower pressure, an injector directly connecting the said reservoirs, through which the fluid flows from the high pressure reservoir to the low pressure reservoir, said injector having a plurality of nozzles projecting in the direction of flow, with means for repeatedly admitting and entraining additional quantities of the same fluid at a lower pressure than that in the said reservoirs, a compressor receiving the fluid from the low pressure reservoir, for compressing the fluid from the low pressure reservoir and for forc-

ing a quantity of the same back into the high pressure reservoir.

2. In apparatus for compressing a gas such as air, the combination of a reservoir for holding the same at a given pressure, a reservoir for holding the gas at a relatively lower pressure, condensing means in the form of a nozzle directly connecting the said reservoirs, through which the gas flows from the high pressure reservoir to the low pressure reservoir, said condensing means having a plurality of nozzles projecting in the direction of flow with means for repeatedly entraining additional quantities of the said gas at a lower pressure than that in the said reservoirs, and means for compressing the gas taken from the low pressure reservoir and for forcing it back into the high pressure reservoir.

3. In apparatus for compressing air, the combination of a reservoir for holding air at a given pressure, a reservoir for holding air at a relatively lower pressure, condensing means in the form of a nozzle directly connecting the said reservoirs, through which the air flows from the high pressure reservoir toward the low pressure reservoir, said condensing means having a plurality of nozzles projecting in the direction of flow, each nozzle having means for admitting additional quantities of atmospheric air and for entraining the same in the current flowing through the nozzles.

4. In apparatus for compressing air, the combination of a reservoir for holding air at a given pressure, a reservoir for holding air at a relatively lower pressure, condensing means in the form of a nozzle directly connecting the said reservoirs, through which the air flows from the high pressure reservoir toward the low pressure reservoir, said condensing means having a plurality of nozzles projecting in the direction of flow, with means for admitting additional quantities of atmospheric air and for entraining the same in the current flowing through the nozzles, the delivery end of said nozzle delivering directly to said low pressure reservoir, said condensing means including means for admitting air from the low pressure reservoir in an annular current surrounding the high pressure air emitted from the nozzles.

Signed at Los Angeles, California, this 21 day of May, 1929.

WILLIAM B. HALE.