

April 13, 1937.

W. NOBLE

2,076,586

FLUID COMPRESSOR

Filed Feb. 28, 1934

2 Sheets-Sheet 1

Fig. 1.

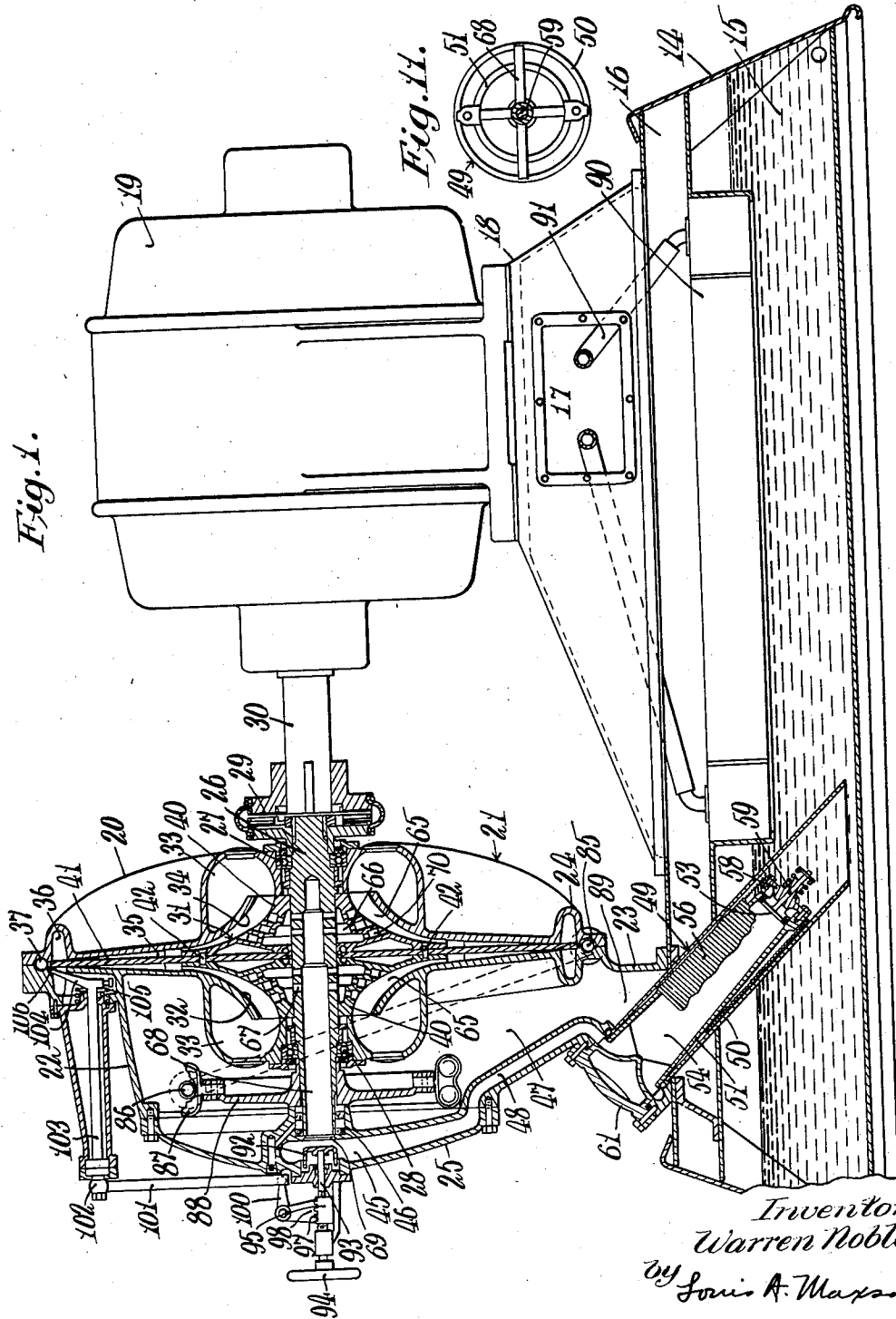


Fig. 11.

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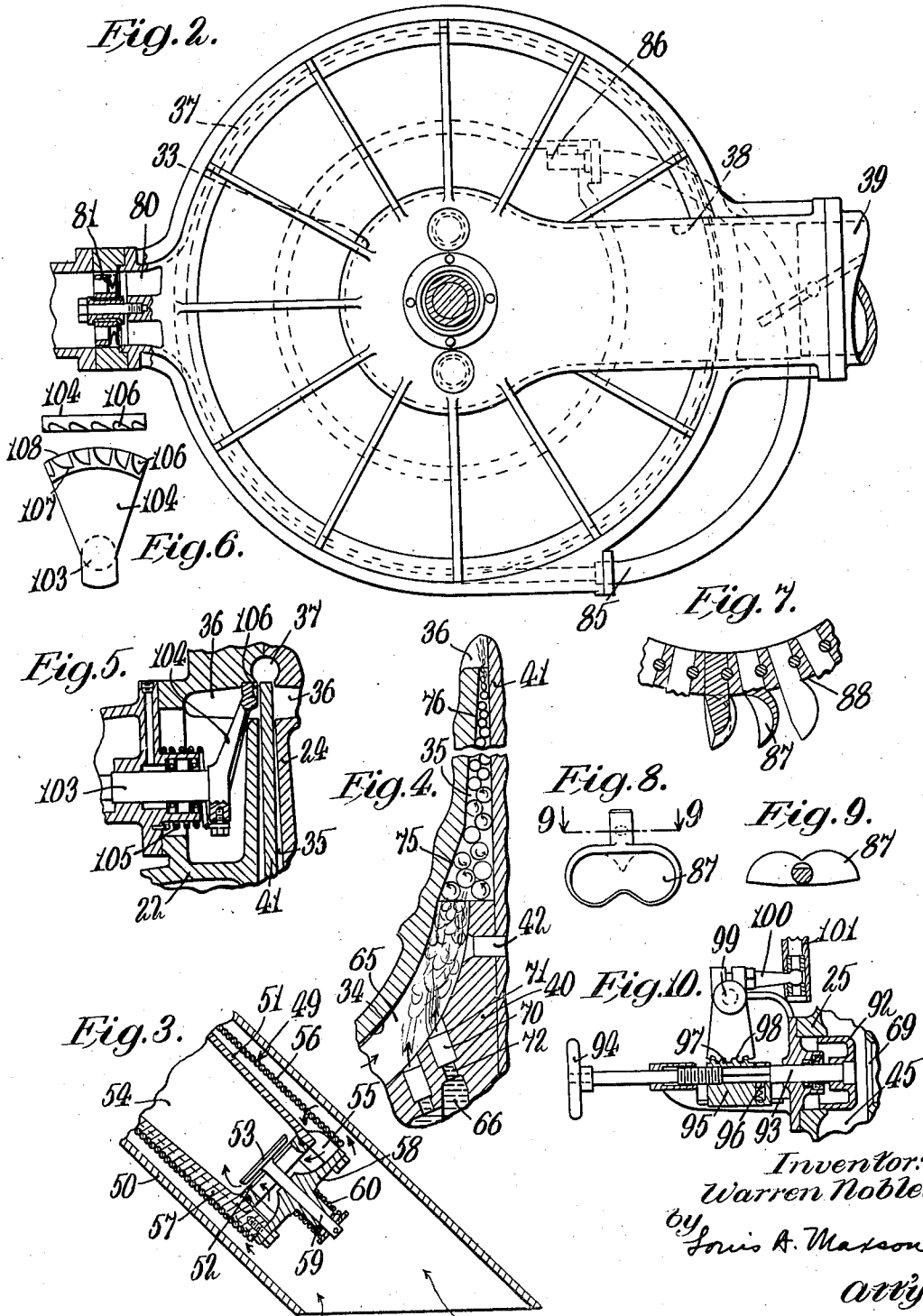
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UNITED STATES PATENT OFFICE

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FLUID COMPRESSOR

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Application February 28, 1934, Serial No. 713,332

32 Claims. (Cl. 230—108)

My invention relates to gaseous fluid compressors, and more particularly to gaseous fluid compressors in which a liquid is employed under the action of centrifugal force for the purpose of compressing the gas.

From one of its aspects my invention relates to the provision of a gaseous fluid compressor in which a liquid, after having had a large amount of energy imparted to it in the course of its action as a compressing medium, is caused to give up that energy and restore it to the power driving system of the compressor in such a manner that there is a minimum loss of power.

From another aspect of my invention, the same comprises the feature of employing, whether in a single stage or in a multi-stage compressor, a liquid, preferably a liquid having a substantial surface tension, both for the purpose of acting to entrain and compress a gas which is to be compressed and to carry away the heat of compression.

Still another aspect of my invention comprises the feature of washing the air during the course of compression in such a manner that all impurities are removed, soluble gases are washed out of the air, and the air humidified and brought to a desired temperature, whereby a system of pumping air of broad application, but of a special benefit for air conditioning work, is provided.

A still further aspect of my invention resides in the provision of a compressor of such character that a completely silent action is accomplished, despite the handling of large quantities of air and the conditioning thereof, as above mentioned, so that a compressor system especially adapted to hospital use is provided.

Yet another aspect of the invention resides in its provision of an improved method of hydraulic compressing, involving mechanical rolling of bubbles of entrained air.

One of the primary objects of my invention is to provide an improved compressor employing a liquid as the compressing medium, and having provision for the recovery of the kinetic energy imparted to the liquid during the compressing process. Another object of my invention is to provide an improved compressor employing a liquid as the compressing medium, having provision for the mingling of the gas to be compressed, in bubble form in the compressing liquid medium, and providing not only the effect of centrifugal force, but also a rolling action for the purpose of effectually accomplishing a compressive action. A further object of my invention is to provide an improved liquid type compressor

having bubble forming and bubble rolling means, whereby the gas to be compressed is intimately mingled with, and thoroughly washed by the liquid compressing medium. Yet another object of my invention is to provide an improved compressor wherein there shall be accomplished not only the function of efficient compression, but the desired cooling and humidifying of the air compressed, so that after re-expansion the air may be suitably conditioned for use in a conditioned-air compartment. Another object of my invention is to provide an improved compressor employing the principle of mingling the gas to be compressed with a liquid compression medium, and having improved separating means for separating the gas from the liquid after compression. Still another object of my invention is to provide an improved direct-contact liquid-medium type of compressor, having improved automatic control means for regulating the quantity of liquid admitted to the compressor, and thereby the output of the compressor, and also the terminal pressure of the compressor. Still another object of my invention is to provide an improved liquid type compressor in which various fluids, having different viscosities and different surface tensions, may be employed to imprison bubbles of air or other gas, and subject such bubbles to a rolling-down action concurrently with the development of increasing centrifugal pressures as the size of the bubbles diminishes. Still another object of my invention is to provide an improved compressor of the liquid type having associated therewith cooling means, by means of which the terminal temperature of the liquid to be compressed can be controlled and varied. Yet another object is to provide an improved method of compressing gaseous materials. Other objects and advantages of my invention will hereinafter more fully appear.

In the accompanying drawings in which there is shown for purposes of illustration one form which my invention may assume in practice,—

Fig. 1 is a view partially in elevation and partially in vertical central section through a compressor unit in which the invention is embodied in one of its forms.

Fig. 2 is a view in end elevation with parts broken away of a part of the compressor mechanism proper.

Fig. 3 is an axial section on an enlarged scale showing the liquid intake of the compressor.

Fig. 4 is a fragmentary diametric section through a portion of the pump rotor and a portion of the casing.

Fig. 5 is an enlarged fragmentary detailed section through a portion of the automatic liquid supply control.

Fig. 6 shows a side elevation and an end view of one part of the automatic liquid control.

Fig. 7 is a fragmentary view of the Pelton wheel forming a part of the compressor.

Fig. 8 is an end view and Fig. 9 a view on the line 9-9 of Fig. 8 showing one of the bucket-pairs of the Pelton wheel.

Fig. 10 is a fragmentary view on an enlarged scale showing details of construction of the liquid control valve.

Fig. 11 is an end view of the liquid intake connection.

Referring to the drawings, and at first particularly to Fig. 1, it will be noted that a suitable base 14 provides a large internal chamber 15 and a smaller upper internal chamber 16, the latter communicating with a chamber 17 in a hollow motor support 18, which supports a driving motor unit 19 aligned with a compressor 20 upon the base 14. The compressor comprises a plural part casing generally designated 21 and made up of a body element 22 providing a pedestal 23, another body element 24 and an end element 25. Within the body elements 22 and 24 there is journaled a hollow shaft 26 in suitable bearings 27 and 28, and this shaft is connected herein through a flexible coupling 29 with the motor shaft 30. The shaft 26 supports a rotor structure generally designated 31, which rotates in a chamber of symmetrical cross section 32, said chamber comprising a pair of air admission spaces 33 one of which is formed within each of the casing parts 22 and 24, bubble forming chambers 34, compression spaces 35, air discharge spaces 36, and a liquid race 37, all of the several parts mentioned being part in casing member 22 and part in casing member 24 and symmetrically arranged with respect to the central plane of the rotor 31. Air is supplied to the spaces 33 through a conduit 38 formed in the casing and connected to a source of supply through a pipe 39. The rotor itself is made up, as herein shown, of three elements, a pair of bubble forming elements or nozzle elements 40 and a plate or central element 41. The latter may assume various forms and may be constructed, if desired, as a plane smooth surfaced plate or it may be provided with spiral vanes under certain circumstances. The parts of the rotor are all held together by suitable rivets or the like 42.

It will be observed that the shaft 26 is hollow and this hollow shaft communicates with a chamber 45 formed in the casing element 25, this chamber being sealed, by a suitable seal type packing 46, from a space 47 within the casing member 22. A suitable conduit 48 formed in the wall of the casing member 22 leads to a combined strainer and suction valve mechanism 49 arranged in position to extend through the chamber 16 into the chamber 15. This mechanism includes a sleeve 50 in which is mounted a tapering suction member 51, at whose lower end a valve seat 52 is formed to receive a valve 53, which controls the communication between the space 54 within the suction member and a space 55 to which liquid can attain access only through a strainer 56 supported by means of suitable ribs 57 formed upon the outside of the suction element 51. A head 58 in which the valve 53 is slidably guided by means of a stem 59 forms a closed lower end to the space to which liquid is first admitted after passing the strainer 56. A light spring 60 main-

tains the valve 53 closed so that when the pump is primed, the priming will not be lost before a suction has been established. The upper end of the liquid intake apparatus is closed by a suitable head 61.

The bubble forming devices of the rotor may be smooth, or may be provided with a series of curved tapering passages 65 communicating at their larger and inner ends with the air admission spaces 33, said passages being closed on their outer sides by walls of the stationary casing. The bubble forming portions further each comprise central chambers 66, communicating through passages 67 with the hollow interior 68 of the shaft 26 which in its turn has communication through its valve controlled mouth 69 with the space 45 to which liquid is drawn, after the pump is running, through the liquid intake. One or more series, preferably several, of relatively radially extending bubble forming or nozzle devices 70 extend between the water spaces 66 and the air admission spaces or grooves 65. The nozzle or bubble forming devices may assume various forms, and are here shown as having relatively enlarged mouth or discharge portions 71, and smaller liquid jet forming portions 72. It will be observed that the space 65 or spaces (depending upon the nature of the exteriors of members 40) are bounded at their inner sides by the rotor structure and at their outer sides by a stationary casing wall. It will be noted, moreover, that radially outwardly, beyond the bubble forming members 40, there is a relatively sharp angle of approach of the casing or rotor chamber wall to the rotor plate 41 and then a more gradual taper as respectively shown at 75 and 76. The form and angle of this wall is, of course, variable in accordance with the speeds, the dimensions, and other design features of the compressor. At the outer edge of the spaces 35 there is, as has been noted, a relatively large air separation groove 36, with portions at each side of the outermost part of the rotor disc, and beyond the latter a water race 37. The air separation groove or grooves 36 communicate with a discharge passage 80 having any suitable form of discharge valve 81, herein a valve being used which is covered in my copending application Serial No. 713,336, filed of even date herewith.

In the normal operation of the compressor as so far described, it will be understood that after suitable priming, if necessary, the compressor will automatically draw in liquid through the intake valve 53, after the same has been strained through the strainer 56, and will cause the liquid to pass through the hollow interior 68 of the shaft 26 and out through the nozzles or bubble makers 70 where the liquid under the action of centrifugal force will be caused, in passing into the space and also after impinging upon the casing walls, to entrain air,—partially perhaps by a slug action in the upper part of the mixing chambers 65, in part perhaps by absorption, and largely in the form of bubbles, in the highly agitated state in which the liquid flows out of the chamber 65 into the tapered space 75. After the liquid with its entrained air enters the space 75, it is subjected to increasing centrifugal force, and due to the presence of a rolling action between the plate 41 and the stationary casing wall 76, the compressing action will be facilitated and a high compression, whose value may be readily determined according to well known principles of design, will be built up. As the fast moving films of liquid containing highly compressed air pass through the narrow spaces be-

tween the inner edges of the air discharge pockets and the rotor, the compressed air will separate from the moving films of liquid, and the latter, adhering to the extremely fast rotating plate 41, will enter the liquid race 37 from which they will be discharged through a passage 85 and a nozzle 86 to act upon the buckets 87 of a Pelton wheel 88 which is fast to the shaft 26. After acting upon the Pelton wheel the liquid will flow through the passage 89 to the chamber 16 and will there flow through a cooling radiator 90, having suitable fluid supply and discharge connections 91, before returning to the liquid storage space 15.

The amount of liquid supplied to the hollow shaft 26 is controllable by valve 92 having a manual adjustment, through rotation of its stem 93 by a hand wheel 94, to limit its maximum opening, but constantly subject to close adjustment by automatic means as will presently be described.

To obtain manual adjustment of this valve, the stem 93 is threaded for axial adjustment within a non-rotatable sliding block 95, and is held against unintentional angular movement by a spring pressed plunger 96 engaging a flattened surface of the stem. The automatic adjusting means consists of a rack 97 secured to the block 95, and an arcuate rack 98, meshed with the rack 97 and pivotable through a shaft 99, and turned with that shaft by an arm 100 secured to said shaft. The arm 100 is connected by a link 101 with an arm member 102 upon a shaft 103 which supports a member 104 whose position varies with the quantity of liquid passing through the compressor. The member 104 is in the form of a fan-shaped member supported by the shaft 103 and normally maintained in a certain angular position by a torsion spring 105. The member 104 projects through one of the air spaces 36 into close contiguity to the periphery of the rotor disc 41 and is provided with a series of bucket-like recesses 106 sealed at their lower edges 107 and having open outer ends 108 so that only when an excess amount of water is passing through the compressor is there exerted upon the member 104 a marked rotative effort. When too much water does come through the compressor, through its action upon the buckets or grooves 106, there will be imparted to the member 104 a rotative force, which, through the shaft, arms and link described, will move the valve 92 toward closed position and thereby reduce the amount of liquid attaining access to the interior of the rotor.

The general mode of operation may now be further described. The quantity of liquid being varied, there will be a variation in the maximum pressure for a given speed, for the specific gravity of the mixture will control the maximum centrifugal force attainable. The cooling of the radiator 90 will control the terminal temperature in an evident manner. The specific gravity of the liquid medium used will affect the pressure, and the viscosity and surface tension of the liquid medium will also affect efficiency. The compressor will be silent, and will wash, and humidify dry air. It will remove soluble gaseous impurities from the air. In other words, it will be ideally adapted for air conditioning. It will subject the air both to centrifugal force, and to a rolling action upon the bubbles in a diminishing space. This rolling action will be as it were spiral, because of the circumferential and radial components, and the rolling action will be concurrent with increasing pressure due to centrifugal force. It will recover the kinetic energy received by the liquid during the imparting of centrifugal force

thereto. There will be noted to be very few moving parts, almost no wear, silence, automatic control—an ideal combination for air-conditioning use, and the possibility of high pressures in a single stage machine, though there is adaptability to plural staging. There is also provided an improved method of hydraulic compression involving the novel feature of bubble formation and rolling down, and the attendant use of increasing centrifugal force. These and various other uses and advantages of the improved compressing unit will be clearly apparent to those skilled in the art.

While there is in this application specifically described one form which the invention may assume in practice, it will be understood that this form is shown for purposes of illustration, and that the invention may be modified and embodied in various other forms without departure from its spirit or the scope of the appended claims.

What I claim and desire to secure by Letters Patent is:—

1. In a compressor, a casing, a rotor therein, a liquid constrained to movement through said casing and to which centrifugal force is imparted by said rotor, means carried by said rotor for effecting entraining of air by said liquid, and separate liquid and air discharges having direct communication with said rotor at radially different portions of the latter.

2. In a compressor, a casing, a rotor therein, a liquid constrained to movement through said casing and to which centrifugal force is imparted by said rotor, means carried by said rotor for effecting entraining of air by said liquid, and separate liquid and air discharges respectively radial of and transverse to said rotor.

3. In a compressor, a casing, a rotor therein, liquid supply means communicating with said rotor, gaseous fluid inlet means to said casing, and gaseous fluid and liquid discharges at spaced annular zones adjacent the periphery of the rotor.

4. In a compressor, a casing, a rotor therein, liquid supply means communicating with said rotor, gaseous fluid inlet means communicating with said rotor, gaseous fluid discharge grooves at the outer edges of the rotor, and a liquid discharge beyond the periphery of the rotor.

5. In a compressor, a casing, a rotor therein, liquid supply means through the rotor, gaseous fluid inlet means through the casing, said casing and rotor providing a tapering compression space, and gaseous fluid and liquid discharge passages at different radial distances from the rotor axis.

6. In a compressor, a casing, a rotor therein, a liquid supply to said rotor, an air inlet provided by said casing, said rotor effecting a mingling of air and liquid and compression of the former, a liquid discharge at the periphery of the rotor, an air discharge for largely separating the air from the liquid prior to discharge of the latter, driving means for the rotor, and a Pelton wheel having a nozzle supplied from said liquid discharge and connected to said rotor for rotation therewith.

7. In a compressor, a casing, a rotor therein, means affording a liquid supply to the center of said rotor, means providing an air inlet near the center of said casing, said casing and rotor having walls approaching each other towards the periphery of the rotor, and relatively close for a considerable distance inwardly from the periphery, and separate air and liquid discharges having separate communications with the rotor.

8. In a compressor, a casing, a rotor therein, a

liquid supply to the center of said rotor, an air inlet near the center of the casing, bubble forming nozzles on said rotor, said casing, and rotor co-operating to roll said bubbles during centrifugal compression, and discharge means for the air and liquid.

9. In a compressor, a casing, a rotor therein, a liquid supply to the center of said rotor, an air inlet near the center of the casing, bubble forming nozzles on said rotor, said casing and rotor co-operating to roll said bubbles during centrifugal compression, and discharge means for the air and liquid differently spaced radially of the casing.

10. In a compressor, a casing, a rotor therein, means affording a liquid supply to said rotor, air inlet means communicating with said rotor, a regulating valve for the liquid supply, and means including a device governed by the volume of liquid passing across the periphery of the rotor for controlling said valve.

11. In a compressor, a casing, a rotor therein, a liquid supply to said rotor, air inlet means leading to said rotor, means for freeing the liquid of air at and for returning the liquid from the periphery of the rotor to its source of supply, and means for controlling the temperature of the liquid in its passage between the edge of the rotor and the source.

12. The method of compressing a gas which comprises as steps, formation and entraining of bubbles of gas in a stream of liquid of progressively increasing pressure, and rolling said bubbles to decrease their size mechanically as well as hydraulically.

13. The method of compressing a gas which comprises as steps, providing a moving stream of air, discharging jets of liquid thereinto to cause a bubbly mixture, subjecting said mixture to progressively increasing pressure and concurrently subjecting the same to a rolling action.

14. The method of compressing a gas which comprises as steps, providing a conelike sheet of air moving with diminishing thickness and increasing velocity from the apex towards the base thereof, discharging into the same liquid in broken-up form and at an angle to the flow of the air stream to produce a bubbly mass or quasi-emulsion in the form of a sheet corresponding in shape to the surface of a flattening cone, and substantially increasing the unit pressure in said mass by centrifugal action and effecting relatively opposite movement between the opposite surfaces of said last mentioned sheet.

15. The step in gas compression, of rolling gaseous bubbles in a liquid compression medium between converging surfaces.

16. The step in gas compression of rolling gaseous bubbles in a liquid compression medium between contiguous surfaces while increasing the fluid pressure.

17. The step in gas compression of subjecting gaseous bubbles in a liquid compression medium to concurrently increasing pressure and rolling action.

18. The step in gas compression of subjecting the mingled gas and liquid to a rolling action spirally.

19. The method of gas compression consisting of subjecting successive portions of mingled gas and liquid to a rolling action spirally and to a concurrently increasing hydraulic pressure.

20. In a compressor, a casing, a rotor in said casing, means for supplying commingled gaseous

fluid and liquid to said casing for a compressive action thereon by said rotor, and means for substantially separating the compressed fluid from the liquid before the edge of the rotor is reached.

21. In a compressor, a casing, a rotor in said casing, means for supplying commingled gaseous fluid and liquid to said casing for a compressive action thereon by said rotor, means for substantially separating the compressed gaseous fluid from the liquid before the edge of the rotor is reached, and separate discharge means for said compressed gaseous fluid and said liquid.

22. In a compressor, in combination, a rotor in the form of a flat metal disc mounted to rotate on a stationary axis coincident with its own axis and having annular, opposite, lateral fluid engaging portions of substantial radial dimension and smooth throughout their entire radial and circumferential extent, and means forming a chamber for said rotor and providing a radially-free path for fluid for guiding fluid from the portions of said rotor nearer the axis thereof towards the periphery thereof as said rotor turns.

23. In a compressor, in combination, a rotor in the form of a flat metal disc having a relatively thin, imperforate, smooth-surfaced body, and means forming a chamber for said rotor providing smooth walls for the conducting of fluid outwardly radially of the rotor.

24. In a compressor, a casing having a compression chamber, a rotor in said chamber in the form of a flat metal circular disc, means for supplying commingled air and liquid to said compression chamber for a compressive action thereon by said rotor, and means for separating the compressed air from said liquid.

25. In a compressor, a casing having a compression chamber, a rotor in said chamber in the form of a flat, circular metal disc, means for supplying commingled air and liquid to said compression chamber, discharge means adjacent to the periphery of said rotor for discharging the compressed air from said chamber, and peripheral discharge means for discharging liquid from said chamber.

26. In a compressor, a casing, a rotor in said casing, means for supplying commingled air and liquid to said casing for action thereon by said rotor, discharge means for the compressed air and for said liquid, and means including an element projecting into said air discharge means and controlled by overflow of liquid to said air discharge means for automatically regulating flow of liquid to said casing.

27. In a compressor, a casing, a rotor in said casing, means for supplying commingled air and liquid to said casing for action thereon by said rotor, discharge means for the compressed air and said liquid, means including an element projecting into said air discharge means and controlled by overflow of liquid to said air discharge means for automatically regulating flow of liquid to said casing, and means associated with said automatic control means for manually regulating the liquid flow.

28. In a compressor, a casing having a compression chamber, a rotor in said chamber, means for supplying commingled air and liquid to the compression chamber for compression therein upon rotation of said rotor, discharge means adjacent the periphery of said rotor for compressed air, and collection and discharge means at the periphery of said rotor for the liquid.

29. In a compressor, a casing having a com-

pression chamber, a rotor in said chamber, means for supplying commingled air and liquid to the compression chamber for compression therein upon rotation of said rotor, discharge means adjacent the periphery of said rotor for compressed air, collection and discharge means at the periphery of said rotor for the liquid, and means governed by the thickness of the liquid transversely of the rotor, at the periphery of the latter, for controlling the rate of liquid supply.

30. In a compressor, a casing having a rotor therein, means for introducing air and liquid into said casing for action thereon by said rotor, said rotor effecting a centrifugal compression of said air, means for separating the compressed air, and means receiving said liquid at the periphery of the rotor and conducting it substantially tangentially therefrom, a wheel coaxial with the rotor and axially spaced therefrom for aiding in

driving the rotor, and conducting means receiving the liquid from said substantially tangential discharge and supplying it to said wheel.

31. In a compressor, in combination, a rotor rotatable on a stationary axis and providing an outer thin smooth annular portion of substantial radial extent, and a housing providing smooth walls opposed to the sides of said annular portion and approaching the latter laterally towards the periphery thereof.

32. In a compressor, in combination, a rotor rotatable on a stationary axis and providing an outer thin smooth annular portion of substantial radial extent, and a housing cooperating with said rotor to provide a passage for fluid of diminishing dimension, axially of the rotor, towards the periphery of the latter.

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