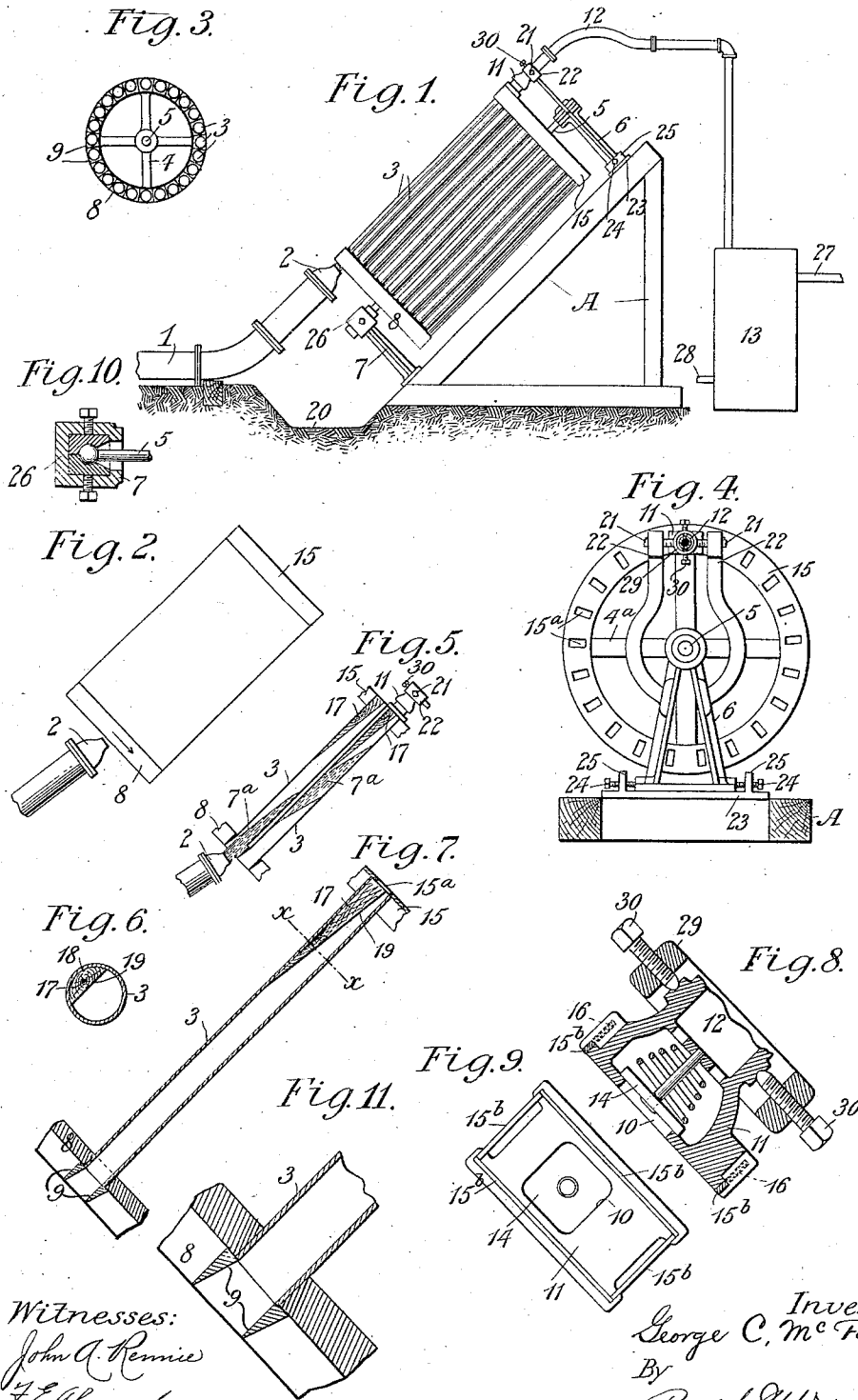


G. C. McFARLANE.
ELASTIC FLUID COMPRESSOR.
APPLICATION FILED JULY 28, 1910.

1,065,825.

Patented June 24, 1913.



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UNITED STATES PATENT OFFICE.

GEORGE C. McFARLANE, OF DENVER, COLORADO.

ELASTIC-FLUID COMPRESSOR.

1,065,825.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, GEORGE C. McFARLANE, a citizen of the United States, residing at Denver, in the county of Denver and State of Colorado, have invented certain new and useful Improvements in Elastic-Fluid Compressors, of which the following is a specification.

My invention relates to elastic fluid compressors and more particularly to that class, wherein liquid under pressure is employed to force charges of an elastic fluid successively, into a suitable container.

Among several types of air compressors of the prior art, there is one wherein the liquid, usually water, under pressure, was discharged in a series of jets from revolving nozzles into the mouths of a circularly arranged series of compression tubes extending radially relative to the jets and communicating with a suitable reservoir. In another, a single movable nozzle was oscillated to discharge a jet of water into a series of compression tubes successively. In either type, the discharge into the tubes, of successive slugs of water spaced apart by volumes of air, resulted in a commingling or emulsion of the air and water which necessitated the insertion of a separator in the system between the compression tubes and the air reservoir, thereby increasing the expense and reducing the efficiency, the entire mechanism being cumbersome and ill-adapted for general use.

One advantage of my invention is that the entire energy of the liquid compressing medium is employed to compress the air, the full kinetic energy of a flying slug of liquid being directed against a charge of air, and when the latter is forced into a suitable receiver, the slug of liquid has been brought to rest, its energy has been expended, and it flows away. In former constructions, the liquid commingles in large volumes with the high pressure air, in the pressure receiver, so that in compressing air to 80 pounds gage pressure by means of water at 160 pounds gage pressure, the ratio of water to compressed air would be about three volumes of water to one volume of compressed air.

Another advantage of my invention lies in the shape of the compression tubes through which the slugs of liquid travel to drive the air into the reservoir. As energy va-

ries as the square of the velocity, an increase of 50 per cent., in the cross-sectional area of the tube, decreases the energy 55.5 per cent. In compressing a gas, the pressure curve is a parabola, and in the first stages of compression very little energy is required, but as the slug of liquid or the piston nears the end of its stroke, the pressure against which it works mounts rapidly, and possibly three-quarters of the energy is expended in the last quarter of the stroke. Thus it is obvious that in a compression tube having even a gradual increase in cross-sectional area, the slug or piston of liquid will lose its main energy before the real work of compression begins. In my invention, I decrease the cross-sectional areas of the compression tubes at their discharge openings to enable the entire kinetic energy of the slug of liquid to be directed toward compressing the air and forcing it into the receiver.

One object of my invention is to provide a portable air compressor readily set up or taken down, comprising few parts and inexpensive to manufacture.

Another object is to enable the air to be forced into the receiver or reservoir directly by the pressure of the liquid piston, without, however, effecting the mixture of the air and liquid, such as would necessitate the admission of any large quantity of the latter to the receiver. This object I attain by moving one or more compression tubes into and out of the path of a stream of liquid under pressure, the compression tubes, also being moved into and out of communication with an air receiver so that the air compressed or pushed ahead of the slugs of liquid discharged into the tube, is admitted to the receiver, after which the tube is moved out of communication with said receiver to make room for the succeeding tube and to enable the first-named tube to become replenished with air.

A further object is to enable the compressor to operate with varying liquid pressures to regulate the degree of compression of the elastic fluid; and to obtain a high degree of compression with a low pressure of liquid, or vice versa.

In short, the main object of my invention is to simplify and improve elastic fluid compressors employing liquid as a medium of compression, so that the maximum kinetic energy of the liquid may be utilized in the

least expensive manner, both as regards equipment and power.

Other objects and advantages will be hereinafter set forth.

5 In the accompanying drawings, Figure 1 is a side elevation, illustrating one embodiment of my invention. Fig. 2 is a detail plan, illustrating one angle at which the stream may be delivered to the compression tubes. Fig. 3 is a view of the receiving end of the compression cage. Fig. 4 is a view of the discharge end thereof, together with the supporting pedestal. Fig. 5 is a longitudinal cross-section through two adjacent tubes, showing the slugs of liquid therein. Fig. 6 is a view of one of the tubes in cross-section, on line *x-x* of Fig. 7. Fig. 7 is a detail sectional view through one of the compression tubes. Fig. 8 is a sectional view of the bonnet communicating with the air receiver, into which the tubes deliver the compressed fluid. Fig. 9 is a bottom plan, showing the face of the bonnet. Fig. 10 is a detail sectional view of the step bearing for the shaft 5, and Fig. 11 is an enlarged sectional detail of the mouth of one of the compression tubes.

Liquid, as water, under pressure is conveyed from any suitable source, preferably natural, by a pipe 1 to a nozzle 2, preferably projecting upwardly, to deliver its stream into the mouths of several compression tubes 3, 3, successively, said tubes lying parallel with each other and arranged in a rotatable circular series to form a cage. The tubes are supported in such arrangement by heads 4, 4^a, mounted on a shaft 5 carried by the upper and lower pedestals 6 and 7. The tubes are comparatively short and open at both ends to the atmosphere, and the shaft or axis 5 may be horizontal or vertical, which would necessitate a horizontally or vertically placed nozzle, but to avoid sharp bends in the water conduit 1, I prefer to elevate the nozzle at an angle of say, 35 to 45 degrees to the horizon, with its discharge opening just clearing the mouths of the tubes (Figs. 1 and 2), the axis 5 being arranged at the same angle to the horizon as is the nozzle.

The compression tubes 3 are set closely together and the nozzle 2 is inclined to one side of the vertical plane of the axis of the cage (Fig. 2) to cause the stream to impinge slightly against one wall of each tube whereby to rotate the cage on its axis, to effect the presentation of the respective tubes successively to the stream. In normal operation, the inclination of the stream to the tubes is proportioned to give the correct speed of rotation to the cage, so that as the latter rotates, each tube will pass across the stream to slice off therefrom a solid slug of water. The tubes thus in effect, cut the stream into cylindrical slugs

7^a (Fig. 5) having their opposite ends inclined at an acute angle to the axis of the tube, and lying parallel with each other. The orifice of the nozzle is made, say, about 5 to 10 per cent. less in area than the cross-sectional area of each tube, not only because the stream starts to expand slightly after it issues from the nozzle, but more particularly, because at the instant the slug enters the tube, its speed is retarded by friction between itself and the tube, thereby increasing its sectional area; and in order to utilize the efficiency of the stream by preventing waste, the tubes are increased in area to accommodate the increased sectional area of the slugs.

Preferably, the receiving ends or mouths of the compression tubes are separated from each other by hoods formed by concentric annular flanges 8 carried by the lower head 4 to form a circular trough into which the mouths of tubes 3 open, said flanges projecting in advance of the open mouths of the tubes. The space or trough between the flanges is divided into sections by partitions 9, 9 to form funnels or hoods tapering from a substantially rectangular opening, to the circular tube section at their inner ends (Figs. 7 and 11) to collect the liquid and lead it to the tube 3. The hood described and illustrated is not essential, but is desirable.

The entrance of the slug of water under pressure into the tube, compresses the air therein (when the discharge opening of the tube is closed), said air being driven ahead of the slug traveling along the tube. As the lower ends of the tubes pass across the stream, the upper ends of said tubes successively glide beneath the closed face of a bonnet or hollow head 11, having an opening 10 therein constituting the receiving end of a pipe 12 leading to an air receiver or reservoir 13, to enable the air driven ahead of the slug to escape from the tube, a check valve 14 preventing the return of the air admitted to the bonnet. To insure a tight joint at the juncture of the bonnet and the compression tubes, the upper ends of said tubes are preferably seated in a ring 15 constituting the periphery of the upper head 4^a. The discharge openings of the tubes communicate with apertures 15^a in the outer face of said ring which is machined, a seal being formed between such machined face and the adjacent face of the bonnet around the opening 10 therein, by wearing strips 15^b, (Figs. 8 and 9) seated in grooves or recesses in the face of the bonnet and held against the face of the ring, as by springs 16. The unapertured portion of the face of the bonnet 11, under which the tubes first glide, constitutes a closure to block the exit of the air from the tubes, whereby to enable the slugs or pistons 7^a to compress the air

which finally escapes through the opening in the face of the bonnet, when the tubes register therewith, into the air receiver 13.

By arranging that the upper discharge end of a tube shall glide under the bonnet at about the time when the nearly full cross-section of the slug of water is entering its mouth, the full kinetic energy of the slug, less the pipe friction, will be expended in compressing the air in the tube and driving it into the receiver.

One of the main objects of the invention consists in the development of the full kinetic energy of the liquid piston, the utilization of such energy to compress the air and the prevention of the commingling of any great amount of water with the air in the receiver, to which ends it is desirable that the discharge openings of the compression tubes 3 be tapered or reduced in cross-section, to correspond with the face of the forward end of the slug (Fig. 5). As one means to taper the tubes, I secure in the discharge end of each tube 3, a smooth wedge-shaped filler 17, preferably of wood, having a curved face 18 to fit the inner periphery of the tube and an inclined flat face 19 against which the inclined forward end of the piston or slug of water strikes.

Until the discharge opening of the compression tube glides under and is closed by the bonnet 11, the travel of the piston or slug of water 7^a in the tube merely expels the surplus air from the discharge end, but as soon as the discharge end is closed, the slug or piston at once becomes effective to compress the air, the increasing pressure of which operates to impede the velocity of the slug which gradually slackens in speed, and the inclined rear end of the slug begins to gain on the inclined head end which strikes against and conforms to the inclined face of the filler 17 (or the otherwise reduced end of the tube). At this time practically all the air has been driven past the check valve 14 and the increased resistance to the progress of the slug of water, together with its impact against the filler, has brought the slug to rest, so that little if any liquid enters the receiver 13. By thus restricting the cross-sectional area of the tubes, the kinetic energy of the slug is directed toward compressing the air, its energy is conserved as the resistance to its advance increases, and its entrance into the receiver substantially prevented.

It will be understood that even though the slug should possess sufficient energy to pass into the bonnet, yet, owing to the speed of travel of the discharge opening of the tube relative to the bonnet, the registering area of communication is reduced to such a fine orifice that the liquid cannot readily pass therethrough. The gradually decreasing area of communication permits the passage

of air, but prohibits to a great extent, the entrance of liquid to the bonnet, it being easier to pass air through a small aperture than it is to pass water therethrough. As soon as the energy of the slug has been expended, the spent water flows down the tube and out of its mouth into a tail race 20. The weight of such spent water, in flowing down the tubes, aids in rotating the cage so that a very slight lateral inclination of the nozzle 2 is sufficient to produce the desired speed of rotation. The stream is directed into the tubes in the upper arc of their travel to thus utilize the force of gravity to assist in rotating the cage. The pipes empty themselves entirely of water and fill with air before they again cut across the stream.

By two simple adjustable arrangements, the device can be made to accommodate a wide range of water heads, and furnish air at any required degree of compression, such adjustments being obtained by regulating the inclination of the compression tubes 3 to the vertical plane of the stream, and the shifting of the bonnet 11 relative to the discharge ends of said tubes to regulate the time of closure or cut off of the discharge ends of the tubes relative to the entrance of the slugs of water thereinto.

To obtain a high degree of air compression with a moderate water pressure, the bonnet 11 is shifted forward or advanced in the direction of rotation of the tubes, so that the slugs of water in the tubes will expel the air ahead of them into the atmosphere (which necessitates but slight expenditure of energy) until the slugs 7^a have nearly reached the discharge ends of the tubes, at which time, the latter will glide under the imperforate portion of the face of the bonnet, and the full energy of the water will be exerted in compressing a comparatively small quantity of air.

The bonnet, which may be supported in a ring 29 and adjustably held by set screws 30, is adapted for lateral adjustment to time the compression, by oppositely located set screws 21 mounted in the arms of a yoke or cradle 22 secured to the upper pedestal 6.

It is evident that the time of cut off can be regulated to obtain different air pressures in the receiver 13.

To place air under a comparatively moderate compression by utilizing a high head of water, the compression tubes 3 may be inclined at a considerable angle to the vertical plane of the stream by shifting the upper pedestal 6 laterally on the sole plate 23 on which it rests, said plate having set screws 24 in ears 25 to bear against the opposite sides of the pedestal to hold it where adjusted. Such lateral adjustment of the cage is permitted by reason of the ball and socket step bearing 26 in the lower pedestal

7 (Fig. 10) in which one end of the shaft is supported. By thus inclining the cage away from its direction of rotation, the stream is caused to impinge more directly
 5 against the inner periphery of each tube to drive the cage at a higher speed of rotation, so that each tube 3 will slice off a shorter wedge or slug of water than when the
 10 stream is directed more nearly axially of the tubes; and the bonnet 11 is adjusted to close the discharge ends of the tubes at the instant the slugs enter the mouths of said tubes, whereby the energy of the water is called upon to compress the air in the tubes
 15 immediately upon its entry thus retarding its speed of travel, and before the air can be compressed to a high degree, the tubes have passed from beneath the bonnet.

An air discharge pipe 27 leads from the
 20 reservoir 13 which also has an exhaust pipe 28 to draw off the water which may enter the receiver. The cage is preferably mounted on an inclined frame A.

Variations may be made in the form and arrangement of the several parts described, and portions of the invention may be used without others, without departing from the spirit and scope of my invention.

Having thus fully disclosed my invention, what I claim as new, is:—

30 1. In an elastic fluid compressor employing a liquid under pressure as a compressing agent, the combination of a discharge member for the liquid under pressure, and a compression member, one movable relatively to the other, whereby liquid pistons are successively discharged into the compression member to compress the elastic fluid contained therein, such compression member having
 40 a discharge opening, a closure to block the discharge opening to enable the liquid to compress the elastic fluid, there being relative movement between the closure and compression member, and an air receiver, the closure having an opening with which
 45 the discharge opening of the compression member communicates, after having been closed, and with which opening in the closure, the receiver communicates.

50 2. In an elastic fluid compressor employing liquid under pressure as a compressing medium, the combination of several compression tubes having inlet and discharge openings, a delivery member to discharge
 55 the liquid into successive tubes to form separate liquid traveling pistons to compress the elastic fluid in the tubes, means to temporarily close the discharge openings in the tubes successively to enable the traveling
 60 pistons to compress the elastic fluid, a container for the compressed fluid, said means having an opening communicating with said container and with which opening the tubes successively communicate subsequently to
 65 the compression of the elastic fluid therein,

to enable the compressed fluid to escape into the container.

3. In an elastic fluid compressor employing liquid under pressure, as a compressing medium, the combination with a discharge member for said liquid, of several traveling
 70 compression tubes having inlet and discharge openings into the former of which, in succession, the liquid is intermittently discharged, to form liquid pistons to compress the elastic fluid in the tubes, means
 75 to temporarily close the discharge openings of the tubes successively, to enable the liquid pistons to compress the elastic fluid, a fluid pressure container, said means having
 80 an opening communicating with said container, with which opening the tubes communicate subsequently to the compression of the elastic fluid therein, and a check valve interposed between the opening and
 85 the receiver.

4. A hydraulic air compressor comprising a member to discharge liquid under pressure, a rotatable cage comprising several compression tubes having mouths so
 90 arranged as to successively pass across the stream of liquid under pressure, the impact of which against the inner peripheries of the tubes, turns the cage to enable the tubes to slice off slugs of liquid which travel along
 95 the tubes, said tubes having discharge openings, a closure past which the discharge openings of the tubes glide, to temporarily close said openings to enable the slugs to compress the air confined between the closure and said slugs, and an air receiver, said
 100 closure having an opening communicating with the receiver into which the compressed air is delivered.

5. In a hydraulic air compressor, the combination with a nozzle discharging a stream
 105 of liquid under pressure of a series of movable compression tubes successively presented in front of the nozzle to receive a slug of liquid, an air receiver, and a connection leading from the receiver with
 110 which the tubes successively register to deliver compressed air thereto.

6. In a hydraulic air compressor, the combination with a stationary nozzle discharging
 115 a stream of liquid under pressure, of a series of shiftable compression tubes having inlet and discharge openings respectively, the former successively cutting across the stream to slice off a slug of liquid, an air
 120 receiver, and a connection leading therefrom, and with which the discharge openings of the tubes successively register to deliver the air compressed by the slugs.

7. In a hydraulic air compressor, the combination with a nozzle discharging a stream
 125 of liquid under pressure, of a rotatable cage including a circularly-arranged series of compression tubes, each having a mouth cutting across the stream at an angle thereto, 130

whereby the impact of the liquid against the inner periphery of each tube, operates to turn the cage to effect the successive presentation of the mouths of the tubes to the stream, the rotation of the cage causing the tubes to slice off slugs or sections of the stream which travel along the tubes, an air receiver, and a closure having an opening therein communicating with the discharge ends of the tubes successively and with the air receiver to first close the discharge openings of the tubes and then enable the compressed air to escape to the receiver.

8. In a hydraulic air compressor, the combination of a member to discharge a stream of liquid under pressure, a series of compression tubes having mouths and discharge openings, the former traveling past the discharge member to slice off slugs of liquid which operate as pistons in the tubes, an air receiver, a closure for the discharge openings of the tubes, said closure having an aperture leading to the air receiver, with which the discharge openings of the tubes communicate to deliver the air compressed by the pistons thereto.

9. In an elastic fluid compressor employing a projected head of liquid as a compressing medium, a member to deliver said head of liquid, several tubes, having mouths and discharge openings, the former of which are movable across the projected stream to slice off slugs of liquid which operate as pistons in the tubes, means to close the discharge openings of the tubes during a part of their travel, to enable the pistons to compress the air therein, and an elastic fluid receiver with which the tubes communicate subsequently to the compression of the fluid therein.

10. In an elastic fluid compressor employing a stream of liquid under pressure as a compressing agent, a member to deliver said stream, several tubes, having mouths and discharge openings, the former of which pass across the stream to slice off slugs of liquid which act as pistons in the tubes, means to close the discharge openings of the tubes during a part of their travel, to enable the slugs to compress the elastic fluid therein, means to conserve the energy of the slugs as the resistance to their travel in the tubes increases, and an air receiver with which the tubes communicate subsequently to a compression of the fluid therein.

11. In an elastic fluid compressor, compression tubes having inlet mouths and discharge openings, and mounted to move along an endless path, a nozzle to direct a stream of liquid under pressure into the path of the inlet ends of the tubes at such an angle thereto as to impart motion to the tubes to cause them to pass across the stream in succession, to slice off slugs of liquid which act as pistons in the tubes, means to

close the discharge openings of the tubes to enable the pistons to compress the fluid in the tubes, and an elastic fluid receiver with which the discharge openings communicate to deliver the compressed fluid thereto.

12. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a means of compression, a member to deliver said stream, several substantially straight compression tubes, the mouths of which are movable across the stream to slice off slugs of liquid therefrom to act as pistons in the tubes, and a receiver to which the fluid compressed in the tubes by the liquid, is delivered.

13. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of substantially straight compression tubes having mouths, and mounted to have a path of movement intersecting the stream, to be driven thereby, and caused to slice off liquid pistons from the stream, and a receiver with which the tubes communicate to deliver the fluid compressed by the pistons.

14. An elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of compression tubes arranged at an angle to the vertical plane of the stream and adapted to travel across the stream to slice off liquid pistons therefrom, and a receiver with which the tubes communicate to deliver the fluid compressed by the pistons.

15. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of compression tubes arranged at an angle to the vertical plane of the stream and adapted to travel across the stream, to slice off liquid pistons therefrom, a receiver with which the tubes communicate to deliver the fluid compressed by the pistons, and means to adjust the angle of the tubes relatively to the stream.

16. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of compression tubes arranged at an angle to the vertical plane of and adapted to travel across the stream, to slice off liquid pistons therefrom, a receiver with which the tubes communicate to deliver the fluid compressed by the pistons, and means to adjust the device to varying heads of liquid.

17. An elastic fluid compressor comprising a member to deliver a liquid stream at an upward incline, as a compressing agent, a series of compression tubes arranged at about the same incline to travel in front of the member and slice off slugs or sections

of the stream, which operate as pistons in the tubes, and a receiver with which the tubes communicate to deliver the compressed fluid thereto.

18. An elastic fluid compressor comprising a member to deliver a head of liquid in a stream, as a compressing agent, a series of compression tubes arranged to form a drum or cage and having mouths and discharge openings, the former adapted to pass in succession across the stream to slice off slugs of liquid which act as pistons in the tubes to compress the fluid therein, means to close the discharge openings of the tubes to enable the pistons to compress the fluid therein, a receiver with which the discharge openings communicate subsequently to their closure, and a shaft by which the cage is supported to rotate.

19. An elastic fluid compressor comprising a member to deliver a head of liquid in a stream, as a compressing agent, a series of compression tubes arranged to form a drum or cage and having mouths and discharge openings, the former adapted to pass across the stream and slice off slugs of liquid to act as pistons in the tubes, to compress the fluid therein, a closure for temporarily stopping the discharge openings of the tubes to enable the pistons to compress the fluid therein, a receiver with which the discharge openings successively communicate to deliver the compressed fluid, a pivoted journal supporting one end of the cage to enable the latter to swing back and forth, and a shiftable support for the opposite end of the cage, to effect a variation of the inclination of the tubes relatively to the stream.

20. An elastic fluid compressor comprising a member to deliver a head of liquid in a stream, as a compressing agent, a series of compression tubes arranged to form a drum or cage and having mouths and discharge openings, the former adapted to pass across the stream and slice off slugs of liquid to act as pistons in the tubes, to compress the fluid therein, a closure for temporarily stopping the discharge openings of the tubes, to enable the pistons to compress the fluid therein, a receiver with which the discharge openings successively communicate to deliver the compressed fluid, a pedestal having a ball bearing journal to support one end of the cage, a shiftable pedestal supporting the opposite end of the cage to effect a variation of the angle of the latter relatively to the stream, and means to lock the shiftable pedestal where adjusted.

21. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of compression tubes arranged to form a drum or cage and having mouths and discharge openings,

the former adapted to pass across the stream and slice off slugs of liquid to act as pistons in the tubes to compress the fluid therein, a closure for temporarily stopping the discharge openings of the tubes to enable the pistons to compress the fluid therein, a receiver with which the discharge openings successively communicate to deliver the compressed fluid, a pedestal having a ball bearing journal to support one end of the cage, a shiftable pedestal supporting the opposite end of the cage to effect a variation of the angle of the cage relatively to the stream to be varied, a sole plate on which the pedestal rests, ears on the plate and set screws seated in the ears and engaging the pedestal to hold it where adjusted.

22. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of compression tubes arranged to form a cage or drum and having mouths and discharge openings, the former adapted to pass across the stream and slice off slugs of liquid to act as pistons in said tubes, the longitudinal axes of the tubes extending at an angle to the direction of the stream to enable the impact of the liquid against the sides of the tubes to rotate the cage or drum, and means to vary said angle to control the speed at which the mouths of the tubes pass across the stream and the degree of compression of the fluid.

23. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of compression tubes arranged to form a cage or drum and having mouths and discharge openings, the former adapted to pass across the stream to slice off slugs of liquid to act as pistons in said tubes, the longitudinal axes of the tubes extending at an angle to the direction of the stream to enable the impact of liquid against the sides of the tubes to rotate the cage or drum, and means to control the speed of rotation of the cage.

24. In an elastic fluid compressor employing a head of liquid as a compressing agent, a member to deliver said liquid, a series of compression tubes having inlet and discharge openings, the former entered by slugs of the liquid which act as pistons to compress the fluid therein, the tubes being reduced in cross-sectional area, means to close the discharge openings of the tubes, and a receiver with which said discharge openings subsequently communicate.

25. In an elastic fluid compressor employing a head of liquid, as a compressing agent, a member to deliver said liquid, a series of compression tubes having inlet and discharge openings, the former entered by slugs of the liquid which act as pistons to com-

press the fluid therein, the discharge ends of the tubes being constricted, means to close the discharge openings of the tubes, and a receiver with which said discharge openings subsequently communicate.

26. In an elastic fluid compressor employing a head of liquid, as a compressing agent, a member to deliver said liquid, a series of compression tubes having inlet and discharge openings, the former entered by slugs of the liquid which act as pistons to compress the fluid therein, fillers in the discharge ends of the tubes to reduce their cross-sectional areas, means to close the discharge openings of the tubes, and a receiver with which such openings subsequently communicate.

27. In an elastic fluid compressor employing a head of liquid, as a compressing agent, a member to deliver said liquid, a series of compression tubes into which enter slugs of liquid to act as pistons to compress the fluid therein, tapering fillers in the discharge ends of the tubes to gradually reduce the cross-sectional areas thereof, means to close the discharge openings of the tubes temporarily, and a receiver with which such openings subsequently communicate.

28. In an elastic fluid compressor employing a head of liquid, discharged in a stream, as a compressing agent, a member to deliver said liquid, a series of traveling compression tubes having mouths and discharge openings, the former arranged to cut across the stream to slice off slugs of liquid to act as pistons in the tubes to compress the fluid therein, said tubes having their bores adjacent the discharge openings reduced in cross-sectional area to substantially conform to the shape of the leading ends of the liquid pistons.

29. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of traveling compression tubes having mouths and discharge openings, the former arranged to cut across the stream to slice off slugs of liquid which act as pistons in the tubes to compress the fluid therein, and fillers in the discharge ends of the tubes having inclined faces to reduce the bores of the tubes to conform to the shape of the leading ends of the liquid pistons.

30. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of traveling compression tubes having mouths and discharge openings, the former arranged to cut across the stream to slice off slugs of liquid which act as pistons in the tubes to compress the fluid therein, the tubes having their bores adjacent the discharge openings, reduced to conserve the energy of the pistons, as the

resistance to their advance through the tubes increases.

31. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of traveling compression tubes having mouths and discharge openings, hopper-like hoods located in front of each mouth and cutting across the stream to slice slugs of liquid therefrom, and guide them into the tubes to act as pistons to compress the fluid therein, means to temporarily close the discharge openings, and a receiver with which said openings subsequently communicate.

32. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of traveling compression tubes arranged to form a cage or drum, and having mouths and discharge openings, the former adapted to cut across the stream and slice off slugs of liquid which act as pistons to compress the fluid in the tubes, said tubes being of a larger cross-sectional area than the cross-sectional area of the stream, means to temporarily close the discharge openings, and a receiver with which the openings subsequently communicate.

33. In an elastic fluid compressor employing a head of liquid discharged in a stream as a compressing agent, a member to deliver said stream, a series of traveling compression tubes arranged to form a cage or drum and having mouths and discharge openings, the former adapted to cut across the stream and slice off slugs of liquid which act as pistons to compress the fluid in the tubes, partitions separating the mouths from each other, means to temporarily close the discharge openings, and a receiver with which the openings subsequently communicate.

34. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of compression tubes having mouths and discharge openings, the mouths arranged to cut across the stream to slice slugs of liquid therefrom which act as pistons to compress the fluid in the tubes, a bonnet relative to which the tubes travel, to close the discharge openings thereof, a receiver for the compressed fluid, said bonnet having an orifice communicating with the receiver with which orifice the discharge openings successively register subsequently to being closed.

35. In an elastic fluid compressor employing a head of liquid discharged in a stream as a compressing agent, a member to deliver said stream, a series of compression tubes, having mouths and discharge openings, the former of which cut across the stream to slice slugs of liquid therefrom which act as pistons to compress the fluid in the tubes, a

head having a smooth face in which the discharge ends of the tubes open, a bonnet relative to which the tubes travel, and having a face to temporarily close the tubes to enable the pistons to compress the fluid therein, a receiver for the compressed fluid, said bonnet having an orifice communicating with the receiver, with which orifice the discharge openings of the tubes register subsequently to being closed, and wearing material interposed between the bonnet and the smooth face of the head to prevent the escape of the compressed fluid.

36. In an elastic fluid compressor, employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, a series of traveling compression tubes having mouths and discharge openings into the former of which enter slugs of liquid to act as pistons to compress the fluid in the tubes, a closure relative to which the successive tubes travel, to close the discharge openings of the tubes temporarily, to enable the pistons to compress the fluid therein, an adjustable support for the closure to enable the time of closure of the discharge openings to be varied relatively to the travel of the pistons therein, and a receiver with which the discharge openings subsequently communicate.

37. In an elastic fluid compressor, employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said head, a series of traveling compression tubes having mouths and discharge openings, into the former of which enter slugs of liquid to act as pistons to compress the fluid in the tubes, a closure relative to which the tubes travel, to close the discharge openings of the tubes to enable the pistons to compress the fluid therein, an adjustable support for the closure, to enable the degree of compression of the fluid to be regulated, and a receiver with which the tubes subsequently communicate.

38. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said head, a series of traveling compression tubes having mouths and discharge openings into the former of which enter slugs of liquid to act as pistons, a closure relative to which the tubes travel to temporarily close the discharge openings of the tubes to enable the pistons to compress the fluid therein, and means to adjust the closure relatively to the discharge openings to regulate the degree of compression of the fluid.

39. In an elastic fluid compressor, employing a head of liquid discharged in a stream, as a compression agent, a member to deliver, said head, a series of traveling compression tubes having mouths and discharge openings into the former of which enter slugs of liquid to act as pistons, a closure relative to

which the tubes travel, to stop temporarily, the discharge openings of the tubes, to enable the pistons to compress the fluid therein, and an adjustable support for the tubes to vary their inclination relatively to the stream, the closure being mounted for independent adjustment on the support.

40. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, compression tubes into which portions of the stream are discharged to compress the fluid in the tubes, and means to control the degree of compression thereof.

41. In an elastic fluid compressor employing a head of liquid discharged in a stream, as a compressing agent, a member to deliver said stream, traveling compression tubes, the mouths of which pass across the stream to cut slugs therefrom, which act as pistons to compress the fluid in the tubes, and means to control the degree of compression of the fluid.

42. The combination with a supply conduit to discharge a liquid under pressure, of several compression tubes having inlet and outlet openings and mounted so that said inlet openings will travel transversely in front of the supply, to slice the liquid into slugs to act as pistons in the tubes to compress the air therein, a closure for the discharge ends of the tubes to arrest the escape of the air and cause its compression, and a receiver communicating through a port in the closure with the discharge ends of the tubes, successively.

43. In a device wherein gases are compressed by a specifically heavier driving medium, the combination of a conduit to discharge a stream of liquid under pressure, several compression tubes having their inlet and discharge openings open to the atmosphere and mounted to travel transversely of the stream, to enable the inlet openings to slice off slugs of liquid from the stream to act as pistons to compress the gas within the tubes, a closure for the discharge ends of the tubes, and a receiver for the gas compressed between the liquid pistons and the closure, in the respective tubes.

44. In a device wherein gases are compressed by a specifically heavier driving medium, the combination of a conduit to discharge a stream of liquid under pressure, several compression tubes mounted to travel transversely of the stream to enable the inlet openings of the tubes to sever slugs of liquid from the stream, which act as pistons to compress the gas within the tubes, a closure for the discharge openings of the tubes, said compression tubes having their bores at their discharge openings, shaped to conform approximately to the shape of the leading ends of the liquid pistons, and a receiver for the gas compressed between the

liquid pistons and the closure, in the respective tubes.

45. In a device wherein gases are compressed by a specifically heavier driving medium, the combination of a conduit to discharge a stream of liquid under pressure, several compression tubes having inlet and outlet openings and mounted to travel transversely of the stream, to enable the inlet openings of the tubes to sever slugs of liquid from the stream which act as pistons to compress the gas within the tubes, a closure for the discharge ends of the tubes, said tubes having a slightly larger cross-sectional area than the cross-sectional area of the liquid pistons, and a receiver for the gas compressed between the liquid pistons and the closure.

46. In a device wherein gases are compressed by a specifically heavier driving medium, the combination of a conduit to discharge a stream of liquid under pressure, several compression tubes having inlet and discharge openings and mounted to travel transversely of the stream to enable the inlet openings of the tubes to sever slugs of liquid from the stream, which act as pistons to compress the gas within the tubes, means to vary the degree of compression to which the gas is subjected, and a receiver for the gas compressed between the liquid pistons and the closure.

47. In a device wherein gases are compressed by a specifically heavier driving medium, the combination of a conduit to discharge a stream of liquid under pressure, several compression tubes having inlet and discharge openings, and mounted to travel transversely of the stream, to enable the inlet openings of the tubes to sever slugs of liquid from the stream, which act as pistons to compress the gas within the tubes, an adjustable closure for the discharge openings of the tubes to vary the amount of compression to which the gas is subjected, and a receiver for the gas compressed between the liquid pistons and the closure.

48. In a device wherein gases are compressed by a specifically heavier driving me-

dium, the combination of a conduit to discharge a stream of liquid under pressure, several compression tubes having inlet and discharge openings, and mounted to travel transversely of the stream to enable their inlet openings to sever slugs of liquid from the stream, which act as pistons to compress the gas in said tubes, a closure for the discharge openings of the tubes, and a receiver to communicate with said discharge openings, into which the compressed gas is forced, said tubes being adjustable relatively to the direction in which the stream is projected, to operate with the greatest efficiency with streams of varying pressures.

49. In a hydraulic air compressor, the combination with a stationary nozzle discharging a stream of liquid under pressure, of a series of compression tubes having inlet and discharge openings, the tubes mounted to pass in front of the nozzle to cause their inlet ends to successively slice off slugs of liquid which travel along the tubes to compress the air therein, said tubes having their bores near their outlet openings constricted to conserve the kinetic energy of the slugs, and an air receiver with which said outlet openings successively communicate.

50. In a hydraulic air compressor, the combination with a nozzle to discharge liquid under pressure, of a series of compression tubes having inlet and outlet openings, the tubes mounted to pass in front of the nozzle to cause the inlet ends to slice off liquid slugs which enter the tubes and operate as pistons to travel along the tubes to compress the air therein, means to temporarily close the outlet ends of the tubes, and an air receiver with which the tubes successively communicate temporarily to deliver the compressed air.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

GEORGE C. McFARLANE.

Witnesses:

JOHN J. WEBBER,
JONAS W. STARK.