(No Model.) 2 Sheets—Sheet 1.

E. C. NICHOLS.

APPARATUS FOR COMPRESSING AND STORING AIR.

No. 555,178. Patented Feb. 25, 1896.

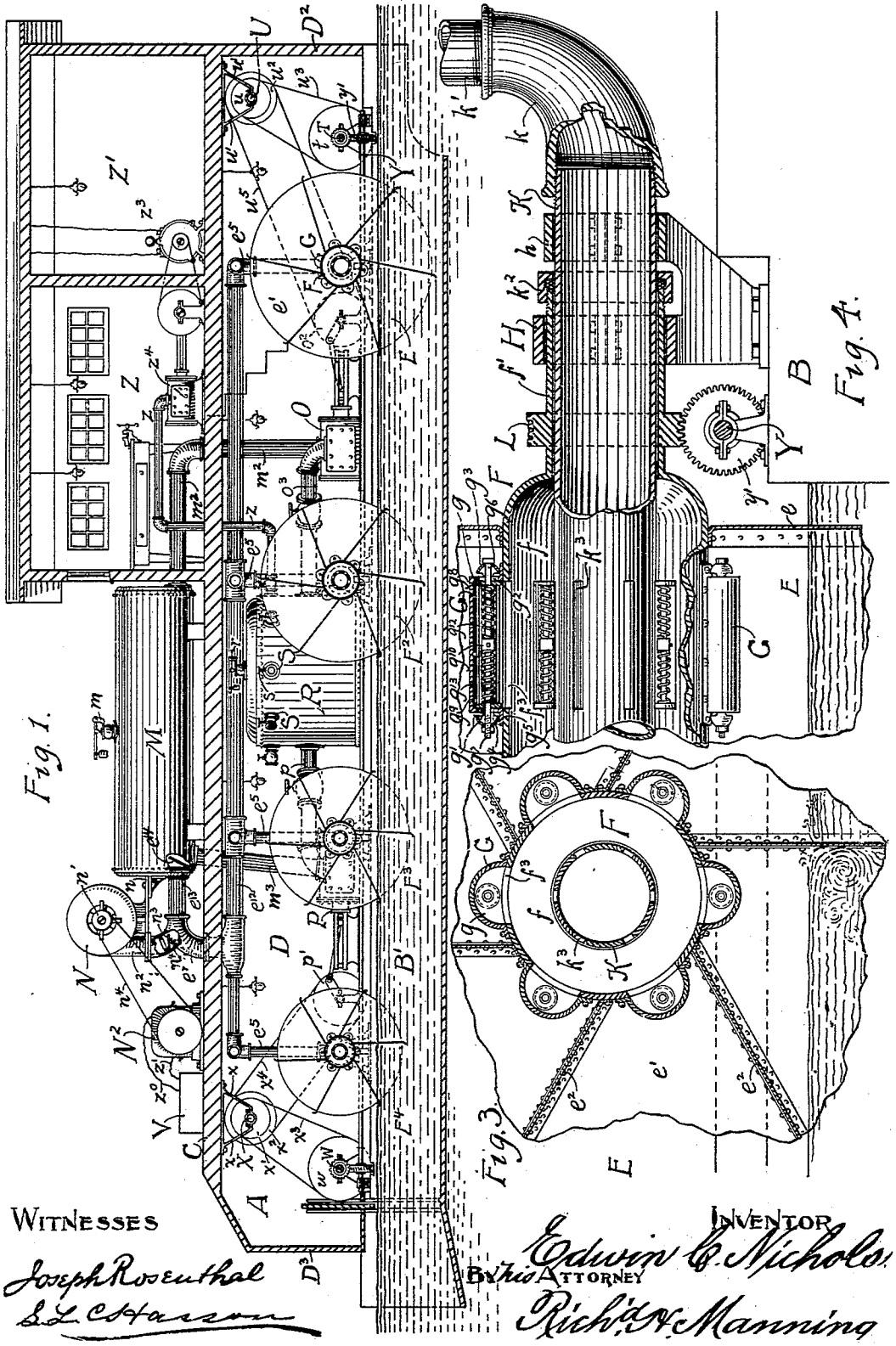

Fig. 1.

Fig. 4.

Fig. 3.

WITNESSES

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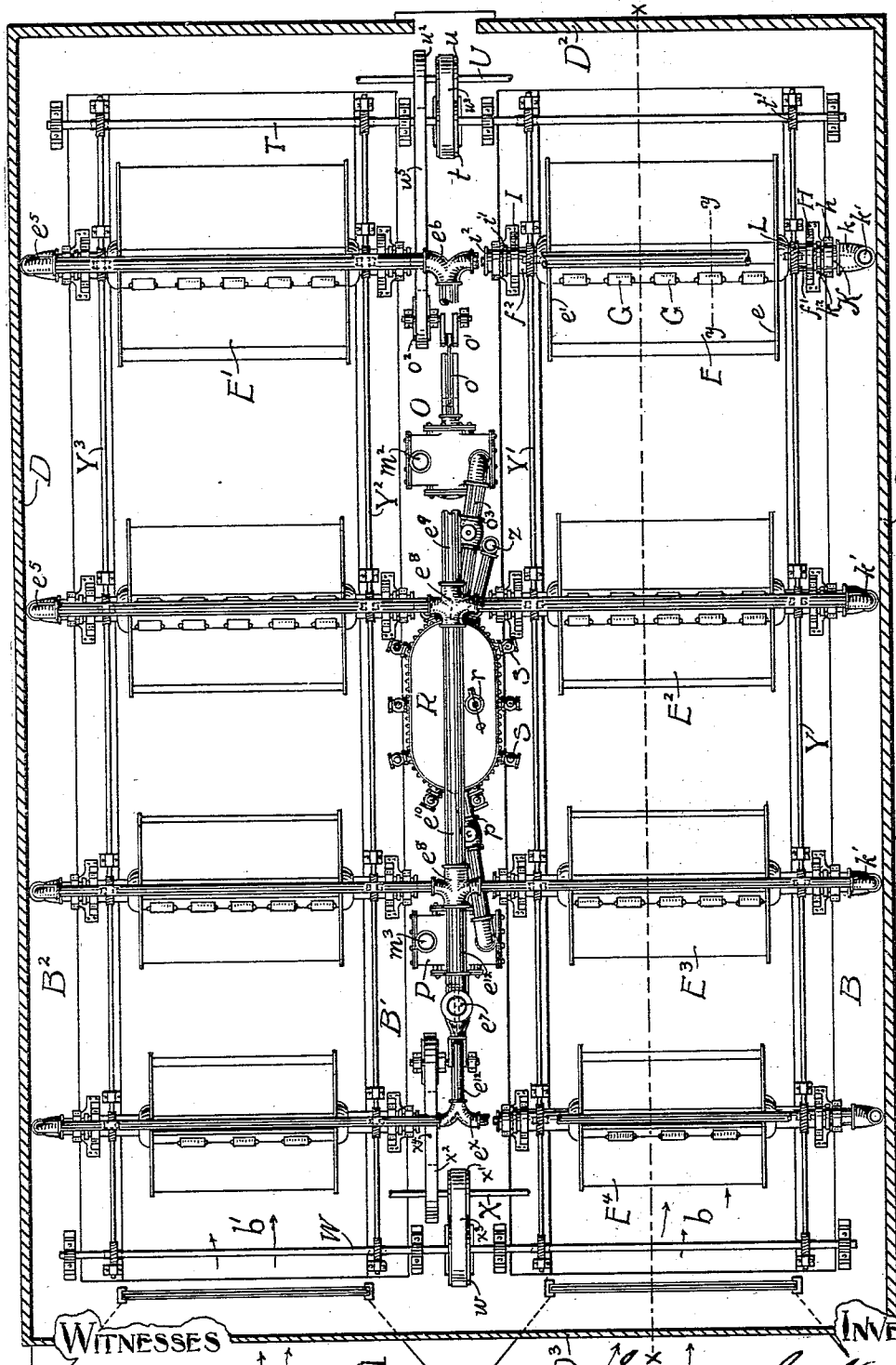

Fig. 2.

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APPARATUS FOR COMPRESSING AND STORING AIR.

SPECIFICATION forming part of Letters Patent No. 555,178, dated February 25, 1896.

Application filed April 12, 1895. Serial No. 545,456. (No model.)

To all whom it may concern:

Be it known that I, EDWIN C. NICHOLS, a citizen of the United States, residing at Topeka, in the county of Shawnee and State of Kansas, have invented certain new and useful Improvements in Apparatus for Compressing and Holding in Reserve for Use Compressed Air and the Handling of Same; and I do hereby declare that the following is a full, clear, and exact description thereof, such as will enable others to make and use the same, reference being had to the accompanying drawings, forming a part of this specification.

The object of my invention is, first, in the initial compression and transmission of the compressed air from the compartment-wheel to the receiver to provide for the excess in the transmission of the air to the receiver, and, second, to obviate back-pressure upon the separate air-compressing chambers of the air-compressing wheels from an accumulation of compressed air in the receiver; third, to condense the compressed air in the receiver and confine the same for economic uses.

My invention consists in the novel construction and combination of parts, such as will first be fully described and specifically pointed out in the claims.

In the drawings, Figure 1 is a vertical sectional view taken upon the line $x\ x$ of Fig. 2, showing the central float of the barge and its raised decks supporting the air-receiver, also showing the series of graded compartment-wheels upon the floats, the conducting-pipes from each wheel to the air-receiver, the air-forcing apparatus connected with the receiver, the air-condensing pumps, the supply-reservoir for the compressed air, and the pipes leading from the pumps thereto. Fig. 2 is a plan view of the floats supporting the barge, with the upper deck removed, showing the sluiceways and the series of compartment-wheels supported by the floats and within the sluiceways, the power-transmitting shafts directly above and also on each float in power connection with the compartment-wheels, the main compressed-air-conveying pipe connected with the receiver, and the separate pipes extending from the compartment-wheels to the main pipe, also showing the air-condensing pumps, the supply-reservoir, and the air-conveying pipes from the pumps to the reservoir. Fig. 3 is a detail cross-sectional view of the shaft on wheel E in one of the compartment-wheels, taken on the line $y\ y$ of Fig. 2, showing broken portions of the sides and ends, also portions submerged in the water and confining the air. Fig. 4 is a longitudinal vertical sectional view of the end of the shaft of one of the compartment-wheels, with its shaft-bearing and power-conveying gear, also showing the valve-boxes and spring-actuated valves, and the internal slotted air-conveying tube.

Similar letters of reference indicate corresponding parts in all the figures.

A in the drawings represents a barge composed of separate floats B B′ B^2.

The intermediate float, B′, is considerably wider than each of the floats B B^2, and this float is made to carry the air-condensing pumps and compressed-air-supply reservoir, hereinafter described. The float B is arranged parallel in position with and a suitable distance from the float B′, and between these floats is a sluiceway b. The float B^2 is also arranged in position parallel with and upon the other side of float B′, and between said floats B^2 B′ is a sluiceway b' of the same width as the sluiceway b. Above the floats B B′ B^2 is a raised deck C, extending also over the sluiceways b b' and from the rear ends of said floats nearly to the forward ends. The deck C is supported in position by the vertical side D of the barge, which extends along the outer edge portion of the float B^2 from the rear end portion of said float nearly to the forward end portion of said float, and also by means of a side D′ of the same length on the float B. (Shown in section on Fig. 2.) The barge A is further inclosed beneath the deck C by means of a wall D^2, which extends from the rear end portion of the side D over the sluiceways b b' and float B′ to the rear end portion of the side D′ on float B and vertically to the under side portion of the deck C.

To the forward end of the side D is connected a wall D^3, which extends over the respective sluiceways b' b and float B′ and is connected at the other end with the forward end portion of the side D′. The walls D^2 D^3 rest upon and bind the separate floats one with the other and maintain the said floats the proper distance apart.

For the purpose of obtaining the compressed air a rotary air-compressor is arranged within the sluice *b*. Said compressor consists of a revoluble compartment-wheel E. The axis of said wheel consists of separate hollow parts F and K

The main body of the part F consists of a longitudinal case or cylinder which extends in length from a point in a vertical line with the inner side of float B′ to a corresponding point in line with the inner side of the float B^2, within which is formed a chamber *f*. The ends of said cylinder are made smaller in diameter, so as to form hollow journals, one of which journals, *f′*, extends over the float B and the other journal, f^2, over the float B′.

The sides of the wheel E consist of circular plates *e e′*, one of which plates is secured to the outer side portion of and near one end of case F, and the other side, *e*, is secured rigidly to the outer side portion of the said case and near the other end of said case. The separate compartments of the wheel are formed by plates e^2 e^2, each one of which plates extends in a transverse direction from the inner side portion of the side *e* to the inner side portion of the side *e′* and from the outer side portion of the case F to the periphery of the sides *e e′* and at an oblique angle to a line drawn through the axis of the case F. In arranging the plates e^2 e^2 on the case F the lower edges of the adjacent plates are placed at a considerable distance apart, so as to afford room for the valve-boxes, hereinafter described, and also make tight joint with the sides *e e′* and the said case. Between the lower edges of the adjacent plates e^2 e^2 and in the case F are a series of openings f^3. (See Fig. 4.)

Rigidly attached to the outer side portion of case F and near one side of the opening f^3 is a box G, which extends in a curved line over the opening f^3 to the other side of said opening.

The box G is provided with close-fitting ends *g g′* so as to prevent any leakage of the compressed air in the case F. In one end *g* of box G is in opening g^2. Extending in a curved line over said opening g^2 and rigidly attached to the end *g* is a yoke g^3. In the other end, *g′*, of box G is an opening g^4, to which end is attached a yoke g^5, which is similar to the yoke g^3. Through the yoke g^3 is inserted the screw-threaded end of bolt g^6, which end is also extended through the opening g^2 in the end *g*, thence through the opening g^4 in the end *g′*, and through the yoke g^5 on said end, and a nut g^7 is fitted upon said screw-threaded end of said bolt outside of said yoke g^5. Within box G and on the bolt g^6 and fitting over the opening g^2 is a sliding valve g^8, and on the same bolt and fitting over the opening g^4 is a sliding valve g^9. Between the respective valves g^8 g^9 and on bolt g^6 is secured a lug g^{10}. Extending around the bolt g^6 is a spiral spring g^{12}, one end of which spring bears against the valve g^8 and the other end against the lug g^{10}. Upon the same bolt is a spiral spring g^{13}, one end of which bears against the valve g^9 and the other end against the lug g^{10}. Over each opening in the case F is arranged a box which is constructed precisely the same as the box G.

Between each pair of plates forming the blades of the wheel are a series of openings corresponding in number to those between the plates described and provided with boxes which are similar to the box G.

Upon the upper side portion of the float B and bolted securely thereto is a journal-box H, which receives the end of the hollow journal *f′*, the said end of said journal extending a short distance beyond the outer side of said journal-box. Upon the float B′ is a journal-box I, which receives in a like manner the hollow journal f^2 of case F. Through the hollow journal *f′* is inserted one end of a closely-fitting stationary tube K, which extends through the case F and also through the hollow journal *f′* and a short distance beyond the end of the said journal. The end of the tube K extending outside of the journal *f′* is supported within a close-fitting ring or bearing *h*, which is connected with the same base as the journal-box H and is made to support the said end of the stationary tube K in exact alignment with the tube and without causing friction upon the hollow journal *f′*. The end portion of the tube K is screw-threaded externally, and to said end is fitted one end of an internally-threaded elbow *k* and to the other end is fitted the lower end of an upwardly-extending air-conveying pipe *k′*.

The end of the hollow journal *f′* which extends to an intermediate point between the journal-box H and bearing *h* is also screw-threaded. Around the tube K, between the said journal-box and the bearing for tube K, is fitted closely a thimble k^2, a portion of the length of which is internally screw-threaded so as to fit the screw-threaded end of the hollow journal *f′*, and is provided with suitable packing to insure a tight joint. The tube K at its other end is fitted within a bearing upon the float B′, which bearing is precisely the same as the bearing *h*, and supports the end of said tube without frictional contact with the hollow journal f^2. Said end of tube K is also provided with an internally-screw-threaded thimble *i*, which is precisely the same as the thimble k^2, and is fitted to the end of the hollow journal f^2 of case F in the same manner as described of the said thimble k^2. The extreme end of the tube K is externally threaded and said end closed by means of a cap i^2. (See Fig. 2.) In the tube K, opposite the opening f^3 on the case F, are longitudinal openings k^3. Said openings are made at distances apart on said tube corresponding to the position of the openings f^3 in the case F. Upon the hollow journal *f′* is rigidly attached a worm-gear L, which is operated in the manner hereinafter described.

In the sluice *b* a short distance from wheel

E is placed a wheel E^2, which is constructed and arranged to operate in precisely the same manner as the wheel E. In the sluice *b* are also arranged other compartment-wheels, E^3 E^4, all of which are graded in diameter, the wheel E^2 being a degree smaller than the wheel E and the wheel E^3 a degree smaller than the wheel E^2, the wheel E^4 at the entrance of the sluice being the wheel having the smallest diameter. Said wheels E E^2 E^3 E^4 are also gradated in width, the front wheel, E^4, having the least width and the other wheels in the series being made respectively wider by degrees, thus enabling the same currents of water to actuate each wheel without being diverted. In the sluice *b'* are mounted a series of compartment-wheels of the same diameter as the respective wheels E^2 E^3 E^4 and which are arranged in like position in the sluiceway.

To the ends of the air-conducting tubes, journaled on the top of the float B and connected with the respective compartment-wheels E^2 E^3 E^4, are connected elbows and vertical conducting-pipes which are precisely the same as the pipe *k'* and elbow *k* on the wheel E. To the end of the air-conducting tube on the wheel E' on the float B^2 is connected an elbow and upwardly-extending pipe e^5, which is precisely the same as the elbow and pipe *k* on the wheel E. To each tube in the series of compartment-wheels in sluice *b'* are connected similar conducting-pipes e^5.

The respective pipes *k'* and e^5 connected with the compartment-wheels E E' extend nearly to the under side portion of the deck C, and are bent at right angles and extended toward each other to a point directly above the float B' and connected with a three-way pipe-joint e^6. The conducting-pipes *k'* and e^5 belonging to the compartment-wheels B^4 and the wheel in line in sluice *b'* are connected with a three-way joint $e^\times$. The other pipes in the series are connected with the four-way joints e^8 e^8. To one of the pipe-joints e^8 is connected the conducting-pipe e^9, which is also connected with the three-way joint e^6. The respective joints e^8 e^8 are connected by a pipe e^{10}. From the joint $e^\times$ to the joint e^8 is connected a pipe e^{12}. I have illustrated these pipes in series decreased in size corresponding to the capacity of each wheel to generate the compressed air. This, however, may be uniform throughout the system without departing from my invention.

Upon the upper side of the deck C is a receiver M, similar to a steam-boiler in construction and provided with a safety-valve *m*.

To the pipe e^{12} is connected one end of an elbow-joint e^7, which extends upwardly through the deck C and toward the end of the receiver M and is connected with said receiver by the pipe e^{13} extending from said elbow. Within the receiver M and closing the opening to pipe e^{13} is a self-closing valve e^{14}.

Upon the end of the receiver M above the pipe e^{13} is a bracket *n*, and upon said bracket is mounted a rotary air-forcing fan-wheel N, of the ordinary well-known construction, which is provided with a driving-shaft *n'*, which shaft is operated as hereinafter described. From the fan-case extends downwardly a pipe n^2, which is connected with the elbow-joint e^7. In the lower end of the pipe n^2 near the elbow-joint e^7 is arranged an ordinary check-valve n^3, which checks the escape of the compressed air passing through the elbow e^7. The valve n^3 is retained against its valve-seat by a spring n^4, the tension of the spring being sufficient for that purpose.

Upon the float B' directly beneath the air-conducting pipe e^9 is an air-condensing pump O of well-known construction. The piston *o* of the pump extends toward the rear end of the float B', and upon its crank-shaft *o'* is a band-wheel o^2, which is operated as hereinafter described. To the other end of the receiver M from that having the air-induction pipe e^{13} is connected one end of an eduction-pipe m^2, which extends in a downward direction and is connected with one side of the pump O receiving the air. Upon the same float and beneath the air-conducting pipe e^{12} is an air-condensing pump P, which is the same as the pump O, and having a driving-pulley *p'*.

To the under side portion of the receiver M and near the end having the entrance-pipe e^{13} is connected one end of a pipe m^3, the other end of which pipe is connected with one side portion of the pump P receiving the air. Upon the float B', between the respective pumps O and P, is arranged a supply-tank R, which is circular in form and extends in height from the float B' nearly to the pipe e^{10} over said tank in position. Said tank is also provided with a safety-valve *r*. To the other side of the pump O, expelling the air, is connected one end of a pipe o^3, the other end of which pipe is connected with the supply-tank R. To the pump P and the side expelling the air is connected one end of a pipe *p*, the other end of which pipe is connected with the supply-tank R. In the upper side portion of the tank R are distributing-nozzles S, which are closed severally by the valves *s* in each nozzle.

At the rear end and upon the top of float B is journaled one end of a line-shaft T, the other end of which shaft passes over the respective sluices *b b'* and float B, and is journaled upon the upper side portions of the floats B' B^2. Upon shaft T above the float B' is a band-pulley *t*. Above the shaft T and journaled in the hangers *s s* on the under side portion of the deck C is a line-shaft U, which is short in length and carries a band-pulley u^2. On the same shaft U is a band-pulley u^4, the diameter of which is a degree larger than the wheel u^2. Over the pulley u^2 is placed one end of a band u^3, the other end of which band extends over the pulley *t* on the shaft T and the ends are connected in the usual manner. Over the pulley u^4 is placed

one end of a band w^5, the other end of which band is extended over the band-wheel o^2 on the crank-shaft of the pump O, and the ends are connected together in the usual manner.

At the forward end of the floats and journaled at one end upon float B is a line-shaft W, the other end being journaled on the float B^2 and between said ends on float B'. Upon the said shaft above the float B' is a band-pulley w. Above the shaft W and journaled on the hangers $x\ x$ on the under side portion of the deck C, above the float B', is a shaft X, which carries the respective band-pulleys $x'\ x^2$. The shaft X is short in length and corresponds with shaft U at the rear end of the barge. Over the pulley x' is placed one end of a band x^3, the other end of which band is extended over the pulley w on the shaft W in the float B', and the two ends are connected in the usual manner. Over the pulley x^2 is placed one end of a band x^4, the other end of which band is extended over the pulley p' on the crank-shaft of the pulley P, and the two ends are connected together in the usual manner.

The main cross line-shafts T and W are actuated by the longitudinal shafts Y Y' Y^2 Y^3 on the respective floats B B' B^2 in the following manner: On the shaft T near the journal-bearing therefor on the float B is a worm-gear t'. On the end of the shaft Y directly beneath the gear t' is a worm-gear y'. Said shaft Y extends directly beneath the gear L on the hollow journal f'', and beneath said gear is a worm-gear y', which meshes with the gear L and is the same in construction as the gear y' at the end of said shaft. Said shaft is also provided with like gear, which engages with the gear on the respective hollow journals of each of the wheels E^2 E^3 E^4 journaled in the float B, and the respective shafts Y' Y^2 on the float B' and the shaft Y^3 on float B^2 are parallel with each other and each provided with worm-gear which engages with the shafts W and T, and also with the hollow journals on the respective compartment-wheels, so as to transmit power with regularity to the cross line-shafts W and T.

I have shown upon deck C in rear of the receiver M the separate compartments Z Z', one of said compartments containing a dynamo Z^3 and the other compartment a compressed-air-operating engine Z^4, which is made to operate the driving-shaft of a dynamo Z^3 in the apartment Z'. In this one illustration of the mode of utilizing the power of the condensed compressed air the conductor z, which is connected with the engine Z^4, is connected with one of the air-supply nozzles S on the tank R and the valve operated to permit the full flow of the compressed air.

Upon the forward portion of the deck C near the fan-wheel N is an electric motor N^2. Close in position to the motor N^2 is a storage-battery V. To the poles of the storage-battery are connected the conductors of electricity z^0 z', which are connected with the respective poles of the motor. Over the driving-shaft of the motor is placed one end of a belt n^4, the other end of which belt is extended around the driving-shaft n' of the fan-wheel N, and the two ends are connected together in the usual manner. The power to operate the motor N^2 may be obtained from the dynamo Z^3 on the rear end of the deck if preferred.

In the operation of the invention the floats B B' B^2, which are of sufficient buoyancy, are placed in a stream of water and the barge properly anchored. In this position the respective compartment-wheels in each sluice are submerged in the water a distance corresponding to the diameter of each wheel. The sluiceways being open to receive the passage of water between the respective floats operate the compartment-wheels. In each revolution of the wheels the separate compartments confine a volume of air lying upon the surface of the water equal to the dimensions of the compartment, which under the fluid-pressure or rising pulsations of the stream compresses the air within a small compass, and the pressure of this air overcomes the pressure of the springs g^{12} g^{12} and finds an escape through the openings f^3 in the case F, the valves g^8 g^9 self-closing after the admission of the compressed air and as soon as the inward pressure of the air exerted to open the valves has ceased. As each compartment of the wheel enters the water in succession the discharge of the compressed air becomes large in quantity and is secured in the case F which provides for the excess of compressed air during the time occupied in transmitting the compressed air through the tubes. Upon entering the tubes K the compressed air passes through the pipe k' to the main pipes e^9 e^{10} e^{12} and thence into the receiver M on the deck C. The combined action of the compartment-wheels generates primarily a large quantity of compressed air. This quantity in passing into the receiver M is prevented from being retarded and reacting so as to cause back-action in the tubes K, and causing a consequent retarding of the movement of the compartment-wheels, by means of the air-forcing apparatus N which when operated from the power received from the line-shaft W causes an accelerated movement of the compressed air within the receiver.

The motor N^2 is made to operate the air-forcing apparatus when the air begins to check the action of the compartment-wheels, and this results from any excess of the compressed air in the conducting-pipes being retarded in its admission to the receiver N. The power of the compressed air, it will be observed, retains the valve in the pipe n^2 closed until a movement backward occurs in the compressed-air pipes. The compressed air in the receiver M then passes to the pumps O and P, which are also driven by the power of the cross line-shaft, and the compressed air entering said pumps is condensed and forced into the supply-tank R, from

which it is taken through the pipe z and made to operate the air-engine Z^4, which in turn operates the dynamo Z^3, or other use to which it may be applied, such as ventilation of rooms and other purposes where the power can be applied. The delivery of the compressed air from the tank R through other supply-openings S furnishes power in one or more directions, as its use may be required.

Having fully described my invention, what I now claim as new, and desire to secure by Letters Patent, is—

1. An air-compressing apparatus comprising a receiver having an opening for the admission of the compressed air and a self-closing valve, a revolving air-forcing compartment-wheel having separate compartments and a receiving-chamber at the axis of said wheel having an opening to each compartment of said wheel, and a self-closing valve, and a conductor of compressed air connected with said chamber and said receiver substantially as and for the purpose described.

2. An air-compressing apparatus comprising a receiver having an opening for the admission of the compressed air and a self-closing valve, a revolving air-forcing compartment-wheel having separate compartments, an air-conducting pipe at the axis of said wheel having an opening therein and a chamber concentric with said air-conducting pipe at the axis of and connected with said wheel and having openings to each compartment of said wheel and a self-closing valve substantially as and for the purpose described.

3. In an apparatus for compressing air a receiver having an opening for the admission of the compressed air and a self-closing valve, a sluice and a revolving air-forcing compartment-wheel in said sluice and an air-conducting pipe connected with said receiver having air-passages and extending in the direction of and through the axis of said wheel and supported upon the sides of said sluice and an air-receiving chamber concentric with said air-conducting pipe connected with said wheel and adapted to rotate independently of said air-conducting pipe and having openings to each separate compartment and a self-closing valve to each opening substantially as and for the purpose described.

4. In an apparatus for compressing air a receiver having an opening for the admission of the compressed air and a self-closing valve, a sluice and a revolving air-forcing compartment-wheel in said sluice having separate compartments, and a chamber at the axis of said wheel having openings communicating with each compartment of said wheel, and valves to said openings, a conductor of compressed air connected with said chamber and said receiver and air suction and force apparatus having a conductor connected with the conductor for compressed air substantially as and for the purpose described.

5. In an air-compressing apparatus a generator of compressed air and a receiver, a conductor connected with said generator and said receiver, and a suction and force apparatus having an induction-pipe connected with said conductor of compressed air as and for the purpose described.

6. In an apparatus for compressing air a receiver having an opening for the admission of compressed air and a self-closing valve, a storage-tank and an air-compressor having an eduction-pipe connected with said receiver and an induction-pipe connected with said storage-tank and a compressed-air generator having a pipe connected with said receiver substantially as and for the purpose described.

7. In an apparatus for compressing air, a generator of compressed air and a receiver having a self-closing valve, and a conductor from the generator to the receiver, and a blast-fan having a source of air and a conductor for the air-blast having a check-valve extending from the said fan, and connected with said conductor of compressed air and means for operating said fan substantially as and for the purpose described.

8. In an air-compressing apparatus a revolving air-forcing compartment-wheel having separate compartments, a chamber connected with each compartment concentric with the axis of said wheel having openings for the admission of the compressed air communicating with each compartment, and a self-closing valve to each opening substantially as and for the purpose described.

9. In an air-compressing apparatus a revolving air-forcing compartment-wheel having separate compartments, a chamber connected with each compartment concentric with the axis of said wheel and having valve-boxes in each compartment provided with openings for the admission of the compressed air at each end and a valve to each opening and a spring for each valve substantially as and for the purpose described.

10. In an air-compressing apparatus a revolving air-forcing compartment-wheel having separate compartments, a chamber connected with each compartment concentric with the axis of said wheel and having valve-boxes in each compartment and openings for the admission of the compressed air at each end, yokes connected with the outer side portion and each end of the said valve-boxes extending over said openings and a valve-carrying rod connected with said yokes and sliding valves on said rod within said valve-box adapted to close said openings and a lug on said rod and a spring on said rod having one end extending against said lug and the other end against one of said valves substantially as and for the purpose described.

11. In an air-compressing apparatus, a receiver having an opening for the admission of the compressed air and a self-closing valve, a revolving air-forcing compartment-wheel having separate compartments, a chamber connected with each compartment concentric

with the axis of said wheel having openings and a slotted tube, said tube and chamber having separately-supported concentric sleeves, a valve-box extending over each one of said openings in said chamber having a self-closing valve and a conductor for the compressed air connected with one of said sleeves and with said receiver substantially as and for the purpose described.

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Witnesses:
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