(No Model.) 4 Sheets—Sheet 1.

E. C. NICHOLS.

APPARATUS FOR FORMING AND PRESERVING CHANNELS.

No. 585,116. Patented June 22, 1897.

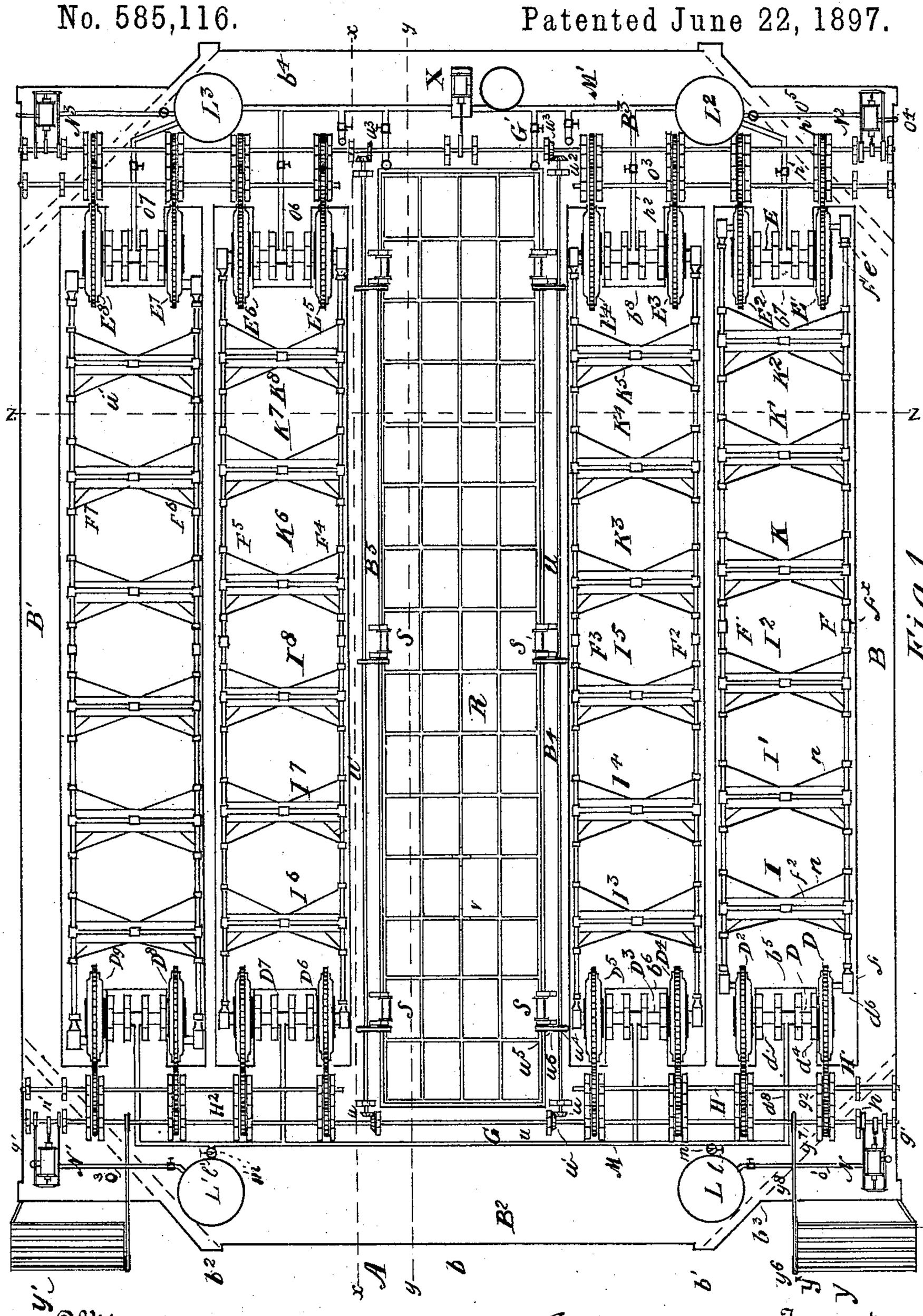


Fig 1.

Witnesses
H. R. Pennington
R. C. Keller

Inventor
Edwin C. Nichols
By his Attorney
Richard F. Manning

(No Model.)

4 Sheets—Sheet 2.

E. C. NICHOLS.

APPARATUS FOR FORMING AND PRESERVING CHANNELS.

No. 585,116. Patented June 22, 1897.

Fig 3.

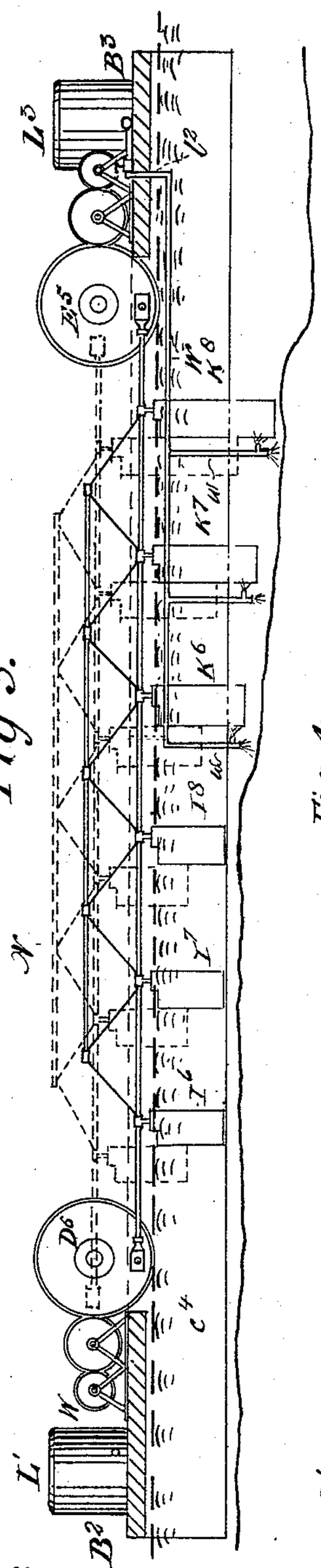


Fig 4.

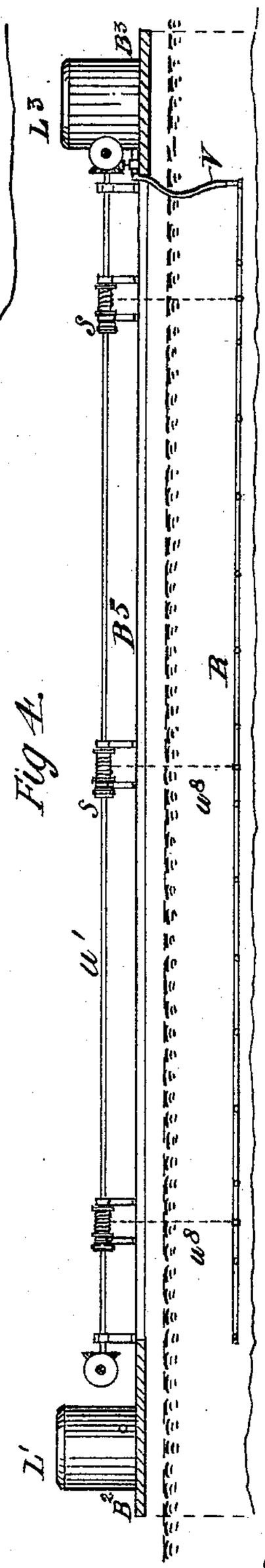
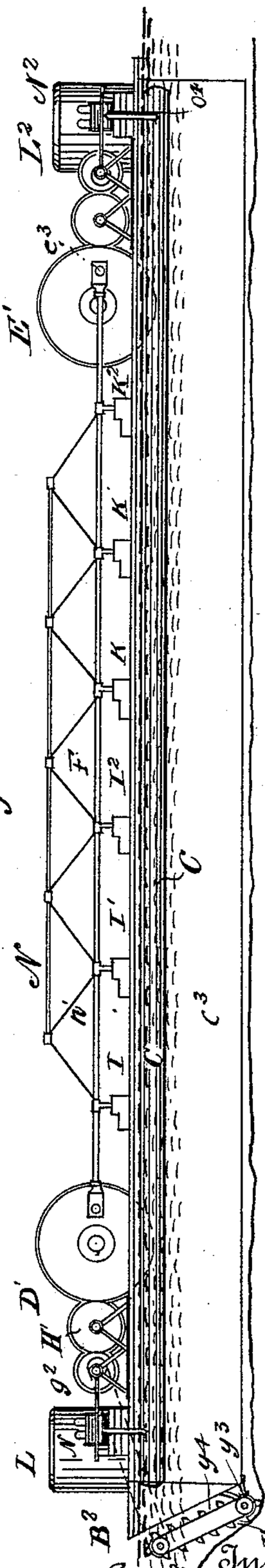


Fig 2



Witnesses

W. E. Pennington

B. C. Dudley

Inventor

Edwin C. Nichols

By his Attorney

Richards & Manning

(No Model.) 4 Sheets—Sheet 3.

E. C. NICHOLS.

APPARATUS FOR FORMING AND PRESERVING CHANNELS.

No. 585,116. Patented June 22, 1897.

Fig 6

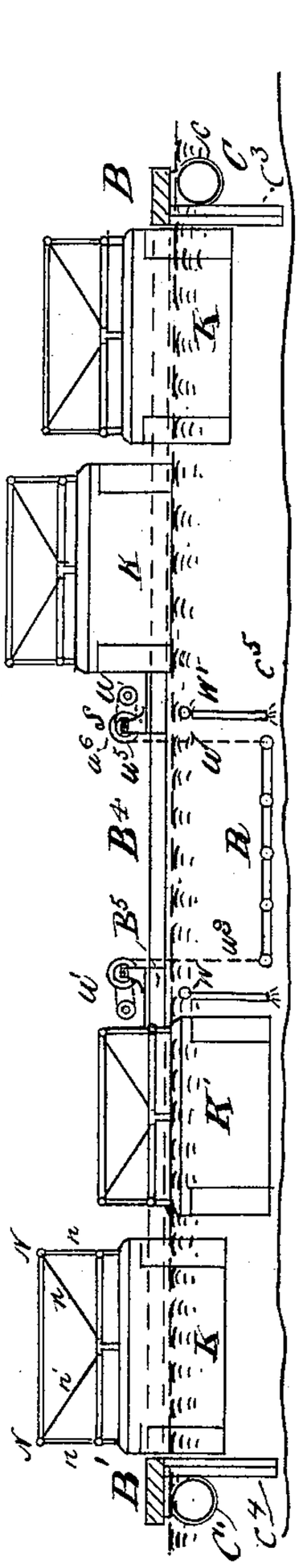


Fig 5.

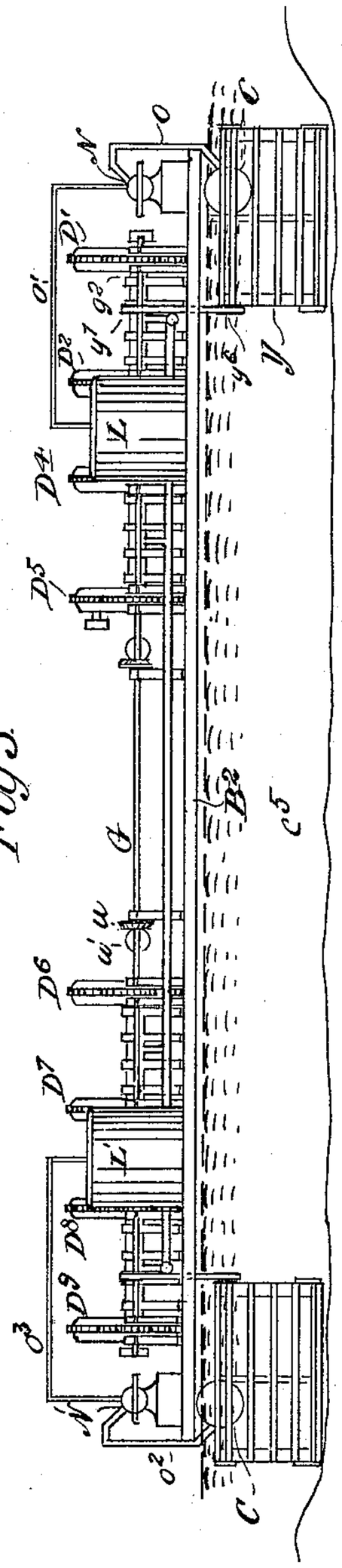
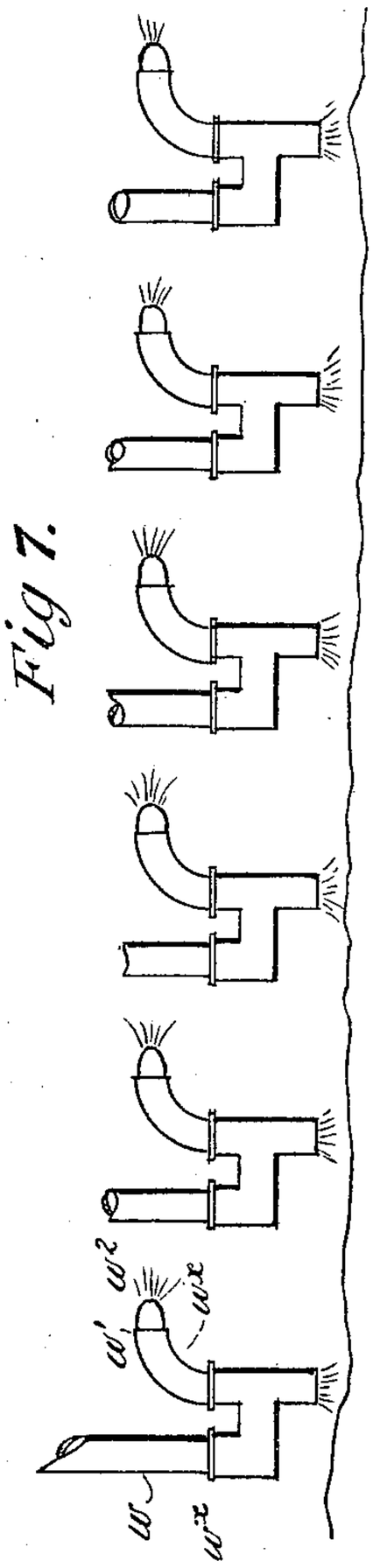


Fig 7.



Witnesses
D. K. Tompkinson
R. S. Hollis

Inventor
Edwin C. Nichols.
By his Attorney
Richards & Manning

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 4 Sheets—Sheet 4.

E. C. NICHOLS.

APPARATUS FOR FORMING AND PRESERVING CHANNELS.

No. 585,116. Patented June 22, 1897.

Fig 10.

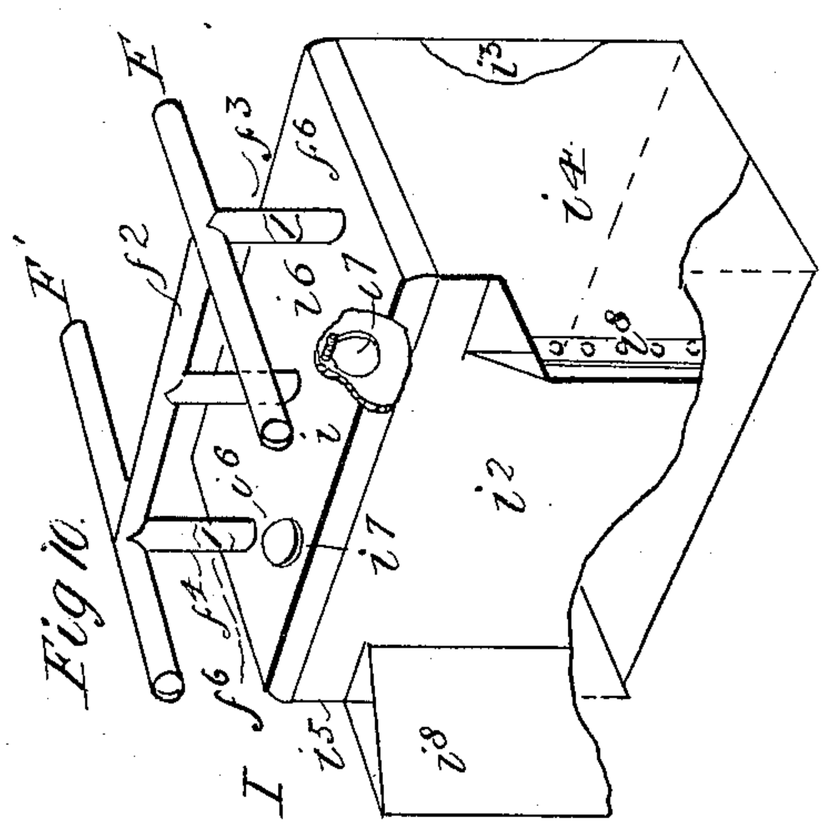


Fig 11.

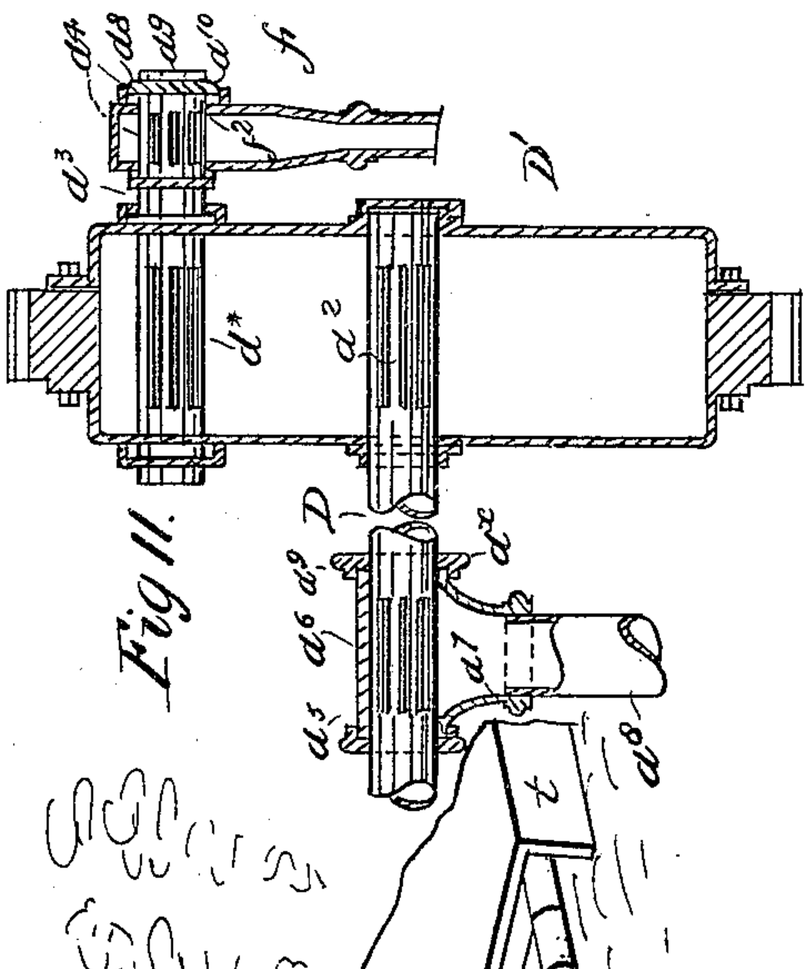


Fig 8

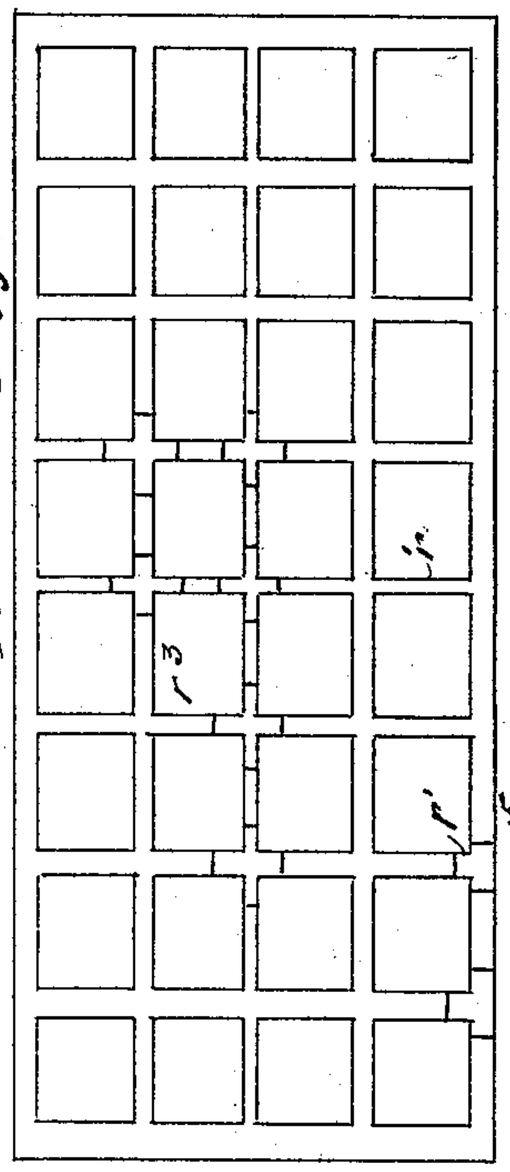
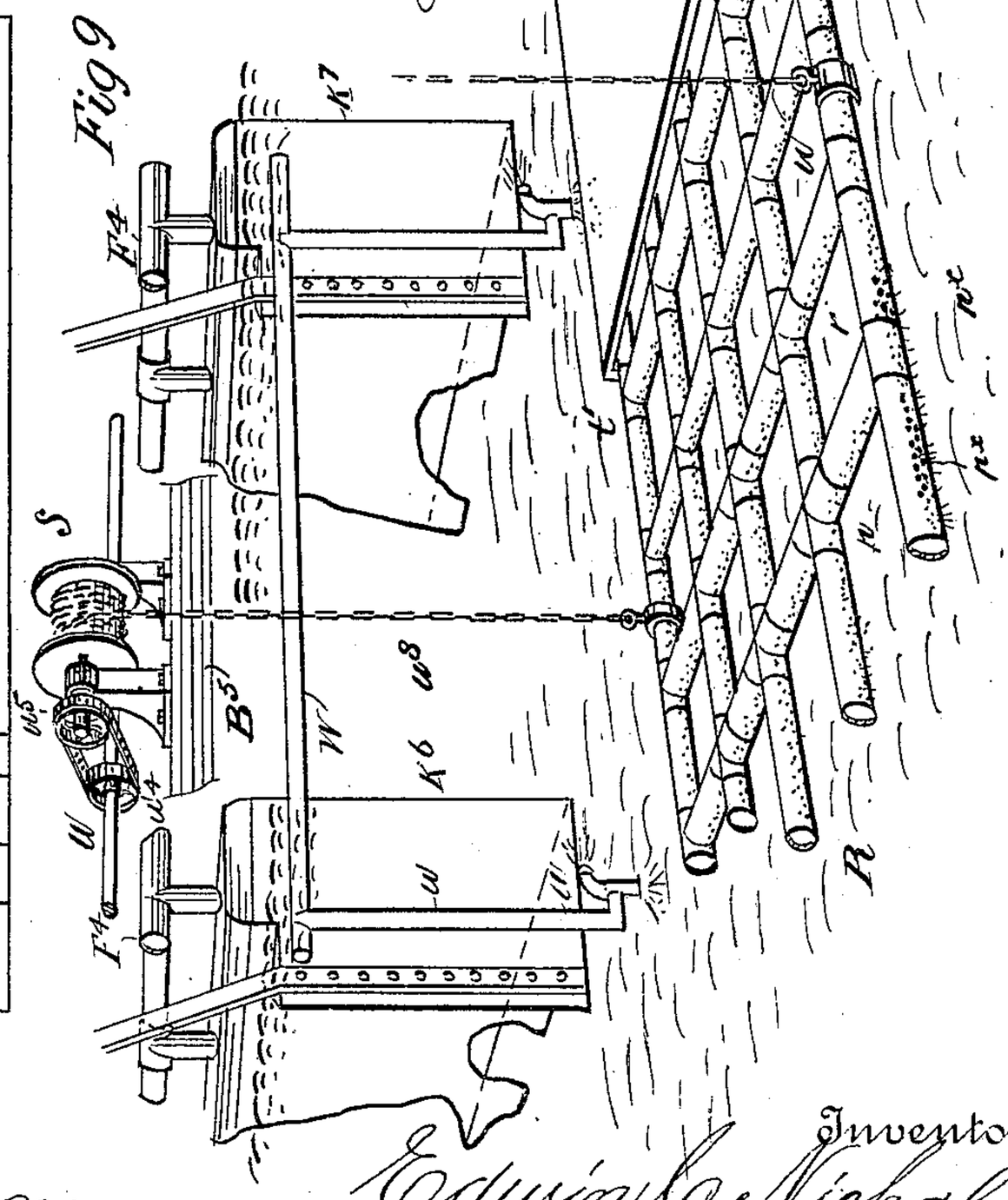


Fig 9



Witnesses

H. R. Fornbrun

R. C. Bartlett

Inventor

Edwin C. Nichols

By his Attorneys

Richey & Manning

UNITED STATES PATENT OFFICE.

EDWIN C. NICHOLS, OF TOPEKA, KANSAS.

APPARATUS FOR FORMING AND PRESERVING CHANNELS.

SPECIFICATION forming part of Letters Patent No. 585,116, dated June 22, 1897.

Application filed August 14, 1896. Serial No. 602,809. (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 Forming and Preserving Channels; and I do hereby declare that the following is a full, clear, and exact description of the invention, reference being had to the accompanying drawings, forming a part of this specification.

The invention has for its object, primarily, the removal of soil, debris, and the formation of channels permanent in character by submarine blasts of compressed air; and it consists in the novel means and mode of procedure, hereinafter more fully described in detail, and specifically pointed out in the claims.

In the drawings, Figure 1 is a plan view of the apparatus with the respective parts in operative positions and the arched sluice removed. Fig. 2 is a side view of the apparatus. Fig. 3 is a longitudinal sectional view taken on the line *x x* of Fig. 1. Fig. 4 is a longitudinal sectional view taken on line *y y* of Fig. 1. Fig. 5 is a front end view of the apparatus. Fig. 6 is a transverse sectional view taken on line *z z* of Fig. 1. Fig. 7 is a side view of one of the channel-pipes, showing alternate means for changing the direction of the air-blasts. Fig. 8 is a plan view of the compressed-air-distributing channel-forming pipe-frame. Fig. 9 is a broken detail view in perspective of one of the longitudinal beams forming the hatchway, showing the compressed-air-blast coffers in position for the blast, the channel-forming pipe-frame, the sluice-forming arched cover to the frame partially removed, the compressed-air-conveying pipes connected with the pipe-frame, and the frame-elevating windlass, showing the compressed air applied and the material dislodged and rising with the compressed air. Fig. 10 is a detail view in perspective of one of the air-compressing cups. Fig. 11 is a sectional view of one of the hollow gear-wheels and the axle and sleeve, also showing in section the hollow crank-pin and the end of the connecting-pipe.

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

The apparatus consists in detail of a water carriage or barge A, (reference now being made to the drawings,) the top portion of which comprises a rectangular-shaped frame formed by the parallel side beams B B′, the forward ends of which are connected by the transverse beam B^2 and the rear ends by the beam B^3.

Beneath the beam B is a hollow air-tight cylindrical case or receiver C, corresponding in length with said beam, and which, besides holding compressed air, sustains the frame above the surface of the water. Said case C is connected with the under side portion of the beam B, at suitable points on the said beam, by means of the U-shaped braces *c*. Beneath the beam B′ is a case C′ for compressed air, precisely the same in construction as the case C, and secured to the beam B′ in the same manner.

To the under side portion of the beam B is attached a wall or side c^3, which extends from one end of said beam to the other and downwardly a considerable distance below said beam and upon the inner side of the cylinder C. Upon the other side of the water-carriage is a side c^4, which is attached at the under side portion of the beam B′ and corresponds in length and position to side c^3 and extends downwardly the same described distance. Between the sides c^3 c^4 is the sluice c^5.

To afford room for the storage-tanks on the water-carriage, a forward extension of the beam B^2 is provided by the beam *b*, which is the same thickness as said beam B^2 and extends a short distance in opposite directions from a point on said beam equidistant from beams B B′. The beam *b* is supported at each end by the bars b' b^2, extending from the under side portion of the beam B^2. To one of said bars b' b^2 at one end of the beam B^2 is connected a brace-bar b^3, the other end of which bar extends at an angle to beam B and to the outer edge of said beam. The bar b^2 is braced in the same manner as bar b' and prevents the binding of the journal-bearings and shafts. At the other end of the water-carriage is an extension b^4 of beam B^3 rearwardly, which beam is comparatively short in length and supported in the same manner as described of beam B^2. At a point on beam B^2, a little more than one-third the described dis-

tance from the inner edge portion of beam B to the inner edge portion of beam B′, is connected rigidly one end of a beam B^4, the other end of which beam is connected with the inner edge portion of beam B^3. At a point on the inner edge of beam B^2, a little more than one-third the described distance from the inner edge of beam B′ to the inner edge of beam B, is attached rigidly one end of a beam B^5, the other end of which beam is connected with the inner edge portion of beam B^3 at the same described distance from beam B. Between the respective beams B^4 B^5 is a longitudinal opening or hatchway for the channel-frame, hereinafter described.

On the inner side portion of the beam B^2, between the respective beams B B^4, are separate rearwardly-extended jogs or supports b^5 b^6. Upon support b^5 are journal-bearings d d', arranged a short distance apart in a transverse direction to the water-carriage and elevated a suitable height above the said support. In said journal-bearing is a hollow shaft D, comparatively short in length. Upon one end of shaft D is a rigidly-connected hollow compressed-air-conveying gear-wheel D′, which extends below the level of the upper surface of the support b^5 and in the space between the beam B and the adjacent sides of the support b^5. In shaft D, within the hollow wheel D′, are perforations or slots d^2. Upon the other end of shaft D is a hollow gear-wheel D^2, which is precisely the same as wheel D′ and extends below the level of the upper surface of support b^5 and upon the other side of said support.

Upon the outer side portion of wheel D′ near the periphery is a hollow crank-wrist d^3, which is also perforated or slotted at d^4. In the shaft D, between the respective wheels D′ D^2, are openings d^5, at suitable distances apart, in the direction of the circumference of said shaft. Upon said shaft D is a sleeve d^6, extending over the openings d^5 and having a neck d^7, extending from the side of said sleeve. To the neck of d^7 is connected one end of a pipe d^8. The ends of the sleeve d^6 are smooth externally, and to each end is fitted, respectively, a flanged collar d^9, between which flange on said collar and the end of the sleeve is a packing $d^\times$. Crank-wrist d^3 within the wheel D′ is slotted at d^*. At the other end of the water-carriage on beam B^3, between the beams B B^4, are forwardly-extended supports b^7 b^8, which are the same in width and in line with the respective supports b^5 b^6 on beam B^2.

Upon the support b^7 is journaled in elevated journal-boxes the hollow gear-wheels E′ E^2, which are constructed and arranged upon a hollow shaft E in precisely the same manner as wheels D′ D^2, said shaft E also being provided with openings and a loosely-connected sleeve in the same manner as sleeve d^6. Upon the outer side portion of each hollow wheel E′ E^2 is a perforate or slotted crank-wrist e'. Upon the crank-wrist d^3 on wheel D′ is journaled one end f of a horizontal pipe F, which is closed at both ends and also at a point $f^\times$ between the opposite ends. Said end f of pipe F is also flattened in a slight degree and thus increased in width, and through which end is a transverse opening f^2, which receives the perforate crank-wrist d^3 on the hollow wheel D′. The outer end portion of the crank-wrist d^3 is screw-threaded at d^8, and upon said end is fitted an internal screw-threaded cap d^9, between which and the opening in pipe F is a packing d^{10}. The other end f' of pipe F is also flattened in a slight degree and provided with a transverse opening and fitted upon the crank-wrist e' on the wheel E′, the outer end of said crank-wrist being screw-threaded and provided with a cap e^3, fitted to said end of said crank-wrist, and a packing between said cap and crank-wrist in the same manner as described of the crank-wrist d^3 and d^9.

To the crank-wrists on the respective opposite hollow wheels D^2 and E^2 are connected the respective opposite ends of a pipe F′, which is constructed and arranged upon the said wheels in precisely the same manner as pipe F.

Upon the rearward extension b^6 of beam B^2 is journaled a hollow shaft D^3, upon which are the hollow wheels D^4 D^5, and upon the forward extension b^8 of the beam B^3 is journaled a hollow shaft which is the same as shaft E, upon which are the hollow wheels E^3 E^4, to which wheels D^4 D^5 E^3 E^4 are connected, respectively, by the pipes F^2 F^3, said wheels and pipes being constructed and arranged upon the respective extensions in precisely the same manner as described of the wheels D′ D^2 E′ E^2 and pipes F F′. Upon the other side of the hatchway and between the respective beams B^5 B′ are separate rearward and forward extensions of the respective beams B^2 B^3, upon which are journaled the wheels D^6 D^7 D^8 D^9 upon the extension of beam B^2 and the wheels E^5 E^6 E^7 E^8 upon the extension of beam B^3, and which wheels are connected with the pipes F^4 F^5 F^6 F^7, extending from those upon one extension with those upon the other extension of said beams, the details of construction being precisely the same as heretofore described of the wheels D′ D^2 E′ E^2 and connecting-pipes F F′.

Upon beam B^2 and extending the entire length of said beam is a line-shaft G. Said shaft is journaled in the respective journal-bearings g g' at each end, which bearings are elevated in position the corresponding height of the shaft D, carrying the wheels D′ D^2, said shaft being arranged a considerable distance forward of the said shaft D and the shafts in line therewith. Upon shaft G, opposite the hollow gear-wheel D, is a small spur-gear g^2, and opposite the respective wheels D^2 D^4 D^3 D^5 D^6 D^7 D^8 D^9 are spur-gears of the same proportions as gear g^2. Between the gear g^2 and the hollow gear D′ and mounted at each end in the journal-bearings h h' on the beam B^2 is a shaft II, which is parallel with

shaft G and extends nearly to the hatchway in one direction and to a position in line with the outer side portion of beam B in the other direction on said shaft H. Between the spur-gear g^2 and the wheel D is a gear H', (see Fig. 2,) which is nearly twice the circumference of gear g^2 and meshes with the said gear and the hollow gear-wheel D'. On shaft H are other gears of the same circumference as gear H' and meshing with the hollow gears D' D^4 D^5 and also with the small gear on shaft G.

Upon the other side of the hatchway in line with shaft H is a separate shaft H^2, upon which are gears of the same circumference as the gear H', which mesh with the gears D^6 D^7 D^8 D^9 and also with the gear on shaft G in the same manner as gear H'.

Upon the rear beam B^3 is a line-shaft G', parallel with shaft G, upon which are small gears which are the same circumference as the gear g^2. Between the wheels E' E^2 E^3 E^4 and line-shaft G' is a shaft of the same length as shaft H, upon which are gears of the same circumference as gear H', which meshes with the gear on said shaft G'.

Between the wheels E^5 E^6 E^7 E^8 and line-shaft G' is a shaft which is the same length as shaft H and pivoted with gear meshing with the gear on said line-shaft and with said wheels.

In placing in gear with the line-shafts G G' the series of hollow gear-wheels the crank-shafts of the wheels D' D^2 E' E^2 are placed at the lowest point of depression, the crank-wrists of wheels D^4 D^5 E^3 E^4 are placed in position one quarter of the circle of rotation, and the crank-wrists on the wheels D^6 D^7 E^5 E^6 in a position to describe a third quarter of a circle, and the crank-wrists on the wheels D^8 D E^7 E at a point of the highest elevation, thereby alternating the position of each pair of wheels in the series.

To the under side portion of the pipes F F' in front of the closed point $f^{\times}$ is connected an inverted air-compressing cup I. Said cup is nearly rectangular in shape, with vertical sides i^2 i^3 and ends i^4 i^5, its top portion i being nearly flat. To the inner side portion of the pipe F, a short distance from the wheels D' D^2, is connected by a pipe-joint one end of a pipe f^2, the other end of which pipe is connected with the inner side portion of pipe F'. To the under side portion of the pipe F is connected by a suitable joint one end of a short pipe or tube f^3, the other end of which tube is inserted within the top portion of the cup I. In said tube is a back-pressure check-valve i^6.

To the under side portion of the pipe F' is connected, by a suitable joint, a tube f^4, precisely the same in length as the tube f^3, which is also inserted within the top i of the cup I and provided with a check-valve f^6. To the tube f^2 is connected a tube which is the same as check-valve i^6 in tube f^3, which is also inserted within the cup I and provided with a check-valve. In the top of the cup I are openings which are closed by the relief-valves i^7, which are upon the inner side of the top i.

Upon the front side of the cup I are forwardly-extended V-shaped wings i^8. The wing i^8 is made by extending the plates composing the ends formed a short distance beyond the line of the front i^2 of said cup, thence bent at an angle and connected with the said front plate i^2, thus forming a triangular projection. Upon each cup I' I^2 are also wings of the same description as the wings i^8. The lower open ends of the cup I extend within sluice c^5 to suitable distance to be withdrawn from the water.

In rear of the cup I is a cup I', arranged a short distance from said cup, and in rear of cup I' is a cup I^2, each connected with pipes F F' and all constructed precisely alike and connected with the said pipes at corresponding distances one from the other. Upon the rear end of the horizontal pipes F F', in rear of the point $f^{\times}$, is connected a compressed-air coffer K, which is constructed nearly the same as the inverted cup I, with the exception of the front wings, the valves, and valve-openings, there being neither on the coffer K.

The sides and ends of the coffer K extend in a downward direction a considerable distance below the line of the lower ends of the cups I I^2 I^3, so as to reach material to be operated upon, or to the depth at which the channel is required to be preserved for the navigation of vessels and outgoing tides, the lower end of the coffer K' extending below the line of the bottom of the coffer K a short distance and the lower end of the coffer K^2 a short distance below the level of the lower end of the coffer K'. Upon the said pipes F^2 F^3 are connected cups I^3 I^4 I^5 and coffers K^3 K^4 K^5, which are constructed in the same manner and arranged in series the same distance apart as the cups I I' I^2 and coffers K K' K^2 on the pipes F F'. Upon the horizontal pipes F^4 F^5, which are the same in construction as pipes F F', are cups I^6 I^7 I^8 and compressed-air-blast coffers K^6 K^7 K^8, which are constructed and arranged in position in precisely the same manner as the coffers K' on the pipes F^2 F^3. Upon the horizontal pipes F^6 F^7 are inverted cups and coffers constructed and arranged in position in the same manner as the cups I I' I^2 and coffers K K' K^2 on the pipes F F'.

In the apparatus so far defined the series of inverted cups I I' on each pair of horizontal pipes are designed to compress air, while the series of coffers are designed to do the work upon the material by the action of blasts of compressed air discharged within each coffer. For the purpose of strengthening the pipes carrying the inverted cups I I' I^2 and coffers K K' K^2 a truss-frame N is connected with the pipe F, extending the length of said pipe, from which the rods n n extend downwardly to the respective portions of the pipes near each cup or coffer. Each pipe in the series of pipes is trussed in the same man-

ner. The cups are also laterally braced by rods n'.

Upon the beam B^2 and upon the end portion of the extension b, near the hollow wheels D^2 D^3, is a compressed-air tank L, and near the other end of said extension is a compressed-air tank L'. Upon the beam B^3 are compressed-air tanks L^2 L^3, located at either end of extension b^4 of beam B^3.

Upon the forward beam B^2 is a longitudinal compressed-air-conveying pipe M, arranged between the respective air-tanks L L' and the gear on the main line-shaft G. One end of pipe M is connected with the pipe d^8 on shaft D, and the other end of said pipe is connected with the pipe on the shaft carrying the hollow gear D^8 D^9 on the other side of the water-carriage. The branch pipes leading from the shaft-carrying gear D^4 D^5 D^6 D^7 are also connected with pipe M in the same manner as pipe d^8. To the pipe M is also connected a branch pipe m, which connects said pipe with the compressed-air tank L. A pipe m' connects the pipe M with the tank L' in the same manner, In the pipe m is a check-valve l. In pipe m' is a check-valve l'.

On the end of beam B^2, in line with the beam B, is a duplex air-compressor N, the piston-rod of which is connected by eccentrics n with one end of the main line-shaft G. At the other end of the beam B^2 is a duplex air-compressor N', the piston-rod of which is connected by eccentrics n' with the other end of the main line-shaft G.

To the top of the tank L is connected one end of a pipe O', the other end of said pipe being connected with the induction-opening to the air-compressor N. To the top of tank L' is connected one end of a pipe o^3, the other end being connected with the induction-opening to the air-compressor N'. (See Fig. 5.) To the induction-opening of the air-compressor N is connected one end of a pipe o, the other end being connected with the compressed-air receiver C beneath the beam B. To the eduction-opening of the air-compressor N' is connected one end of a pipe o^2, the other end being connected with the receiver C' beneath beam B'. To the tank L' is connected one end of a pipe o^3, the other end of which pipe is connected with the induction-opening to the air-compressor N'.

On the beam B^3 in line with beam B is an air-compressor N^2, the piston-rod of which is connected by an eccentric with the main line-shaft G'. To the rear end of receiver C is connected one end of a pipe o^4, the other end of which pipe is connected with the induction-opening of the air-compressor N^2. To the eduction-opening of the compressor N^2 is connected one end of a pipe o^5, the other end of which pipe is connected with the compressed-air tank L^2. At the other end of the beam B^3 is an air-compressor N^3, which has a pipe connected with its induction-opening and receiver C', and a pipe connected with the eduction-opening and tank L^2 in the same manner as described of the compressor N'. To the tank L^2 is connected one end of a pipe M', the other end of which pipe is connected with the tank L^3.

To the hollow shaft carrying the hollow wheels E' E^2 is connected a sleeve which is precisely the same as the sleeve d^6 on shaft D, and to said sleeve is connected a pipe p, which is connected with the tank L^2 and in which pipe is a cut-off valve p'. To the hollow shaft carrying the gear-wheels E^3 E^4 is connected a pipe p^2 in the same manner as described of pipe p, which is connected with the pipe M' and provided with a cut-off valve. A pipe o^6 is connected with the hollow shaft of the wheels E^5 E^6 and with the pipe M', and a pipe o^7 is connected with the hollow shaft carrying the wheels E^7 E^8, each pipe being provided with a cut-off valve, as described of the pipes p p^2.

In the hatchway or longitudinal open space between the respective beams B^4 B^5 and the end beams B^2 B is arranged a movable pipe-frame or channel-mat R, which is raised and lowered in position by elevators or horizontal windlass S on the beams B^4 B^5. Said pipe-frame is rectangular and consists of short lengths of pipe r r, connected together by two and four way pipe-joints. On the sides of the frame the short sections are connected together by the two-way joints r', and the end pipes are connected with the side pipes by similar joints r'. Between the respective sides and ends of the frames the short section of pipes are laid in squares and detachably connected with each other for cleaning purposes by four-way pipe-joints r^3, the short sections extending toward the sides and end of the frame being connected with the two-way pipe-joints r'. The diameter of the sections of the pipe in the central portion of the frame R is decreased, the pipe fittings or joints being correspondingly decreased in size. The under side portion of each section of the pipe in the frame R is perforated, as at $r^\times$.

For the purpose of forming a submerged sluice over the frame R is extended a horizontal plate or cover T. To the outer edge of one of the sides of plate T is attached a downwardly-extended side plate t. To the outer edge portion and opposite side of plate T is attached a side t', which extends in a downward direction the same distance as the side t.

Upon beam B^4, and extending in a longitudinal direction of said beam, is a shaft U, which is journaled in suitable journal-bearings. At one end of shaft U is a bevel-gear u, and in the main line-shaft G is a sliding bevel-gear u', which meshes with the gear u. The other end of shaft U is provided with a bevel-gear u^2, which meshes with a sliding bevel-gear u^3 on the main line-shaft G', which gear u^3 is thrown in and out of gear with gear u^2. On beam B^5 is a longitudinal shaft U',

which is provided with bevel-gear at each end and engages with bevel-gear on the respective line-shafts G G′ in the same manner as shaft U.

On the shaft U is a small pulley u^4, and on the windlass S is a band-pulley u^5. Over the pulley u^4 is placed one end of a band or belt u^6, the other end of which belt is extended over the pulley u^5 and the two ends connected together in the usual manner. The other windlass S on the beam B^5 is connected with the shaft U′ in the same manner as described of the pulleys u^4 and u^6. To the frame R and one side of said frame is connected one end of a rope u^8, the other end of which rope is connected with and extends around the windlass S on beam B^5. To the other side of frame R is connected one end of a rope u^8, the other end of which rope is connected with and extends around the windlass S on the beam B^4.

Compressed air is admitted to the frame R by means of a flexible pipe V, (see Fig. 4,) one end of which pipe is connected with a stop-cock on the tank L and the other end with one of the sections of the pipe-frame R at v. (See Fig. 4.)

Beneath the beam B^5 is a longitudinal stationary compressed-air-conducting pipe W, closed at its forward end, which is secured to the under side portion of said beam. To said pipe, at a point opposite the position of the air-compressing cup K′, when at its full depth in the water, is attached one end of a branch pipe w, the other end of which pipe extends in a downward direction to a position adjacent to the lower end of the inverted cup l and the coffer K, and upon the lower end of said pipe is a pipe-joint having two upwardly-extended necks $w^\times$ $w^\times$. In one of said necks is inserted the lower end of the pipe w. In the other opening or neck is inserted one end of a small pipe w', which is curved and the other end directed toward the rear of the water-carriage A. The outer end of the pipe w' is tapering, as at w^2, and has a jet-opening in the said end.

To the pipe W is connected other downwardly-extended pipes at points corresponding to the several positions of the inverted cups and coffers and which are provided with curved jet-pipes, as described of the pipe w. Beneath the beam B^4 is a horizontal stationary pipe W, closed at one end, from which extend downwardly the pipes w^4, each pipe having a joint provided with necks and jet-pipe, as described of the joint $w^\times$.

To one of the stop-cocks on the tank L^2 is connected one end of a flexible pipe l^2, the other end of which pipe is connected with the end of pipe W′. A separate flexible pipe l^3 is connected with another stop-cock on tank L^3 and with the pipe W in like manner.

Upon the beam B^3 is a stationary engine X of any well-known type, the piston-rod of which is connected by a suitable eccentric with the main line-shaft G′. To the outer edge portion of beam B^2 and near the beam B is connected the upper end portions of separate bars y y', the lower ends of which bars extend in a downward and rearwardly-inclined direction and are retained in a stationary position by brace-rods connected with side C^3 on said beam B. On the upper end and outer side portion are brackets $y^\times$, in which are journaled sprocket-wheels y^2. Upon the lower ends of said bars are brackets carrying sprocket-wheels y^3. Over said wheels y^2 is extended one end of a sprocket-chain y^4, which extends over the sprocket-wheel y^3 and the two ends connected together in the usual manner. To the sprocket-chain upon one bar y is attached one end of an excavatory scoop Y, the other end of which scoop is attached to the sprocket-chain on the bar y'. Upon the journal of one of the sprocket-wheels y^2 is a pulley y^6, and upon the main line-shaft G is a pulley y^7. Over the pulley y^6 is extended one end of a band y^8, the other end of which band is extended over the pulley y^7 on the shaft G and the two ends connected together in the usual manner. Upon the other end of beam B^3, near beam B′, are excavator-scoops Y′, arranged in position upon bars and connected with the line-shaft G in precisely the same manner as the scoop Y.

For the removal of sand-bars and other accretions in rivers, harbors, &c., so as to obtain a channel navigable in depth, the water-carriage A is so directed as to place the excavator-scoops Y Y′ in a position to operate upon the material impeding a forward movement of the water-carriage.

The engine X on the rear beam B^3 is set in motion and the power transmitted to the line-shaft G′, which in turn conveys power to the hollow gear E′ E^2 E^3 E^4 E^5 E^6 E^7 E^8 and the horizontal pipes F F′ F^2 F^3 F^4 F^5 F^6 F^7, which describe alternate reciprocating movements on the respective series of inverted air-compressing cups, and the air-coffers are withdrawn from and submerged in the water within certain intervals of time and in succession dependent upon the speed of the engine, the length of each coffer being sufficient to reach and dislodge the material to a depth suitable for channel purposes, beyond which the action of the compressed air as one element upon the water and also the displacement of the material being effected by the process which will be further considered.

It will be seen that the initial compressed air generated in the series of inverted air-cups passes through the forward portions of the respective pipes F F′ F^2 F^3 F^4 F^5 F^6 F^7 from point $f^\times$ to the hollow wheels D′ D^2 D^4 D^5 D^6 D^7 D^8 D^9 and through the branch pipes connected with the hollow shafts and thence to the pipe M and through said pipe to each tank L L′, the back pressure being checked by valves on the respective tanks. From the tanks L L′ the compressed air is admitted to the pipes o^3 O′ and thence to the air-compressors N N′, where the air is further compressed, and from said air-compressors to the receivers C C′ beneath the side beams of the water-car-

riage, and from the rear end of said receivers the compressed air is admitted to pipes o^2 and thence to the air-compressors N^2 N^3 and again compressed and thence to the storage-tanks L^2 L^3, in which are suitable back-pressure check-valves. The compressed air in tanks L^2 L^3 being thus available and the advance made by the water-carriage having dislodged the material on each side of the water-carriage and in the direction of movement of the receivers C C′ and the material in the line of work of the inverted cups having been dislodged by the cutting of the lower edges of the inverted cups upon the material and intermixed with the water the next step is to loosen the material which momentarily is confined within the area covered by one of the coffers.

In the rotation of the hollow wheels carrying the series of inverted cups and coffers, and during the interval in which one series of coffers is in the lowest position in the circle of rotation of the hollow wheels, the stop-cock on tank L^2, to which is attached the pipe leading to the hollow shaft upon which the coffers are located, is turned to liberate the compressed air, and the blast of compressed air is instantaneously transmitted through the pipe, the hollow wheel, and the crank-wrist to the pipe carrying the coffer and thence upon the water within the coffer, the water is expelled from the coffer, and the force of the air upon the water is communicated to the water and thence to the material underlying the water, and this disturbance causes the material discharged to rise at various lengths in the water, and should the stream have a rapid current the material will be carried away with the power of the water.

Where the outgoing tide is insufficient to carry away large masses of material thrown up by the action of the inverted cups and the coffers, through which the blast is made of compressed air, and the movement is sluggish, the pipe-frame R is lowered in position and permitted to rest upon the incipient channel, the cover over which, as the sides meet the bottom of the channel, extends a considerable height above the said frame R and a submerged arched sluice is formed. During this movement and as the material rises above the level of the arched sluice, the stop-cock on the tank L^2, to which is attached the pipe leading to the pipe W, is opened and the compressed air is liberated through the jet-pipes w', and a blast of the compressed air is directed upon the mixed water and debris at a point a short distance above the sluice, and the material held in suspension is forcibly expelled toward the rear of the water-carriage. Thus it will be perceived that in the employment of a number of the water-carriages an arched sluice may be formed of great length and the power of the apparatus correspondingly increased.

The stop-cock on the tank L^2, with which the pipe leading to the frame R is connected, is opened and the compressed air emitted in blasts upon the material, which is swept through the sluice with the water, and beyond the sluice the material rises in proportion to its gravity and with the ascending currents of air. During the agitation and movement of material in the sluice the inverted cups and the coffers are in motion and cause the commingling of the material with the water and a rapid flow of the water from the bottom of the submerged sluice to the surface of the water.

In linear displacements in succession in harbors the work is effectively augmented by a series of water-carriages with the apparatus, as heretofore described, in a single line and a short distance apart, in which arrangement a passage is forced through a sand-bar and the whole underlying debris set in motion, and while in suspension in the water removed a long distance and beyond the action of the incoming tides. In swift-flowing water the cover T may be dispensed with, and the action of the compressed air directed through the frame R will cause eddies in the water, and with the rising compressed air the material passes upward and is carried along with the stream.

Whenever the position of the water-carriage is changed, the sliding gear on the main line-shaft are thrown into engagement with the gear on the shafts w w', and the frame R is elevated the proper height. The power is then transmitted from the main line-shaft to the windlass and each part of the frame moved at equal degrees of speed.

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

1. An apparatus for forming channels consisting of a water-carriage having side floats, a compressed-air storage-tank, and an air-compressor, driving-shafts at each end of said carriage having cranks, a compressed-air-blast coffer having a pipe connected therewith and said storage-tank, and a support for said coffer having one end thereof connected with one of said cranks at one end of said carriage and also with the crank at the other end of said carriage, and means for operating said driving-shafts substantially as shown and described.

2. An apparatus for forming channels consisting of a water-carriage having side floats, a compressed-air storage-tank and an air-compressor, driving-shafts at each end of said water-carriage having cranks and connecting-pipes having suitable crank connections connected respectively with the cranks at one end and also with the cranks at the other end of said water-carriage, a compressed-air-discharging coffer connected with said pipes on said cranks having opening in both pipe and coffer registering with each other, a flexible supply-pipe connected with the storage-tank for compressed air and the pipes to which said coffers are connected, and an engine operating said driving-shafts and said air-com-

pressor, substantially as and for the purpose described.

3. An apparatus for forming channels comprising a source of compressed air and a perforate pipe-frame arranged beneath the water and upon the surface of the material to be removed, an arched cover extending over said frame, a flexible pipe connected with the source of supply for compressed air, and with one of the pipes in said pipe-frame, substantially as shown and described.

4. In a compressed-air apparatus for submarine air-blasting, a water-carriage having a sluice and suitable side compressed-air receivers, compressed-air tanks at each end of said carriage, hollow wheels at each end of said water-carriage having hollow shafts and crank wrist-pins and openings in said shaft and pin communicating with said wheel, power-conveying pipes having a closed portion between the ends of each pipe connected with the respective wrist-pins at each end of said carriage, and air-compressing cups on one portion of said power-conveying pipes having suitable connections for the compressed-air and back-pressure and relief valves and coffers on the other end portions of said pipes, air-compressors at each end of said water-carriage, means for operating said air-compressors and conductors for the compressed air connected with the air-compressors and the said hollow shafts of said hollow wheels, and also with the said air-receivers, and the said air-compressors and conductors of compressed air connected with the said air-tanks and said air-compressors, substantially as shown and described.

EDWIN C. NICHOLS.

Witnesses:
THEO. F. ORNER,
PAUL HUDSON.