(No Model.) 7 Sheets—Sheet 1.

S. BENSON.

PNEUMATIC TUBE AND MOTOR.

No. 450,958. Patented Apr. 21, 1891.

Fig. 1

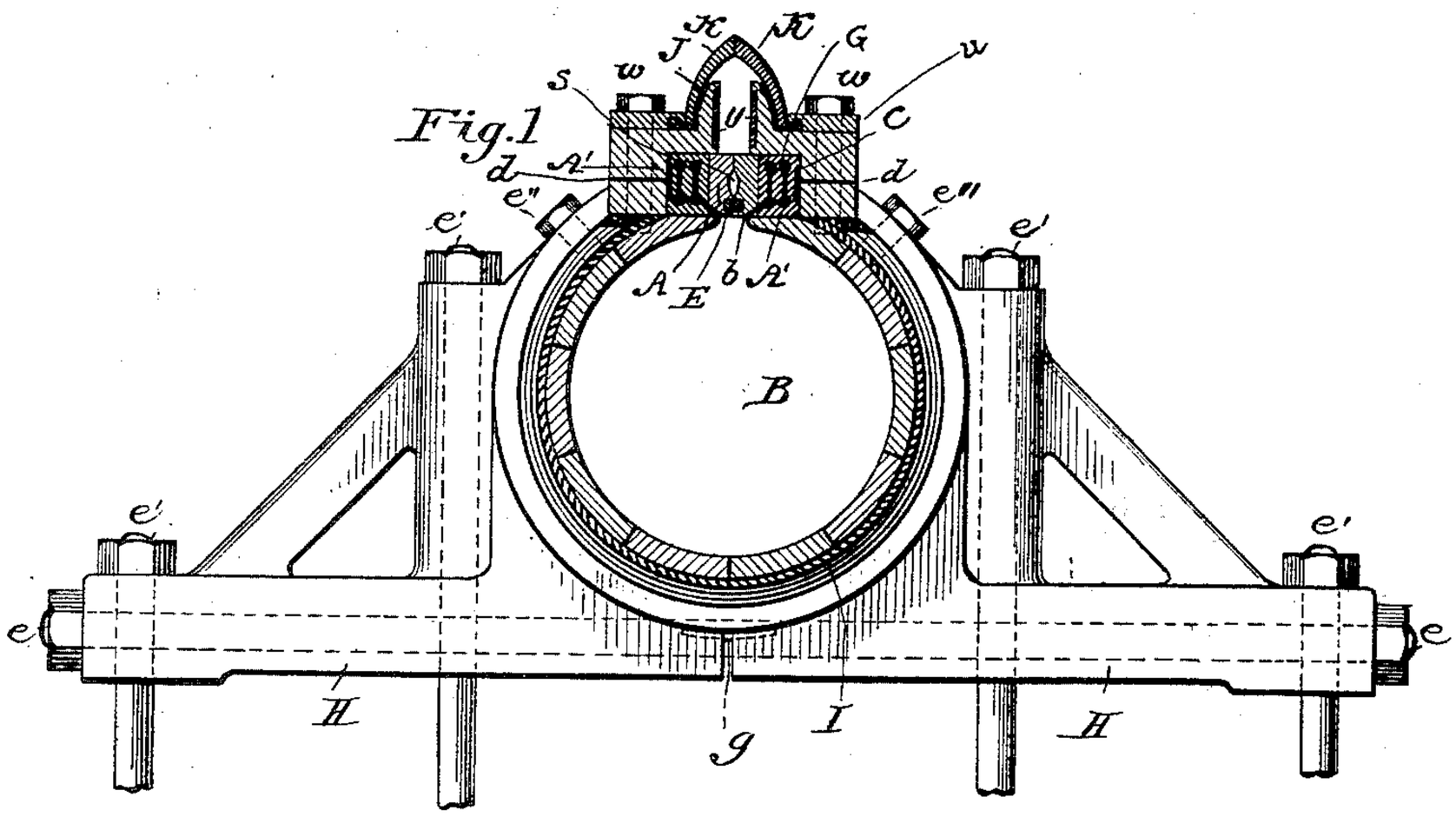


Fig. 2.

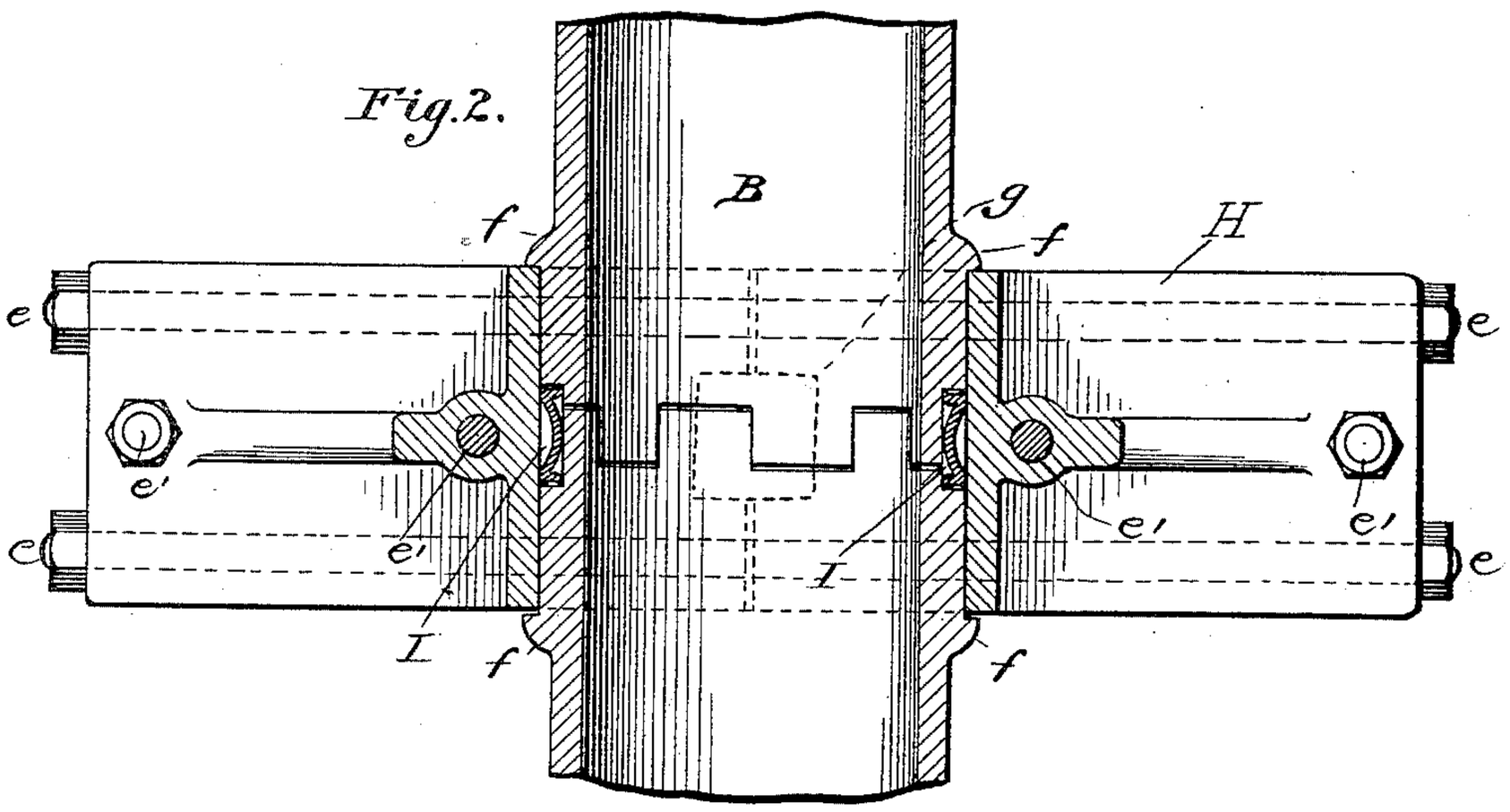
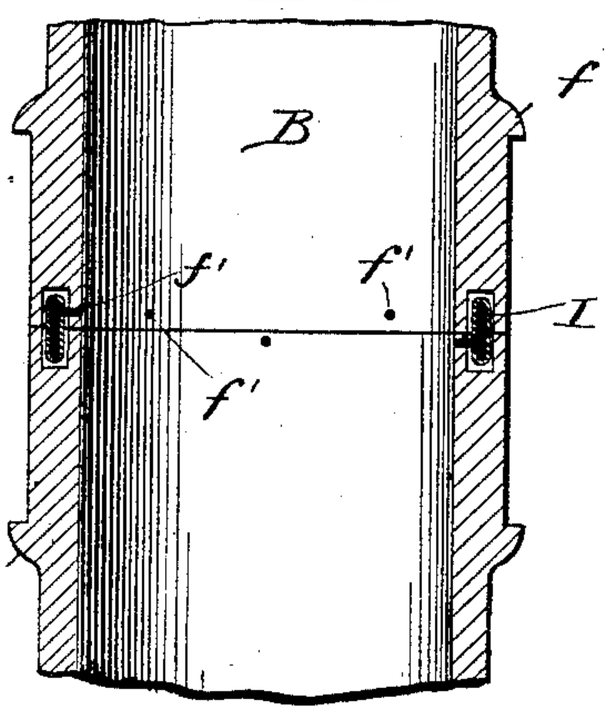


Fig. 3



WITNESSES:

William Twomby
A K Browne

INVENTOR

Samuel Benson

(No Model.) 7 Sheets—Sheet 2.

S. BENSON.

PNEUMATIC TUBE AND MOTOR.

No. 450,958. Patented Apr. 21, 1891.

Fig. 4.

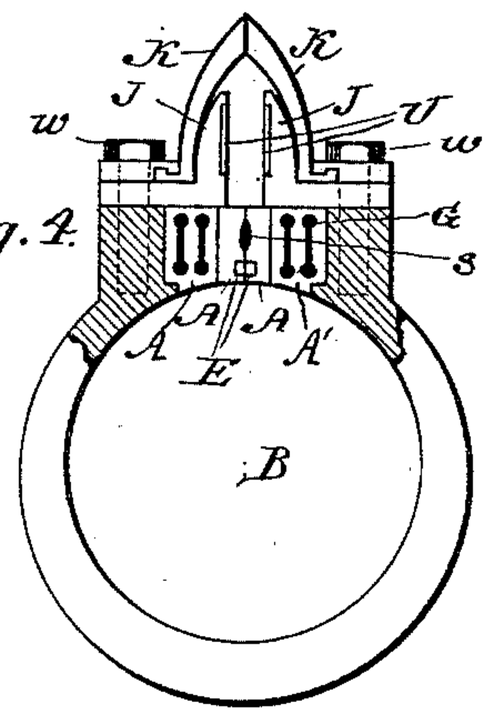


Fig. 5.

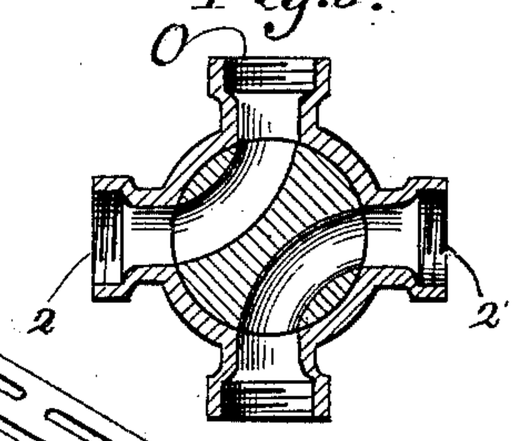


Fig. 6.

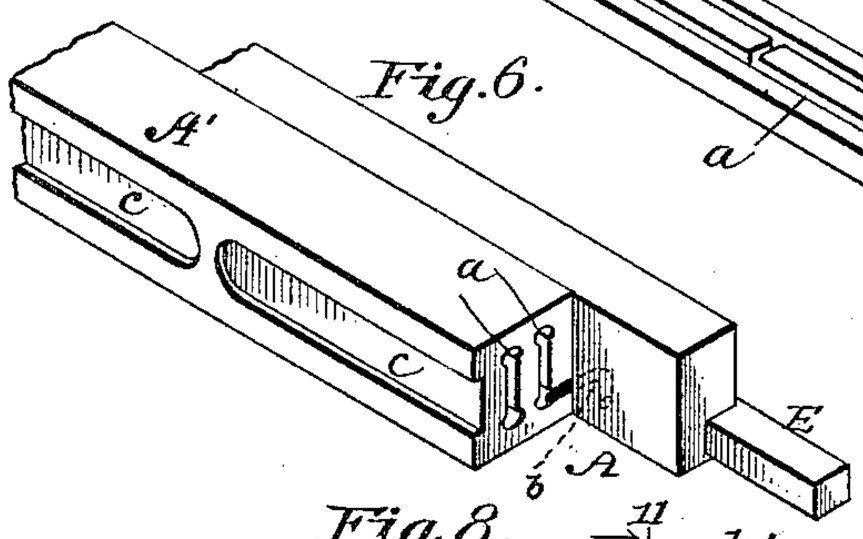


Fig. 7.

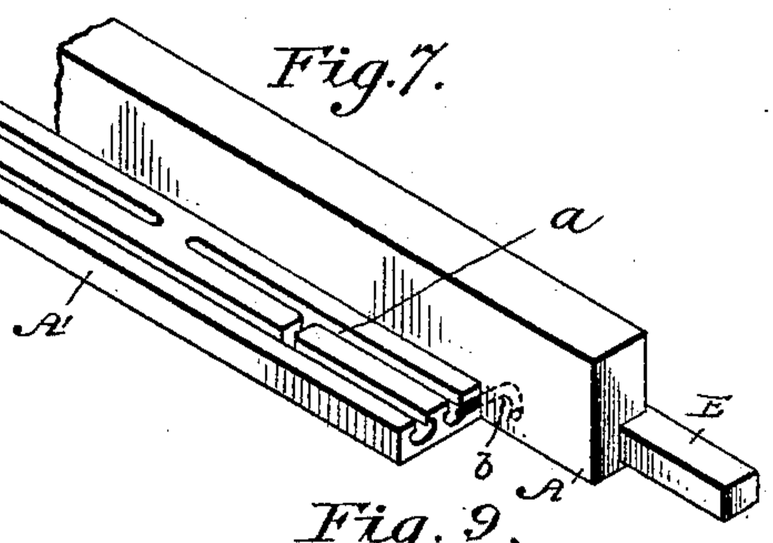


Fig. 8.

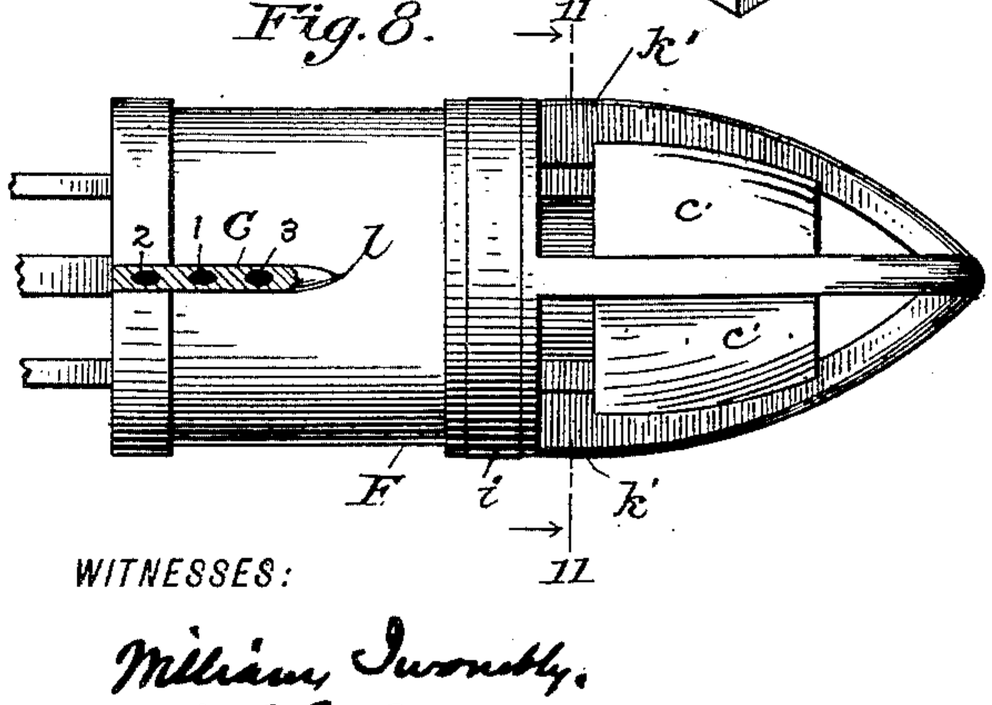
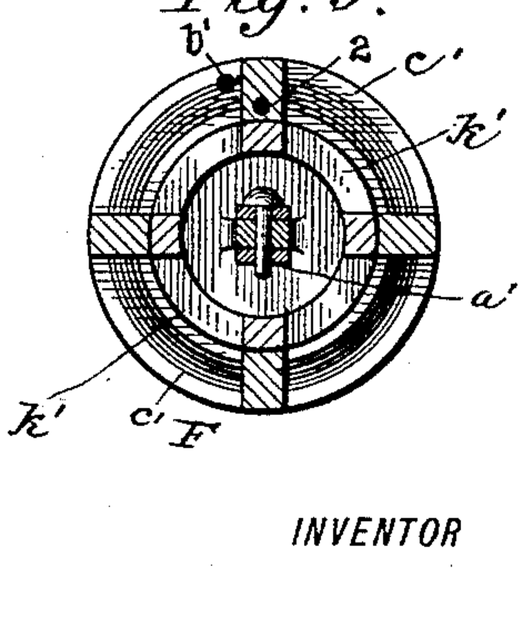


Fig. 9.



WITNESSES:

William Donnelly.
A. K. Browne

INVENTOR

Samuel Benson

(No Model.)

7 Sheets—Sheet 3.

S. BENSON.

PNEUMATIC TUBE AND MOTOR.

No. 450,958. Patented Apr. 21, 1891.

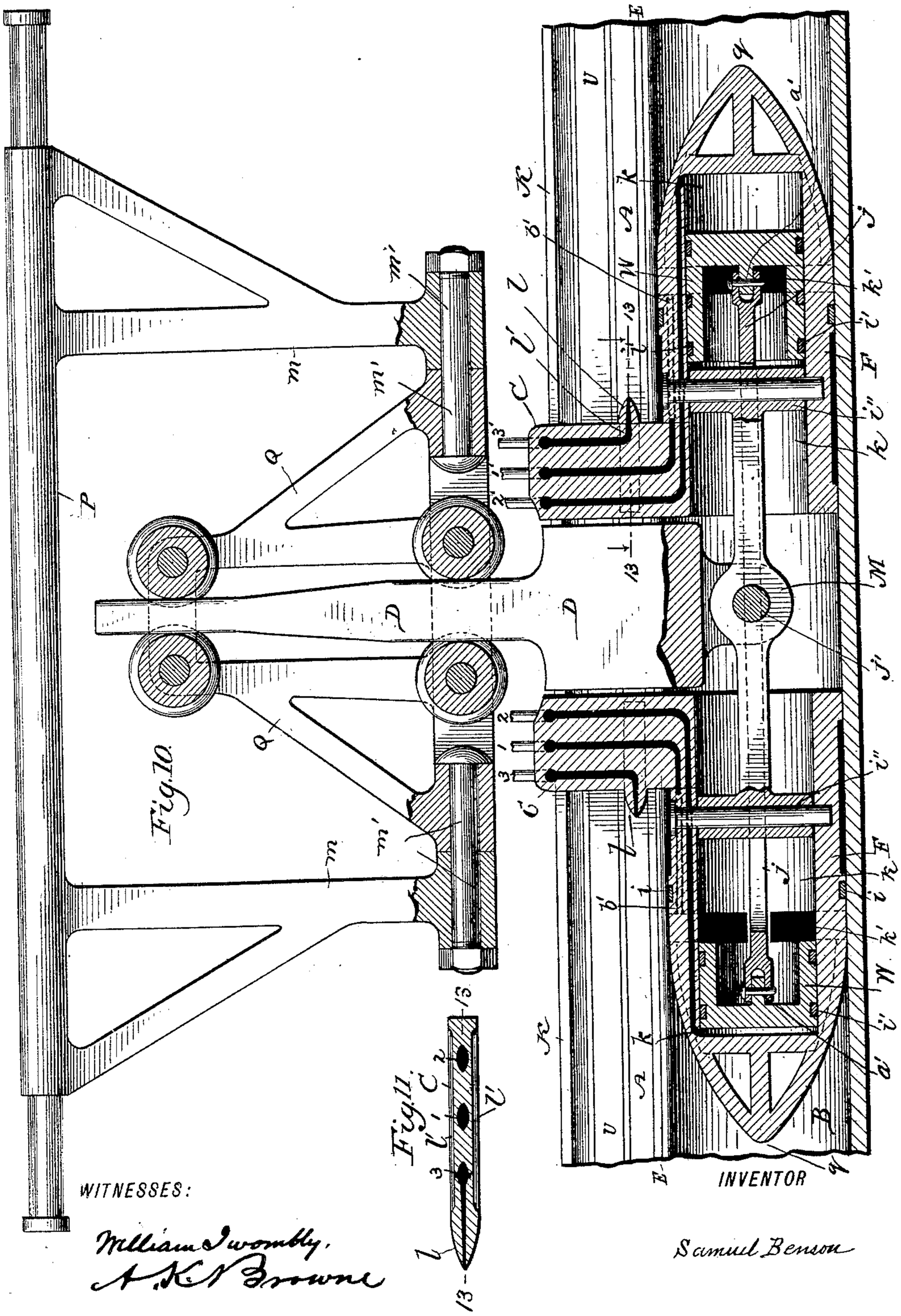


Fig. 10.

Fig. 11.

WITNESSES:

William Twombly.

A. K. Browne

INVENTOR

Samuel Benson

(No Model.) 7 Sheets—Sheet 4.

S. BENSON.

PNEUMATIC TUBE AND MOTOR.

No. 450,958. Patented Apr. 21, 1891.

Fig. 12.

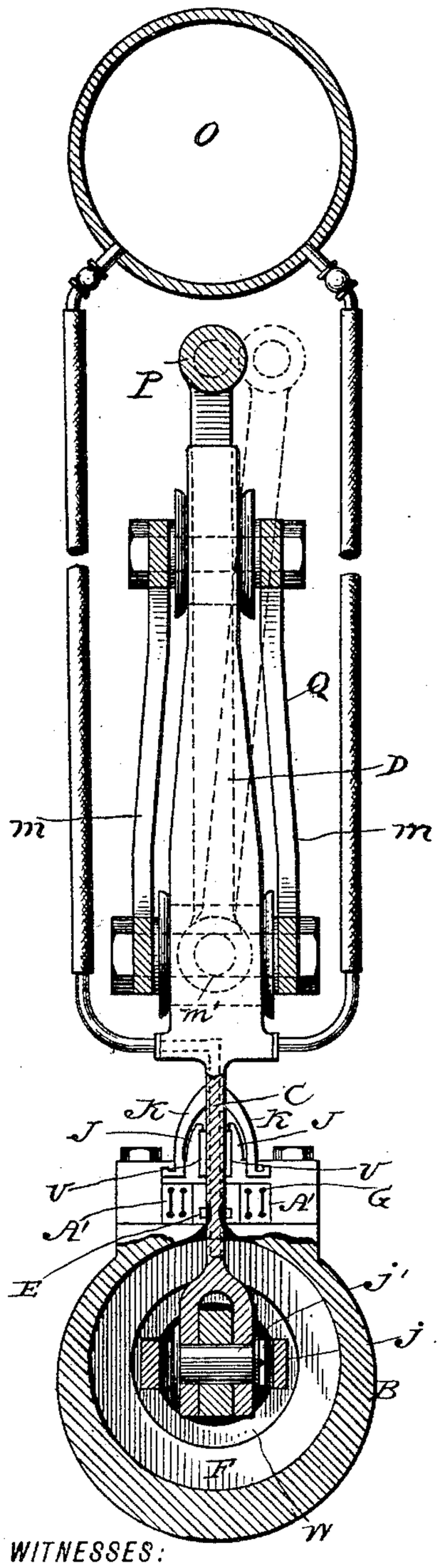
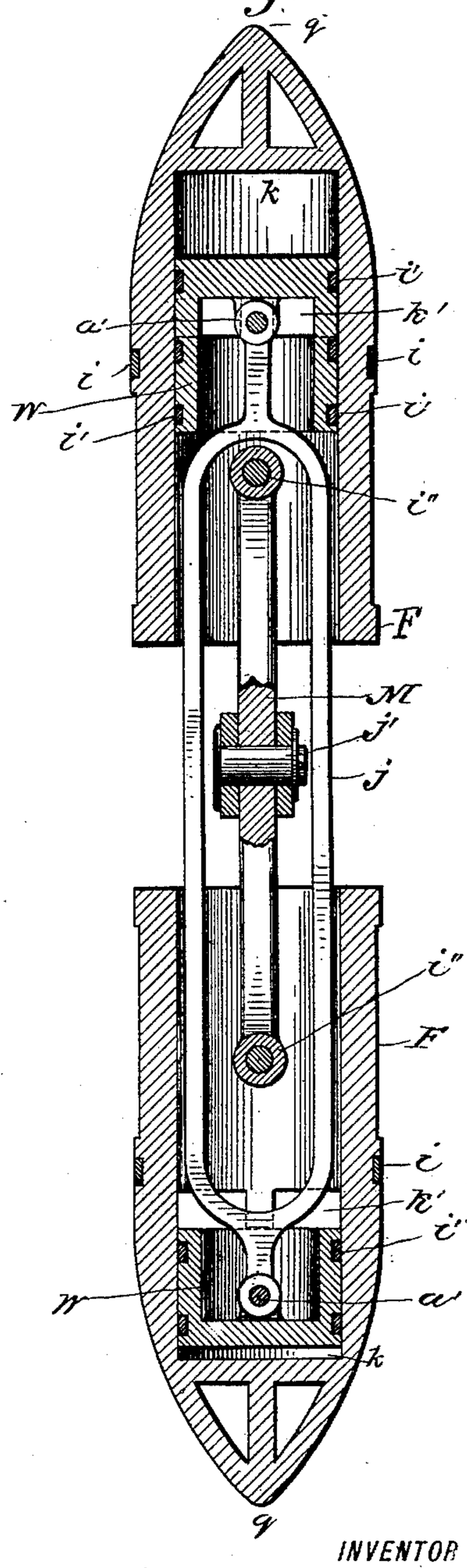


Fig. 13.



WITNESSES:

William Donnelly.
A. K. Browne

INVENTOR

Samuel Benson

(No Model.) 7 Sheets—Sheet 5.

S. BENSON.

PNEUMATIC TUBE AND MOTOR.

No. 450,958. Patented Apr. 21, 1891.

Fig. 14.

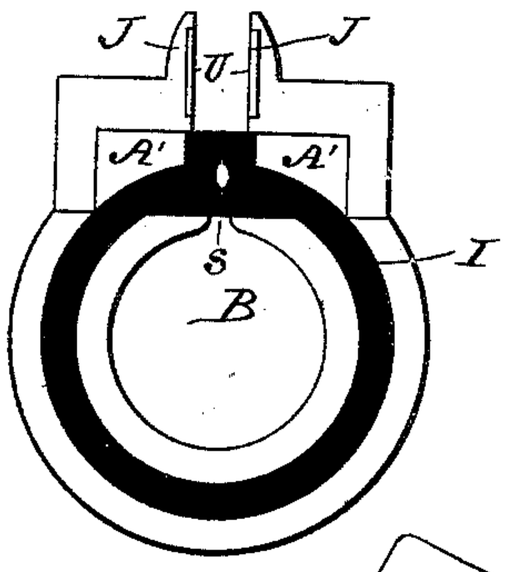


Fig. 15

Fig. 16

WITNESSES:

William Twombly

A. K. Browne

INVENTOR

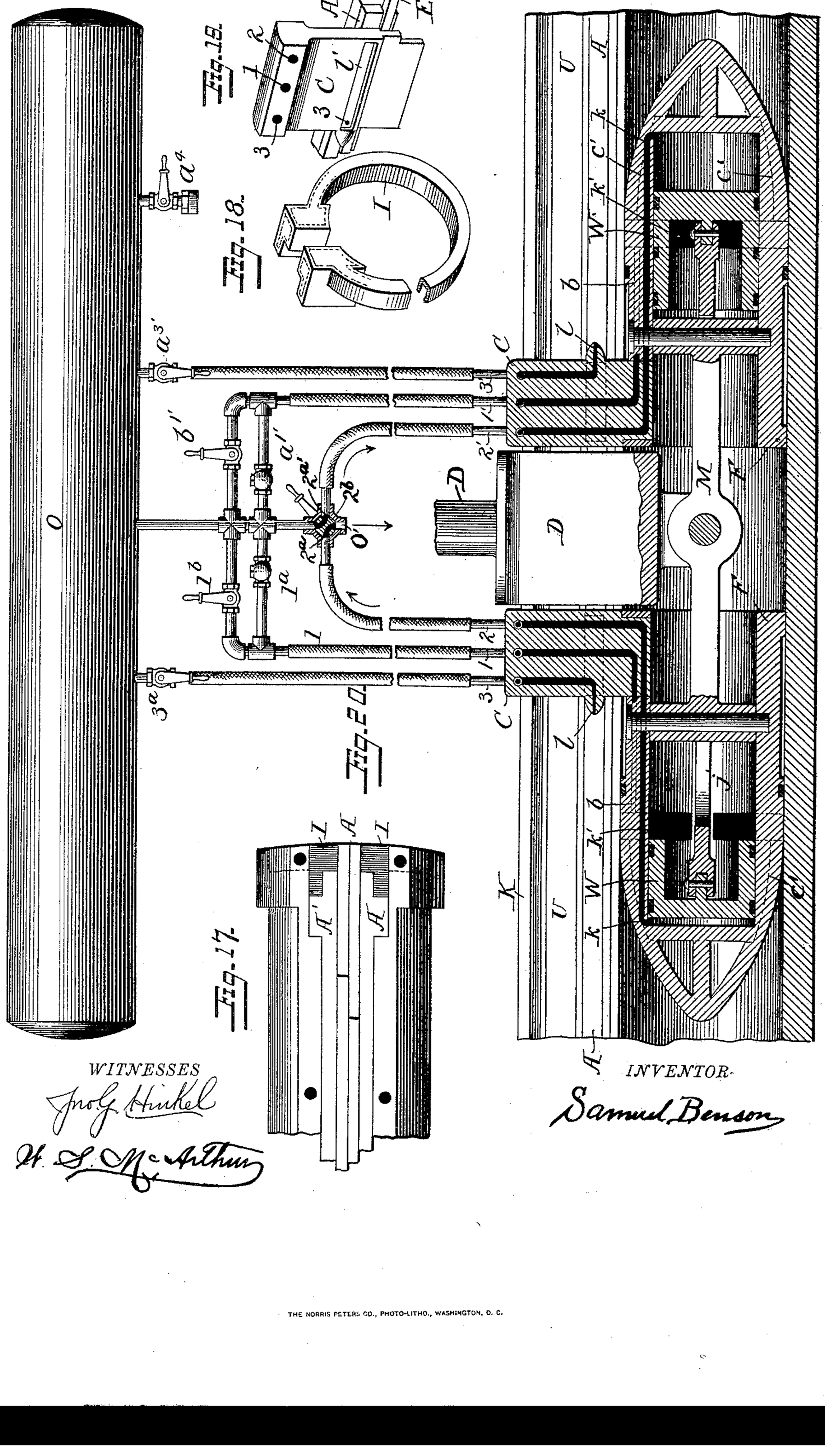
Samuel Benson

(No Model.) 7 Sheets—Sheet 6.

S. BENSON.

PNEUMATIC TUBE AND MOTOR.

No. 450,958. Patented Apr. 21, 1891.



(No Model.) 7 Sheets—Sheet 7.

S. BENSON.

PNEUMATIC TUBE AND MOTOR.

No. 450,958. Patented Apr. 21, 1891.

Fig. 21.

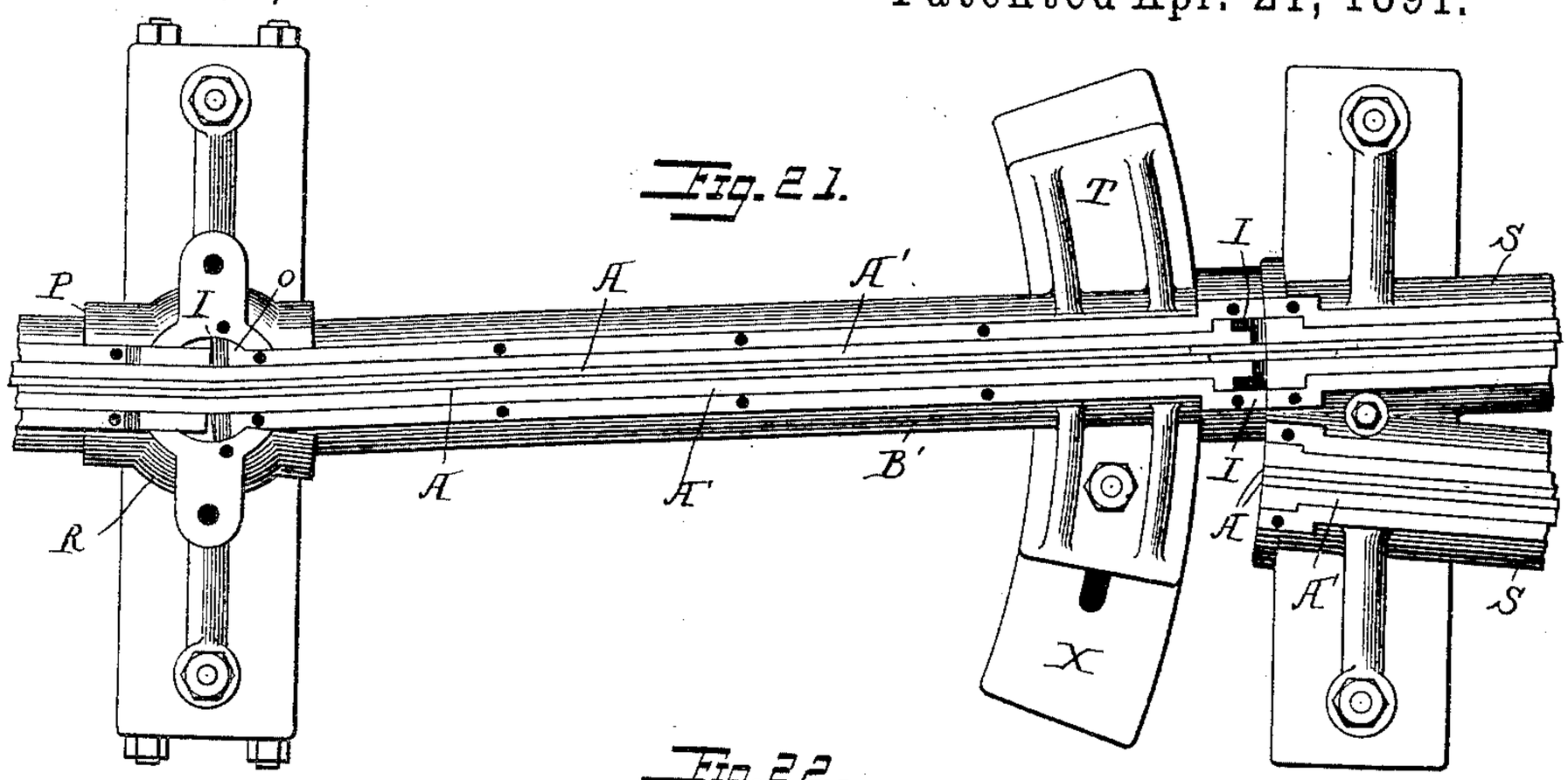


Fig. 22.

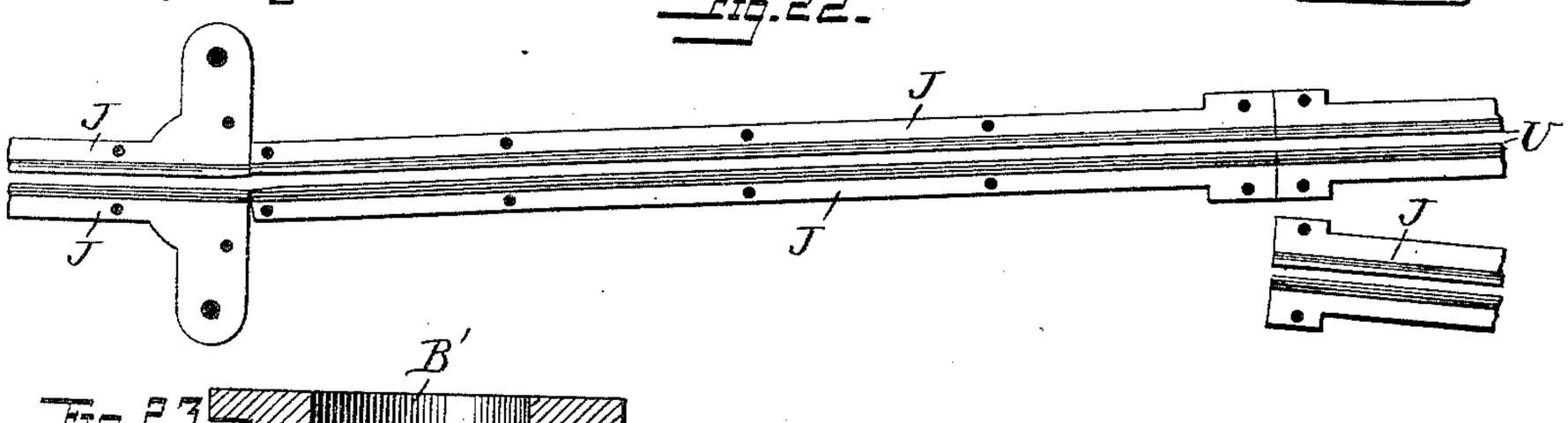


Fig. 23.

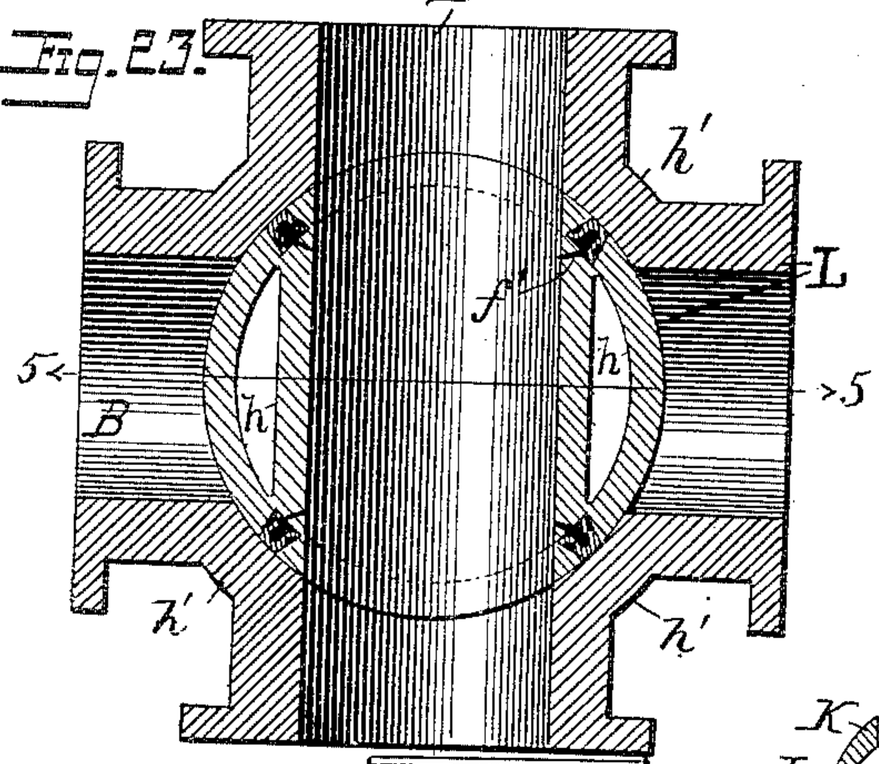


Fig. 25.

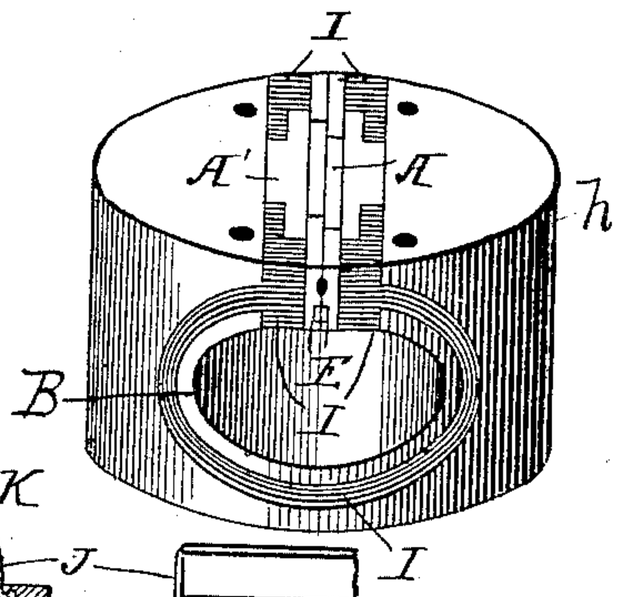
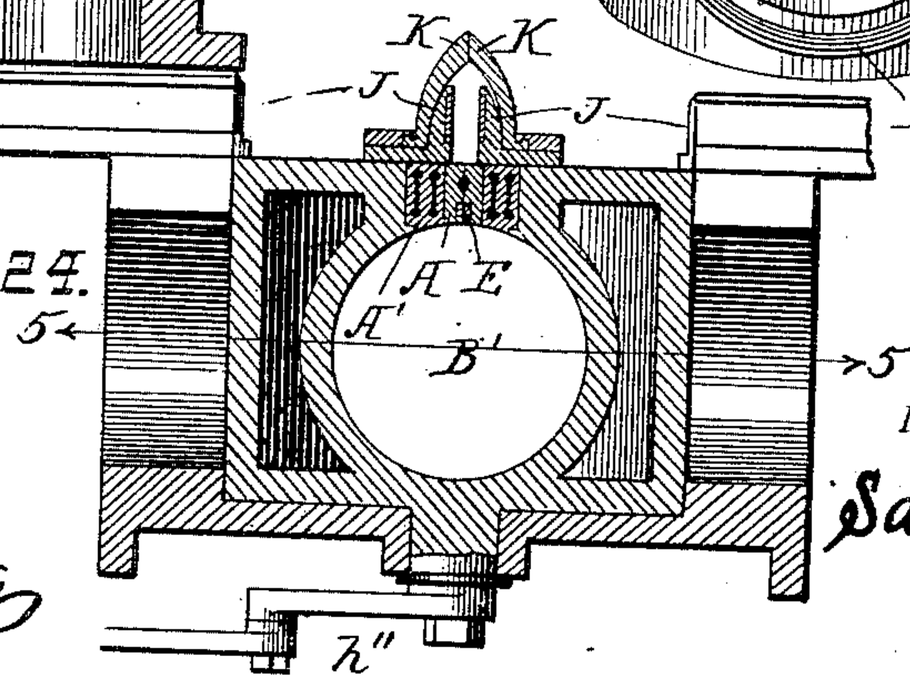


Fig. 24.



WITNESSES.
Jno. J. Hinkel.
H. L. McArthur

INVENTOR
Samuel Benson

UNITED STATES PATENT OFFICE.

SAMUEL BENSON, OF BUTTE CITY, MONTANA, ASSIGNOR OF ONE-HALF TO JOHN M. MONTGOMERY, OF SAME PLACE.

PNEUMATIC TUBE AND MOTOR.

SPECIFICATION forming part of Letters Patent No. 450,958, dated April 21, 1891.

Application filed January 8, 1891. Serial No. 377,074. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL BENSON, a citizen of the United States, residing in Butte City, Montana, have invented new and useful Improvements Relating to Pneumatic Tubes and Motors, of which the following is a specification.

My invention relates to that class of pneumatic motors having a piston within a tube, through which projects a straight flattened arm from the piston, being thereby available as a motor for any adaptable use on the outside of the tube by means of air or other suitable pressure acting against the rear of the piston within the said tube, the tube being provided with a longitudinal slot for the passage of the arm or driving-bar, and being centrally and equilaterally opened therefor by the cleavage of a wedge-shaped bar between a pair of elastic line-valve strips extending along and secured to the opposite edges of the tube-slot and automatically closing after the passage of the said arm or driving-bar, and has for its object, so far as herein set forth, to provide means whereby the tube-joints may be made adjustable to necessary movements without needless leakage and waste of power, and that other parts relating thereto may be so constructed that they shall contribute to the permanency and integrity of the joint system connected therewith. While this motor is obviously adapted to elevators and other uses, this description relates more particularly to rapid transit of passengers and freight.

It is my further object that all devices in these plans shall be adaptable to the operation of motors in either direction on the same line or the interchange of cars and motors with other lines having the same track and tube-gage; also, that the motors may be actuated by direct pressure alone or in conjunction with a partial vacuum or the latter separately.

I accomplish these objects by means of the devices and construction set forth in the accompanying drawings and specification, needless explanations and illustrations of detail obviously implied being omitted, the same letters or figures referring to the same or like parts.

Figure 1 is an end elevation of the combined adjustable coupling and tube-chair, the tube in cross-section showing joints and other details. Fig. 2 is a central horizontal section of Fig. 1, showing interlocking joints of tube, inflatable packing, and other details. Fig. 3 is a horizontal section of tube-joints, showing plain butt-joints, and a modification of the joint-packing shown in Figs. 1 and 2. Fig. 4 is a vertical cross-section of the tube, showing a modification of Fig. 1. Fig. 5 is a horizontal cross-section of a four-way cock. Fig. 6 shows a perspective view of a broken length of the inflatable line-valve strips. Fig. 7 shows the same with the inside arrangement of the cells by means of the sectional view, as set forth. Fig. 8 is a view of the piston from the top, also showing separator in horizontal cross-section. Fig. 9 is a sectional view of Fig. 8 through line 11 11, Fig. 8. Fig. 10 shows a vertical longitudinal section of the tube and pistons and attachments thereto and the self-adjusting relieving-coupler in connection therewith. Fig. 11 is a horizontal section of the separator C in the line 13 13, Fig. 10. Fig. 12 is a central vertical cross-section of Fig. 12, showing tube, driving-bar, connections, relieving movements, receiver, and other details. Fig. 13 shows a horizontal section of the pistons and connections as set forth in Fig. 10. Fig. 14 is an end view of the switch-tube to be seen in Fig. 15, showing arrangement of packing for movable end joints, as at switches, turn and transfer tables or crossings, or other necessary terminals or movable ends of tube. Fig. 15 is a central horizontal section of the switch-tube branches and supports, also showing arrangement of joints and inflatable elastic ring-packing adapted thereto. Fig. 16 is a top plan of the line-strips as it would be seen on the lower or free end of the switch-tube in connection with Fig. 14; also shows a suitable means for securing line-strips at terminals; also, junction with joint-rings. Fig. 17 shows end broken off a switch-tube as seen from the top and flush with the upper face of the line-valve strips, showing the curved end, the dotted lines thereat indicating the ring-packing and chamber; also shows jointure of ring-packing and line-valve strips and enlarged ends of line-strips and conforming chamber, whereby the line-strips are secured. Fig. 18 is a perspective view of an inflatable ring

adapted to the arrangement shown in Fig. 17 and elsewhere, relating to switch ends, crossings, or other transversely-movable ends of tubes. Fig. 19 is a perspective view of a detached separator and broken strip of line-valve, showing the port-openings 1 2 3, all on one side in this case, the shallow chamber *l'*, the nozzle *l*, and the small orifice 3, the enlargement of the separator above the joint-lips, the broken-off line-strip on one side, and the projecting joint-lip E. Fig. 20 is a vertical longitudinal section of the tube and piston and attachments thereto, corresponding with Fig. 10, but having the self-adjusting coupler removed and the shank of the driving-bar broken away to conveniently illustrate the conduction and regulation of the motive fluid between the receiver O and the lower channels. Fig. 21 is a top view of the switch-tube and branches, corresponding to the sectional view of Fig. 15. It shows the top of the switch and branch tubes flush with the upper face of the line-valve strips, said strips being shown continuous through the pivotal end of the tube. Other details of this view are elsewhere described. Fig. 22 shows the cover and guide-strips J J as lifted entirely from the top of Fig. 21, the pieces occupying the same relative positions as when in place and secured by screws *w*, as shown in Fig. 4. Fig. 23 is a horizontal section of a tube-crossing as shown on the line 5 5, Fig. 24. Fig. 24 is a corresponding vertical section shown on the line 5 5, Fig. 23. Fig. 25 is a perspective view of the plug or tube-carrier *h*, showing, in connection with other figures, arrangement of inflatable ring-packing and line-valve strips at terminal ends, the guide-strips and cover J J being removed to exhibit these features.

The construction is, broadly, that of a common two-way cock provided with necessary changes in structure for the purpose set forth.

The plug or tube-carrier *h* is provided with a short section of the tube, with all upper attachments corresponding with the main tube and in alignment with the same at either angle, as shown, and arranged to rotate within the chamber *h'* about its vertical axis. A quarter-revolution in either direction opens and closes opposite tube-openings, thus allowing free passage of the piston and connections through the tube and slot when set in the direction of travel, and by means of the inflatable ring-packing the escape of motive fluid is prevented.

The movement required to change the direction of the tube-crossing may be imparted by the lever *h''* or other suitable means.

The weight of the movable plug or tube-carrier may rest as shown, or may be supported upon a suitable step or bearing under the spindle at *h''* or otherwise.

A' A A A' show in Figs. 6 and 7 and elsewhere the line-valve strips, composed and made of rubber or combinations of rubber with other substances or other suitable materials and best adapted to conditions of the following description.

A A are the inner faces of the line-valve strips—hard, elastic, and anti-frictional. The lips E E are softer, elastic, and slightly project to meet each other from the hard faces A A.

A' A' are the outer strips of very elastic material and inflatable cellular structure.

Figs. 6 and 7 and others indicate very plainly the general features and application, with some simple obvious modifications, to which these inflatable line-valve strips are subject. The hard faces A A resist the tendency of the inward pressure to force them out of the open slot, also resisting the violent thrust of the separator C, as shown in Figs. 1, 4, and 12. The separators C C and all upper following parts being wider than the space between the lips of the line-valve strips while passing through them, and the under part of the separators C C and driving-bar D opposite and parallel to the lips being reduced in width, none of the passing parts come in contact with them, as indicated and exaggerated in Fig. 12. (Shown also in Fig. 19.) As a further precaution to prevent injury to or abrasion of the said lips E E, the separators C C are permanently fixed to the inner ends of the pistons F F, Figs. 8 and 10. This position prevents any perceptible rise or fall of the separators C C. They are always in direct alignment with the divisional line of the line strips or valves, and will readily adjust themselves from cramping or binding in the slot by rolling the pistons slightly, other joints not interfering.

A shallow cavity *s*, (indicated in Figs. 1, 4, and 14,) adapted to receive the separator-nozzle *l*, is provided to facilitate the entrance of said nozzle at all terminal ends, whether stationary or subject to transverse movement, whereby the penetration of the nozzles and separation of the line-valve strips is assured, and damage resulting from end movement of or upsetting the line-valve strips is thereby avoided.

The different layers will be united in the process of the manufacture of the line-strips, and may be made in convenient lengths and spliced by breaking joints, as indicated in Fig. 6, the overlapping ends being united by cementation. The lips E E are preferably located near the edge of the line-valve strip exposed to the greatest pressure and should project somewhat, in order that the lateral pressure resulting from the elastic material and inflation of the cells *a* may press them firmly together, and thus prevent the escape of the propelling-fluid. The lips E E are shown meeting in straight lines. Evident advantages may be attained under high pressure by having them meet in serrated or other corresponding lines. In either case a choice will depend upon local conditions.

The cells *a a a* (shown or indicated in Figs.

6 and 7 and elsewhere) may be made as shown, or of honeycomb or other suitable structure confined within outer walls, as shown, and grouped into longitudinal sections by intercommunicating channels between the interior cells in each determined group. In no case must any group occupy a length of the line-valve strip quite equal to the distance between the piston-packing and the nearest nozzle of the separator C, each group having one or more openings connecting with the interior of the tube, as indicated at *b*, Fig. 1, and elsewhere. By limiting each group as set forth, as the piston is driven along by the pressure within the tube, the strips are inflated by means of the cells and openings described, thus tightly compressing the lips in the rear of the piston; yet they cannot pinch the strips upon the separator, as the inflatable sections are too short to reach it.

In case of using comparatively low pressure, particularly with partial vacuum, the intercommunication of cells with each other or with the tube may be omitted, as sufficient air can be confined during the process of manufacture to secure the required elasticity of the cell action in the line-valve strips. I do not therefore limit myself to any special form or combination of cells with or without communication in elastic inflatable cellular line-valve strips for pneumatic tubes.

Fig. 7 shows a suitable arrangement of cells.

Figs. 1 and 6 show the arrangement of side recesses, which, when used as shown, adapt this system to the action of vacuum, separate from mechanical pressure or in conjunction with it or by direct pressure alone—that is, when arranged as here shown it is applicable to either use, as stated, without further change. If these side recesses be omitted, the combination is adapted to direct pressure only. The recesses *c* are shallow depressions, limited in length for reasons similar to those above set forth. When vacuum is used, the external atmosphere communicating with the recesses *c* by means of the holes *d*, Fig. 1, in sides of valve-chamber G, pressing between the walls of the chamber and the line-strips, force them together, thus securing a tight jointure of the lips E E. The inner walls of the line-valve chamber G may be milled or otherwise roughened to prevent a tendency of the line-strips toward end motion from passage of driving-bar; or lateral projections may be provided on the line-strips, adapted to corresponding chambers at suitable intervals along the tube-slot, the outside lines of the plan view of which would appear as shown at the junction of the switch-tube and branch, Fig. 21.

Fig. 4 shows a modification of the line-strips and the walls of the chamber confining them, whereby the circumferential interior of the tube presents a uniform unbroken face, requiring no offset in the piston-packing, the line-strips projecting farther inward and covering a wider space of the interior tube than is shown in Fig. 1. The side walls of the tube are continuous and form the walls of the chamber, which feature is also applicable to either plan of line-valve-chamber floor shown.

H in Figs. 1 and 2 shows an adjustable tube-coupling and chair for the tube-joints. It is preferably made separable, as shown, provided with compression-bolts *e*, vertical tie-bolts *e'*, and clamping-screws *e''*, which pass through the coupling and screw into the tube, binding them together. Any tendency of the tube-slot to open or close beyond the normal limits of slot-gage may be corrected by the relative adjustments of the bolts *e* and *e'* and the tube and couplings firmly engaged, and the whole permanently secured to the road-bed by the means set forth. This form of chair and coupling may be cast with the tube and used as intermediate support between the joints or cast on the end thereof, forming a socket for the next length of tubing.

Referring to Fig. 2, lugs or shoulders *f f* co-operate to regulate the expansive and contractile action of the tube resulting from changes in temperature, space therefor being allowed between the shoulders *f f* and the coupling-chair. One end of each engaging pair of tube ends is rigidly secured to the combined tube-coupling and chair by means of the shoulder *f* and clamping-screws *e''*. The other end is allowed to move endwise by means of slotted holes in the coupling-box, through which the radial screws *e''* pass. (Not shown.) This arrangement, when secured to the road-bed, confines said action within the limit of each section of tube.

Figs. 1, 2, 3, 14, 15, 17, 18, 21, 23, and 25 show inflatable elastic-joint ring I for the tube end joints, the object being to provide an effective inflatable ring-packing for pneumatic tubes to act in combination with the line-valve strips, which by simple modifications in form or position will seal the spaces at the engaging ends thereof, whether fixed or movable, whether such movement be due to changes in temperature or necessary transverse mechanical movement of short sections of the tube involved in changes of direction of the motors or otherwise, and by means of its elasticity and inflatable action will automatically fill and seal such joint-spaces.

Figs. 1 and 2 show a suitable form of elastic inflatable packing I for interlocking tube-joints. It is made of rubber or other suitable elastic material and molded to conform to the space to be occupied by it, but somewhat larger in all its dimensions, and being provided with closed ends abutting upon the line-valve strips A' A' and the ends of the chamber confining it. The motive fluid is admitted through suitable orifices *f'* or through the joint-openings or otherwise, thereby expanding them outwardly in all directions, facilitated by the curved lines of the packing shown in section in the different figures, thus effectively sealing the joints.

Fig. 14 is an end view of the switch-tube

joint-ring packing and end of the switch-tube shown in Fig. 15, and is applicable to all movable ends, as tube crossings, switches, turn-tables, or other necessary interruptions of the main-tube line, the same general description applying to all ring-joints shown. It will be observed that all movable sections of main-line tube are provided with all attachments of the main tube, the ends of the line-valve strips being enlarged, as shown in Fig. 16, the line-valve-chamber ends being provided with corresponding enlargements, whereby the line-strips are prevented from being driven or forced inwardly. Fig. 3 shows a modification of this inflatable packing as applied to a plain butt-joint, pressure being admitted through orifices *f'* or otherwise. A suitable recess *g* is provided, as indicated by dotted lines in Figs. 1 and 2, for the reception of a metallic plate to support the inflatable joint-packing I at the opening between the lower opposite faces of the coupling and chair H.

The guide-strips J (shown in Figs 1, 4, and elsewhere) form the cap or cover of the line-valve chamber and a slot and guideway for the passage of and lateral support to and wearing-faces for the driving-bar and separators. They are secured to the opposite sides of the tube-slot by screw-bolts *w*, and extend throughout the entire length of the motor-tube system, including movable branches, and may extend downwardly and form the outside walls of the line-valve chamber, as shown in Fig. 1 and elsewhere.

The inner faces of the guide-strips J (shown in Fig. 1 and elsewhere) are preferably lined with metalline or other anti-frictional composition, as indicated at U.

The protection-flaps K are made of rubber or other elastic material, secured to the tube by means of the engaging tongue and groove in the flap and rolled metallic strip *u* and secured by the screw-bolts *w w*. Their function is to open and close during the passage of the motor and to protect the slot from the elements or foreign matter.

Fig. 10 is a vertical longitudinal section of the tube and relating parts containing the pistons and connections and showing the self-adjusting relieving-coupler P Q, attached to or in connection with the driving-bar D.

F F are the main pistons, being cylindrical conical shells, each being preferably cast in one piece. The external surface fits freely within the tube and is provided with suitable packing, as indicated at *i i*, and the inside bored to receive interior piston-valves W W, which latter are nicely fitted to the same and provided with packing, as shown at *i' i'*, and conical ribbed ends *q*, which are intended to correct any irregularities in movable sections of the tube, such as switches, crossings, or necessary valves in the tube, whereby they may be guided into alignment with the tube and passing mechanism in the event of failure of other appliances to fully perform their functions, and are connected together by means of the connecting-rod M and the joint-pins *i'' i''*, and are provided with conducting-channels *c'* to parts *k'*, Figs. 8 and 9. The piston-valves W W are connected by means of the valve-rod *j j* and joint-pins *a' a'*. The driving-bar D is connected to the piston-connecting rod M by means of the joint-coupling at *j'*.

C C are the line-valve-strip separators immovably secured to the pistons F F and preferably cast of suitable metal and provided with channels or ports 1 2 3 and 1' 2' 3'. These ports act in corresponding pairs, each pair performing the same function as numbered, viz: The ports numbered 1 and 1' conduct the motive fluid to or from the tube B and receiver O, as shown in Fig. 10, by means of a downward and horizontal extension of the port to *b'*, Fig. 9, and an upward extension by means of suitable openings, connections, and flexible tubes or ports, as indicated, to the receiver O, Fig. 20, the said receiver being secured to any desirable part of the car.

When the motive fluid is to be supplied to the tube by means of conducting-pipes and regulating-valve system therefor, in connection with a suitable stationary power-plant, the ports 1 and 1' are each supplied with check-valves at convenient points between the outside of the tube and the receiver O, which valves open toward the receiver, as 1^a and *a'*, Fig. 20. The lower open ends of these ports being in free communication with the tube through the pistons, as shown in sectional view of Fig. 9 at *b'*, whenever the pressure in the tube exceeds that in the receiver at either end of the piston the check-valve exposed to this excess will be lifted and the fluid allowed to pass automatically into the receiver until the pressure is equalized or lessened within the tube.

When the motive fluid is supplied to the tube from a receiver on the motor-car, suitable pipe connections and regulating valves or cocks, as at 1^b and $b^{1'}$, are shown in conjunction with the check-valves 1^a and $a^{1'}$, by which motive fluid may be conducted to the receiver from the tube or from the receiver to the tube, whereby the opposite sources of motive supply may be caused to act separately or in conjunction, as may be required.

Ports numbered 2 and 2' communicate with the outer ends of the piston-valve cylinders *k k* downwardly and horizontally and upwardly to receiver O, as indicated in Fig. 20 by letters 2^a and $2^{a'}$. The function of this pair of ports is to act alternately with each other in exhausting the pressure from one end of the valve-cylinders *k k* and admitting pressure from the receiver to the opposite ends of the valve-cylinder, as may be required, to actuate the piston-valves W W, in order to reduce the pressure in the rear of the piston by allowing the motive fluid to pass through the pistons for the purpose of regulating speed, suitable ports *k' k'* being pro-

vided therefor in the main pistons F F. An ordinary four-way cock, (shown in section 2^b,) placed within reach of operator, having the horizontal openings 2^a $2^{a'}$ in communication with the ports 2 and 2′, the upper opening communicating with the receiver and the lower opening O′ with the atmosphere, will meet the requirements for actuating the piston-valves W W. Said valves are shown open, establishing communication between and through the inner ends of the main pistons F F. The four-way cock, Fig. 5, has the openings 2 2′ shown in the reverse direction, which, if connected and under pressure, as described, would close the piston-ports by moving the valves to the right. The ports 3 3′ are connected, as the others are, by means of flexible intermediate connections or hose to the receiver O, each being regulated by the operator by means of stop-cocks 3^a and $a^{3'}$. These ports are designed to conduct the compressed fluids from the receiver down to the nozzles *l l*, Figs. 20 and 11, which are provided with two small lateral openings, Fig. 11, at 3, a third orifice shown in the end, the former opening into shallow chambers *l′*, provided in the sides of the separator, as shown by dotted lines in Fig. 10 and in section, Fig. 11. The object is to provide a film of the motive fluid between the impinging faces of the line-strips and the separator, thereby reducing friction and absorbing heat by means of the pressure of the fluid current passing through them. When necessary, this arrangement may be applied to the sides of the driving-bar D. (See Fig. 19.)

The available novel features of the separators are due to their origin and position upon the motor-pistons, the alignment and freedom from wrenching action from movements of the motor being assured thereby, and line-valve strips and joint-lips protected from injury, as elsewhere shown. Requiring no pivots or space for them between the line-valve strips, much less lateral movement is required for the passage of motor connections between them, resulting in obvious advantages. As these features are not dependent upon the inclosed ports 1 2 3 and 1′ 2′ 3′, I do not limit myself to a separator of this form inclosing ports. It is evident that for short distances or comparatively low speed they may be omitted, and motive fluid for brakes or other uses may be supplied from small air-compressors actuated from the axles of the motor-car or otherwise. In lieu of the ports being in the separators, they may be formed in the driving-bar and connected to the pistons by flexible tubes; but I prefer them as shown when used.

The coupling-shaft P, Figs. 10 and 12, is securely journaled in the car-platform on lines parallel and vertical to the longitudinal axis of the tube and is provided with depending arms *m m*, pivoted at *m′ m′* and supporting a truck Q, also pivoted at *m′ m′*, as shown, and provided with grooved wheels, journaled as set forth, and adapted to move freely in a vertical line upon the rounded shank of the driving-bar D. By means of this self-adjusting coupler the car is free to lurch or rock, lift or fall, without exposing the piston or driving-bar to injurious strains resulting in needless friction and abrasion to the line-valve and guide-strips or piston-packing.

It will be noticed that a free working-space is allowed between the adjacent ends of the separators and driving-bar to permit of necessary radial movement of the latter and to allow equalization of pressure between the pistons within the tube and the atmosphere without—that is, I prefer that this space shall not be air-tight, in order to prevent accumulation of pressure whereby the cellular line-strips would be inflated and caused to shut tightly on the passing bar and separators, aside from the free action of piston and separators.

Figs. 14, 15, 16, 17, 18, 21, and 22 show details and modifications relating to switch-tubes and inflatable joint-rings, Fig. 15 being a lower horizontal longitudinal section of the switch-tube B, branches S S, chair T, sole-plate X, coupling-box R, and packing I. A ball-joint end is shown in the switch-tube at *o*, the tube B engaging therewith in the plain cylindrical throat and collar, as at *p*, in the coupling-box R, which is also formed to engage with and constitute a ball-joint, as at *o*, the box R, being separable and adjustable, provided with packing-strips, as at *g* in Figs. 1 and 2, to support the packing I, which is similar in structure and action to that previously described in the above figures.

The operation of the parts relating to this application having been set forth in the above description, a brief allusion to further ramifications and operations in connection therewith will afford a clearer understanding of the objects, construction, and uses of the devices herein set forth. The tube may be round, as shown, rectangular, or other form in interior transverse section, and may be lined with any suitable anti-frictional material or composition, and should be stiffened externally by having ribs adapted to resist undue opening of the slot from internal pressure, and will be laid between and parallel to the rails or other trackway and provided with a vehicle adapted to said trackway and mounted thereon and connected by means of the self-adjusting coupler and the driving-bar to the main pistons and propulsive action of the motive fluid within the tube and conformable to the impulses and regulation thereof by means of and in the manner set forth or as further explained herein. The road may be elevated or in an inclosed level to avoid accidents from high speed, or may be tunneled. The tube will be provided with suitable valves at stations or other points to act as abutments for the expansive action of the motive fluid in starting and propelling motors in either direction, as required, the same or like valves to act as abutments to stop motors by cumu-

lative compressive action of air or other fluid in advance of piston, safety-valves suitably located, connected, and adjusted acting in conjunction with the abutment-valves, and valves to exhaust the fluid within to the atmosphere without in advance of approaching motor. When the motor is to be actuated wholly or partially by the direct action of the motive fluid generated at contiguous power plants, conducting mains or pipes will issue therefrom and follow the motor-tube and suitable branches, and valves for the passage and regulation of the motive fluid will be provided between the conducting-main and motor-tube. If highly-concentrated motive fluid be used, it may be transported and distributed in suitable receivers and supplied to the motors as needed; or the fluid may be conducted through suitable tubes and the receivers filled therefrom, thence used, and applied to the tube, as and for the purposes indicated elsewhere. For urban passenger or more extended lines and traffic, and from either or both sources of supply of motive fluid to the tube and used separately or in conjunction as required, the speedy transit between contiguous stations may be best attained by a prompt admission of the motive fluid between the motor-piston and abutment-valve, increasing the flow and pressure with the accelerating velocity of the motor within safe limits until the impulse of the accumulated forces and expansive action of the fluids within the tube will project it to the next station. A cushion-valve will be closed at the proper time in advance of the approaching train. The pressure in the advance part of the tube will increase as the speed of the motor is reduced. Surplus pressure not required to stop the train before reaching the cushion-valve may be passed through a safety-valve, acting in conjunction with the cushion-valve properly adjusted, having suitable connections with a main conducting-pipe or into a receiver to be used again in the further propulsion of the motor. Brakes may be used, as also the regulating-valve within the piston, in urgent cases pressure for both purposes being furnished from a suitable receiver, as set forth. The motive fluid remaining in the rear of the tube may be exhausted or still further utilized as the exigencies of traffic or economy may determine. In case of a train leaving simultaneously at a rear station the tube would be exhausted, an abutment-valve closed behind the advance train, and renewed impulse imparted between the said abutment or valve and the said advance train. In traversing greater distances the same principle of initial movement and progressive action would be extended to the limit fixed by the pressure and friction of the fluid within the tube and other conditions involved, when renewed impulse would be supplied from the conducting-main adjacent to the rear of the motor by means of suitable connections and channels between said main and tube, or from a suitable receiver on the car, or from both sources, as before set forth, and by closing an abutment-valve thereat, a series of such valves and connections to be provided therefor and automatically operated, the motor would be projected by such impulses, subject to the control of the operator.

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

1. In combination with a longitudinally-slotted pneumatic motor-tube, the line-valve strips having hard elastic anti-frictional opposing inner faces and projecting inwardly therefrom softer engaging elastic joint-lips outwardly adjacent and integral thereto, the elastic bodies of inflatable cellular structure, whereby the line-strips may yield readily to the passage of a driving-bar and automatically close thereafter and seal the joint in contact therewith, and a conforming longitudinal line-valve chamber constructed and arranged substantially as and for the purposes set forth.

2. In combination with a longitudinally-slotted pneumatic tube, the line-valve strips A′ A A A′, having hard elastic anti-frictional opposing inner faces A A and projecting inwardly therefrom the softer elastic engaging joint-lips E E, the outer body A′ A′ integral thereto, of elastic structure, having defined groups of intercommunicating-cells, and each separate group provided with channels to the motive fluid within the tube, whereby the said line-valve strips are inflatable and all solid surfaces and joints in contact therewith may be tightly sealed, and the longitudinal line-valve chamber conforming to the said line-valve, arranged and constructed substantially as and for the purposes set forth.

3. In combination with a longitudinally-slotted pneumatic motor-tube, the elastic cellular inflatable line-valve strips adapted to open freely for the passage of a suitable driving-bar, whereby movement may be conveyed to a vehicle on the outside of the tube and to automatically close thereafter and to seal the joint-lips and chamber-walls in contact therewith by the combined action of the materials used in said line-valve strips and their elastic cellular structure and the expansive fluid confined within said cells, and conforming longitudinal line-valve chambers adapted to continuous sections, switches, crossings, or other interruptions of the main-line tube, substantially as and for the purpose described.

4. In a pneumatic motor of the class set forth, the elastic line-valve strips having hard faces, softer elastic slightly-projecting and engaging joint-lips, an outer body of elastic cellular structure, and cells inflatable by means of suitable expansive fluid confined therein, whereby the said line-valve strips are expanded and the joint-lips tightly sealed, in combination with a conforming chamber throughout its length and adapted to open and close therein for the passage of suitable connections between the pistons within the

tube and a vehicle to be propelled thereby on the outside of the tube.

5. In a pneumatic motor of the class set forth, the combination of the elastic inflatable line-valve strips, the motor-tube, the adjustable coupling-box, and chair and switch with the inflatable joint packing-rings I.

6. In combination with the described motor-tube, the inflatable line-valve strips, as set forth, adapted to terminal ends or switches, crossings, turn-tables, or other interruptions or branches of the main-line tube, having enlarged ends conforming to corresponding enlargements at the ends of the line-valve chambers, engaging and coacting with inflatable joint-rings at terminal joints, as set forth.

7. In the described pneumatic motor, the line-valve strips, as described, in combination with inflatable elastic joint-rings having conforming and suitable chambers at all tube end joints, substantially as and for the purpose set forth.

8. In the class of motors set forth, the elastic inflatable line-valve strips provided with shallow recesses in contact with the outer walls of the line-valve chambers, in combination with the said chamber having orifices, as at *d*, in communication with the external atmosphere, whereby the joint-lips are sealed when using a partial vacuum, substantially as and for the purposes set forth.

9. In a pneumatic motor of the class described, the combination of a switch-tube, a continuous separable pair of elastic inflatable line-valve strips, as set forth, through the pivotal end of the switch-tube, conforming in construction, position, direction, and functions to the said line-valve strips, as described, for main tube, and continuously connected therewith and terminating at and secured to the swinging end of said tube, the line-valve chamber, the main tube, the adjustable coupling-box and chair R, the inflatable joint-rings I, provided with suitable channels and openings to the motive fluid within the tube, the sliding tube-brace and chair T integral with said switch-tube, the sole-plate, X and branches S S, arranged substantially as and for the purposes set forth.

10. In a pneumatic motor of the class set forth, the switch-tube having a ball-and-socket joint, in combination with the adjustable coupling bar and chair, the inflatable joint-rings thereat, the continuous line-valve strips, the inflatable rings, the line-valve cover and chamber, the sliding tube-brace and chair, the sole-plate, and the tube branches, as set forth.

11. In pneumatic motors of the class set forth, the combination of a continuous pair of separable inflatable elastic line-strips having soft elastic engaging joint-lips and provided with suitable inner opposing surfaces, the separators adapted thereto, whereby the friction and wear attendant therewith are limited to said wearing-faces provided therefor, and the engaging joint-lips are free from contact with parts passing between them within the tube-slot, substantially as set forth.

12. In a longitudinally-slotted-tube pneumatic-motor system, the soft elastic joint-lips E E, engaging in conforming lines and projecting slightly from the inner opposing faces of the inflatable line-valve strips, in combination with said line-valve strips and conforming valve-chamber therefor, the separators C C, having nozzles *l l*, and the driving-bar D, adapted thereto, whereby the said joint-lips are opened and closed without contact with passing motor connections, arranged substantially as and for the purposes set forth.

13. In a longitudinally-slotted-tube pneumatic-motor system, the shallow cavities *s* provided at all interruptions of the line-valve strips or at transversely-movable ends of tube-sections, and fixed ends thereof engaging therewith, in combination with said elastic line-valve strips, the nozzles *l l*, and the separators C C, adapted to engage with and penetrate therebetween, arranged substantially as and for the purposes set forth.

14. In a longitudinally-slotted-tube pneumatic-motor system, the adjustable coupling-box and tube-chair H, having transverse compression-bolts, as *e*, vertical tie-bolts, as *e'*, and radial clamping screw-bolts, as *e''*, passing therethrough and screwed into the tube, the recess, and packing-plate at *g*, in combination with the abutting ends of the tube B, the elastic and inflatable joint-rings I, the elastic and inflatable line-valve strips A' A A A', and line-valve chamber G, constructed and arranged substantially as and for the purpose set forth.

15. In a longitudinally-slotted-tube pneumatic-motor system, the inflatable joint-rings I, having suitable chambers therefor at tube ends, whereby the joints of the tube are sealed, in combination with the said tube, the adjustable coupling-box and chair, and the line-valve strips, substantially as and for the purpose set forth.

16. In combination with the described motor system, the inflatable joint-rings and conforming chambers adapted thereto, whereby the end joints are sealed.

17. In a longitudinally-slotted-tube pneumatic-motor system, the combination of the shoulders *f*, the adjustable coupling box and chair, and the screw-bolts passing radially therethrough, clamping said box and tube together thereat, one engaging end of tube made fast and the other end free to move in slotted holes for bolts *w*, whereby end movement of the tube-sections is limited, substantially as set forth.

18. In a longitudinally-slotted-tube pneumatic-motor system, in combination therewith, the interlocking tube-joints having inflatable elastic joint-ring packing and conforming packing-chambers, the elastic inflatable line-valve strips, and the adjustable tube

coupling box and chair, whereby said joints are automatically sealed, substantially as and for the purpose set forth.

19. In a longitudinally-slotted-tube pneumatic-motor system, the tube-crossing L, adapted to open and close the tube for the passage of motors in a direct or transverse direction and to prevent the escape of motive fluid into the lateral tube branches or cross-lines, having provided therefor the chamber *h'*, the conforming rotatable tube-carrier *h*, and tube-section B' integral thereto, provided with inflatable line-valve strips and chambers therefor and inflatable ring-packing, and means for rotating the said carrier, as at *h''*, or other suitable manner, in combination with the crossing motor-tube lines and devices conforming and adapted thereto, substantially as and for the purpose set forth.

20. In a longitudinally-slotted-tube pneumatic-motor system, the separators C C, located at and fixed to the pistons F F in the position shown and projecting outwardly therefrom through the tube-slot between the line-valve strips and adapted to move freely between the guide-strips of the line-slot, in combination with the pistons F F, the elastic inflatable line-valve strips A' A A A', guide-strips J, and tube B, substantially as and for the purposes set forth.

21. In a longitudinally-slotted-tube pneumatic-motor system, the separators C C, located upon the pistons F F and secured thereto in an integral manner in the position shown and provided with suitable ports or conducting-channels, as 1 2 3 and 1' 2' 3', having extension-channels and connections, as shown, in combination with the elastic cellular line-valve strips provided with suitable chambers therefor, the connecting-pistons F F, the motor-tube and line-slot guide-strips having anti-frictional faces, and the receiver O, constructed substantially as and for the purpose set forth.

22. In a longitudinally-slotted-tube pneumatic-motor system, the separators C C, as shown, having interior ports and suitable terminal extensions and connections, whereby motive fluid may be conducted and its direction and flow determined by the manual or automatic action of suitable valves to coact therewith and provided with rounded points or nozzles *l*, having small end openings and lateral apertures at 3, and communicating side recesses, as *l'*, in combination with the elastic inflatable line-valve strips, the motor-tube, the connected pistons F F, the piston-valves and connecting parts controlled thereby, the driving-bar suitably coupled to a vehicle outside the tube, and the receiver O, substantially as and for the purposes set forth.

23. In a longitudinally-slotted-tube pneumatic-motor system, the separators C C, firmly secured to the pistons in the position shown in any suitable manner, being wider above the line of the joint-lips than the space between them when opened, the under part of the separator and driving-bar being reduced in thickness opposite the lips, the separator practically limited to a line parallel to the tube, whereby the joint-lips are protected from wear or abrasion by the passing parts, in combination with the elastic inflatable line-valve strip having inwardly-engaging elastic joint-lips, the driving-bar conforming with the line of the separators, whereby the said joint-lips are protected, the motor-tube, and the line-valve chamber, substantially as and for the purpose set forth.

24. The ports 1 1', having flexible extensions to the receiver O and horizontal extensions through the pistons F F to the motor-tube beyond the said pistons, whereby motive fluid may be conducted in either direction to or from and between the receiver and tube by means of said ports, and suitable connections and valves therefor, the said motive fluid to be applied and used therethrough, as shown or as may be required, in combination with the longitudinally-slotted tube, the elastic inflatable line-valve strips, the connected pistons, the driving-bar, and a suitable vehicle attached thereto, substantially as and for the purpose set forth.

25. In a longitudinally-slotted-tube pneumatic-motor system, the ports 2 2', having upward flexible connections to a suitable valve or four-way cock, thence to a receiver O, whereby said conducting-ports may be alternately charged and exhausted to actuate the piston-valves, having horizontal extensions therefor through the pistons F F, as shown, in combination with the separators C C, the pistons F F, the elastic inflatable line-valve strips, the motor-tube, the driving-bar, the receiver O, and a suitably-connected vehicle on the outside of said tube, substantially as and for the purposes set forth.

26. In a longitudinally-slotted-tube pneumatic-motor system, the ports 3 3', having flexible connections to a receiver, as O, suitable regulating-valves thereto and apertures through the separators in connection with side recesses *l'* therein, and the inner impinging faces of the elastic line-valve strips, whereby a suitable fluid-current may contribute to reduce friction and to absorb heat from separators, in combination with the elastic inflatable line-valve strips, the line-valve chamber conforming thereto, the tube, the pistons, and a connected vehicle on the outside of said tube, arranged substantially as and for the purpose set forth.

27. In a longitudinally-slotted-tube pneumatic-motor system, the combination of the ports, extensions, valves, and necessary fittings of the ports 1 2 3 and 1' 2' 3' with the separators and pistons, the receiver, the tube, the elastic inflatable line-valve strips, and a connected vehicle outside the motor-tube, arranged substantially as and for the purposes set forth.

28. In a longitudinally-slotted-tube pneumatic-motor system, in combination therewith,

the hollow conical-ribbed pistons F F, connected and articulated as shown, the interior balanced piston-valves W W, connected and articulated and actuated as set forth, and the separators C C, substantially as and for the purposes set forth.

29. In combination with a longitudinally-slotted-tube pneumatic-motor system, the self-adjusting relieving-coupler P Q, journaled into the frame of a suitable vehicle and pivoted at m' m', being vertically, laterally, and radially adjustably connected and arranged substantially as and for the purposes set forth.

30. In combination with the described motor, the guide-strips and chamber-cover J J, provided with anti-frictional guide-faces at U, as and for the purpose set forth.

31. In the described pneumatic-motor system, the balanced regulating-piston valves W W, connected, articulated, and actuated as set forth, in combination with the main pistons F F, the tube B, and a suitably-connected vehicle outside of said tube.

32. In combination with the described motor system, the protection-flaps K, secured to the sides of the slot by bolts w, and the interlocking tongue-and-groove joints of the flap, and rolled metallic strip u, arranged substantially as and for the purpose set forth.

SAMUEL BENSON.

Witnesses:
WILLIAM TWOMBLY,
A. K. BROWNE.