No. 855,959. PATENTED JUNE 4, 1907.

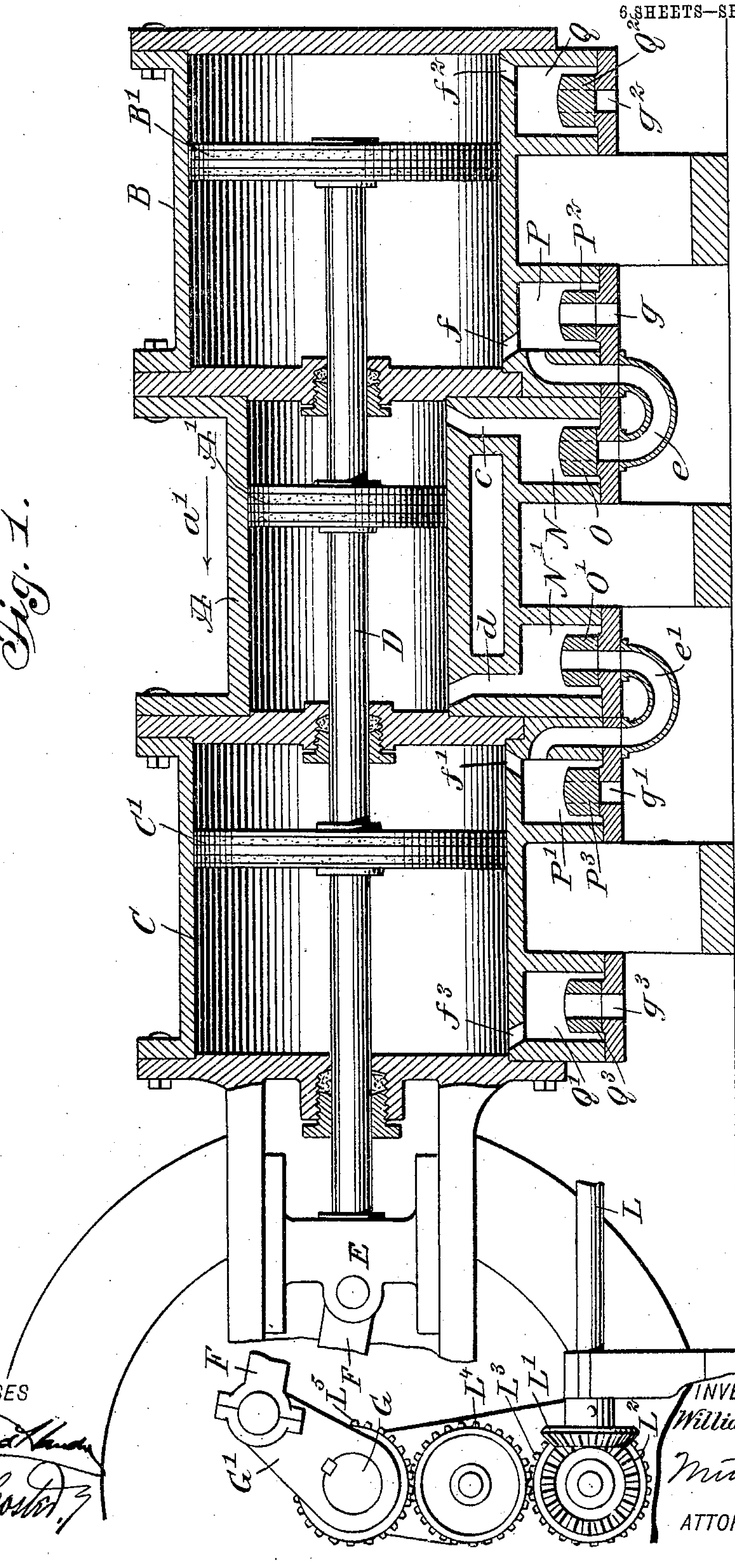
W. S. LYCAN.

TRIPLE EXPANSION ENGINE.

APPLICATION FILED OCT. 20, 1906.

6 SHEETS—SHEET 1.

Fig. 1.



WITNESSES

INVENTOR

William S. Lycan

By Munn & Co

ATTORNEYS

THE NORRIS PETERS CO., WASHINGTON, D. C.

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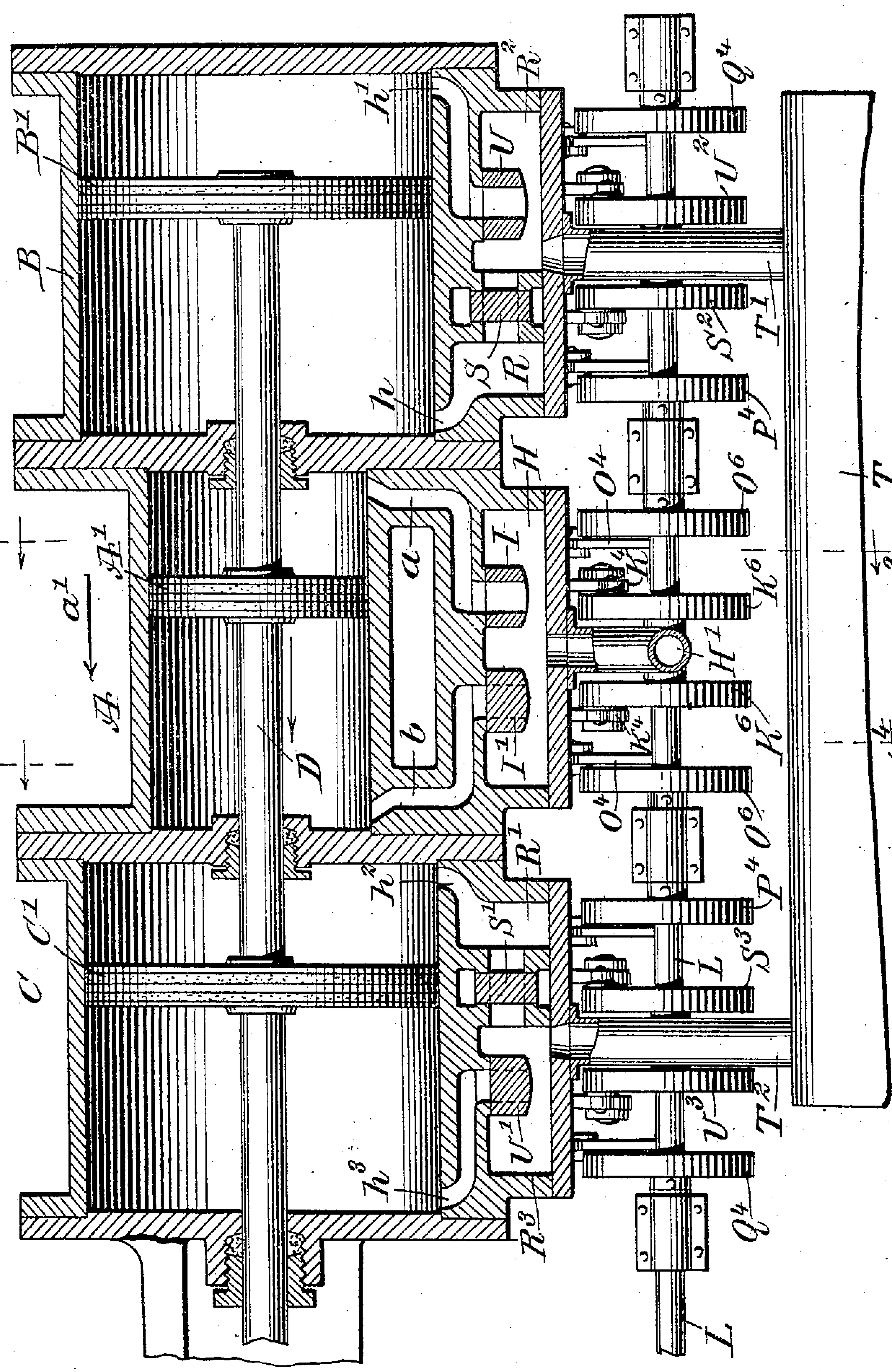
6 SHEETS—SHEET 2.

Fig. 2.



WITNESSES

L. Grinford Handy

Geo. G. Hoster

INVENTOR

William S. Lycan

BY Munn & Co

ATTORNEYS

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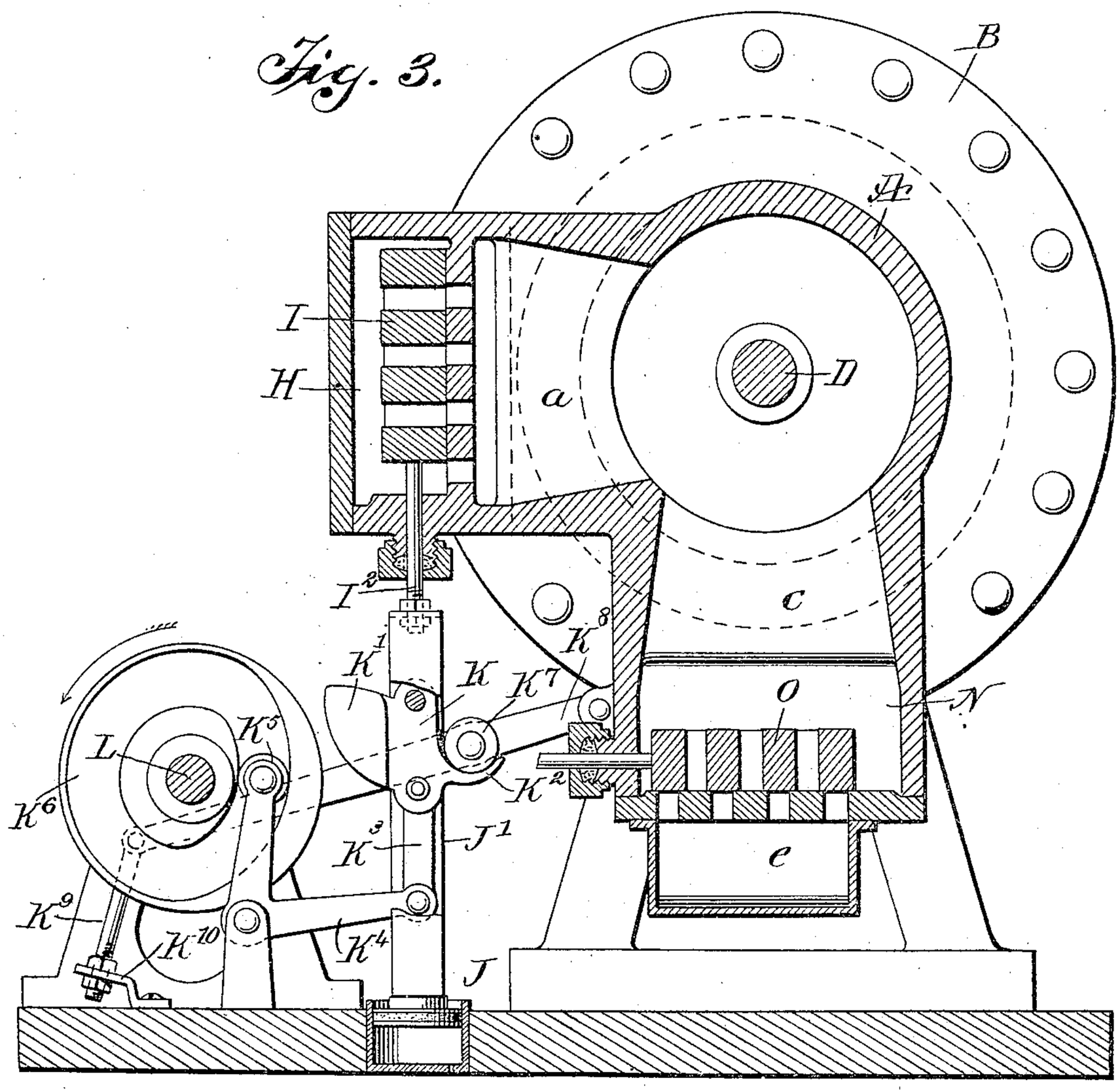
6 SHEETS—SHEET 3.

Fig. 3.



WITNESSES

L. England Hoover

Geo. J. Hoover

INVENTOR

William S. Lycan

BY Munn & Co

ATTORNEYS

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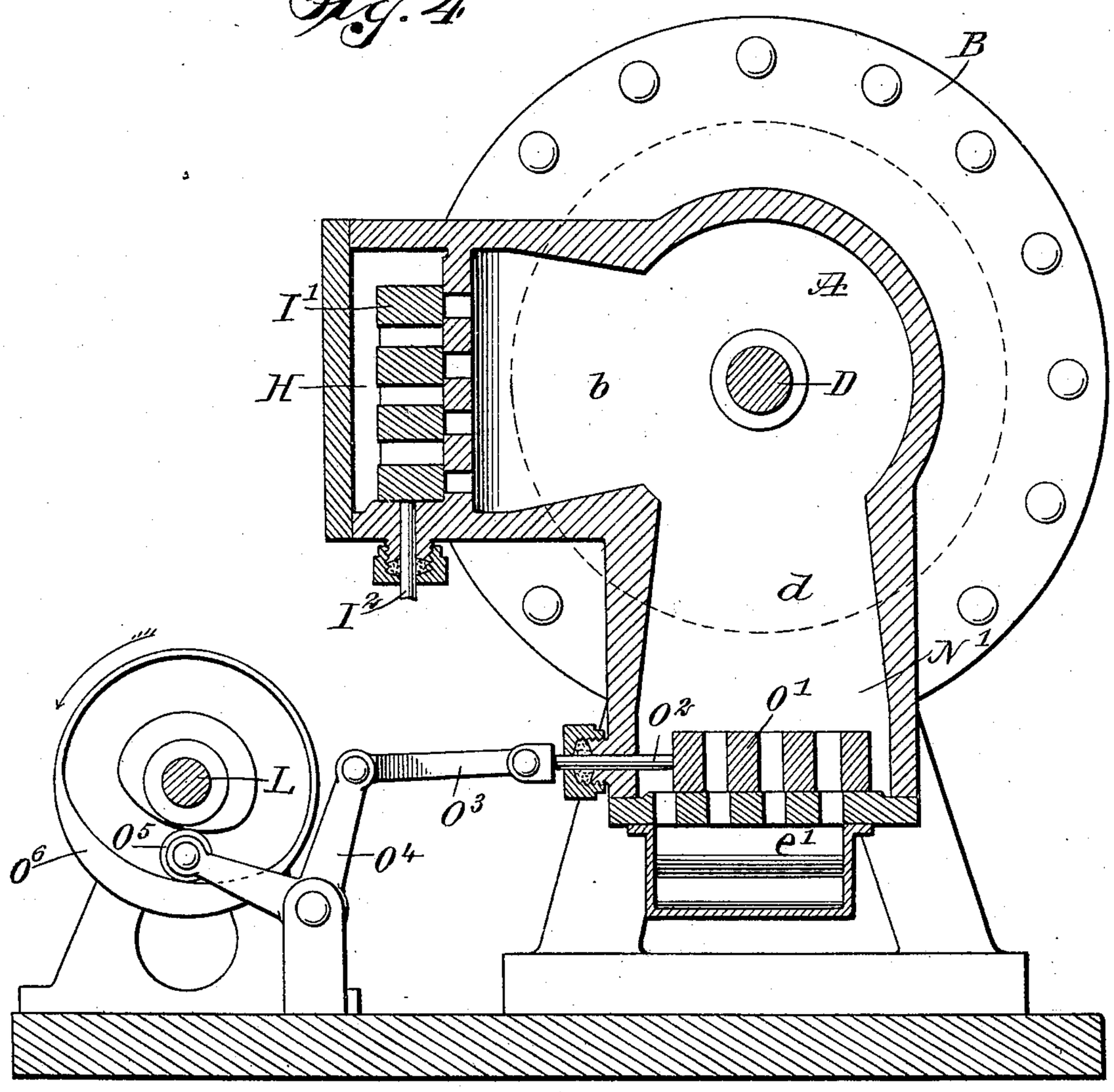
Fig. 4.



WITNESSES

L. Lunsford Handy

Henry Howson Jr.

INVENTOR

William S. Lycan

BY Munn & Co

ATTORNEYS

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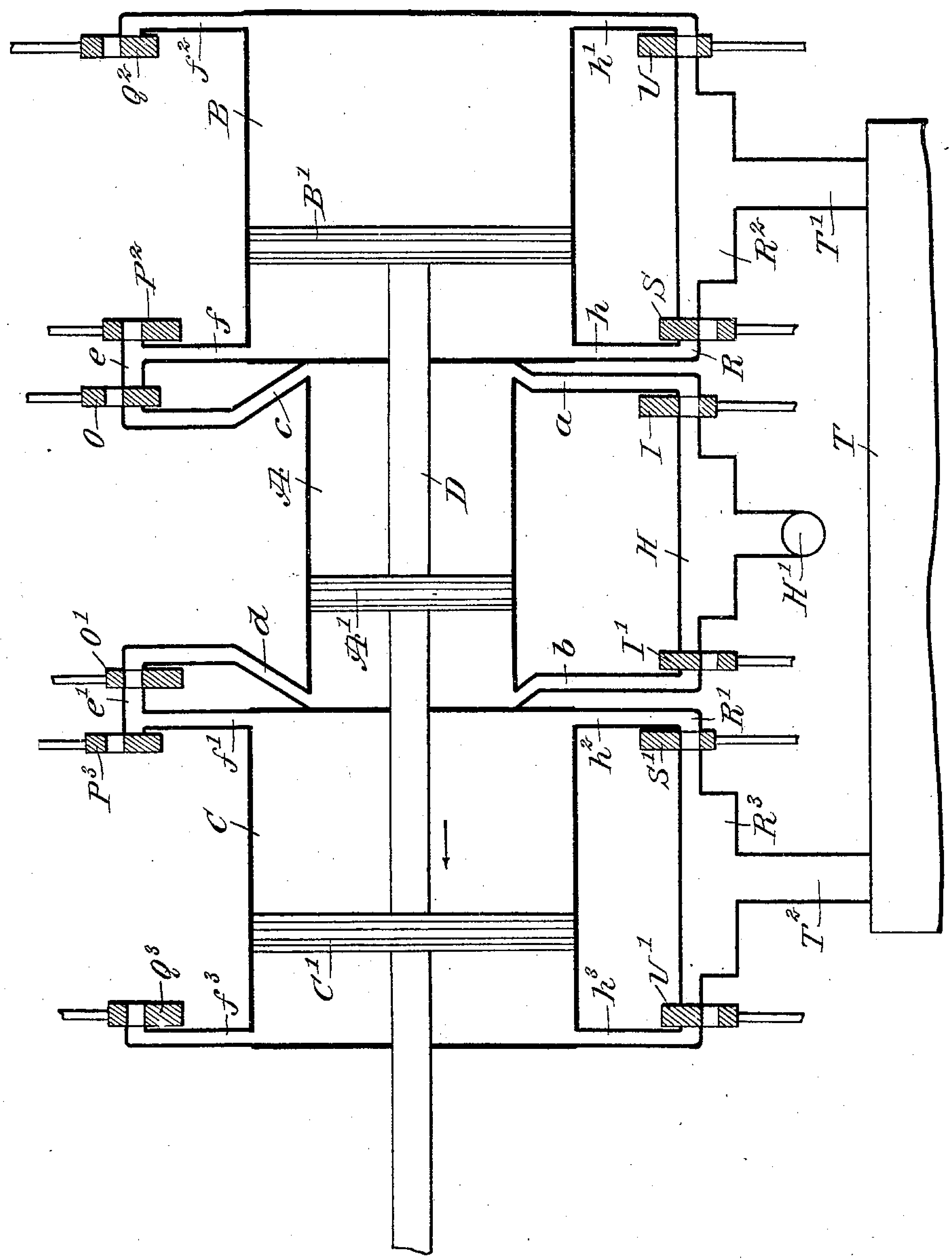
6 SHEETS—SHEET 5.

Fig. 5.



WITNESSES

L. Ginsford Handy

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INVENTOR

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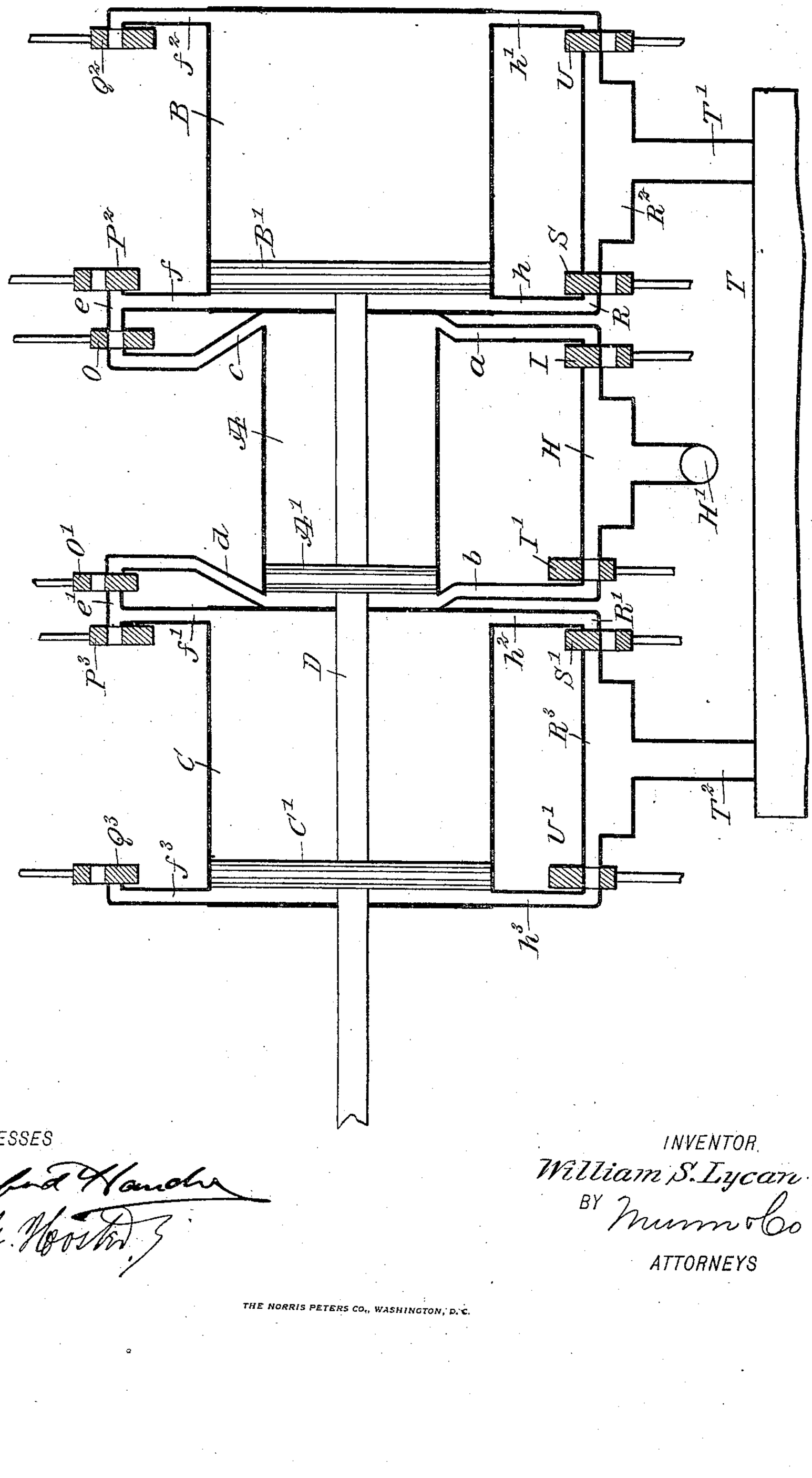
6 SHEETS—SHEET 6.

Fig. 6.



WITNESSES

L. Linford Hanchett

Percy J. Hoover

INVENTOR.

William S. Lycan.

BY Munn & Co

ATTORNEYS

UNITED STATES PATENT OFFICE.

WILLIAM SHIELDS LYCAN, OF MARSHALL, ILLINOIS.

TRIPLE-EXPANSION ENGINE.

No. 855,959. Specification of Letters Patent. Patented June 4, 1907.

Application filed October 20, 1906. Serial No. 339,740.

To all whom it may concern:

Be it known that I, WILLIAM SHIELDS LYCAN, a citizen of the United States, and a resident of Marshall, in the county of Clark and State of Illinois, have invented a new and Improved Triple-Expansion Engine, of which the following is a full, clear, and exact description.

The object of the invention is to provide a new and improved triple expansion engine, arranged to utilize the motive agent to the fullest advantage and without back pressure during the third expansion.

The invention consists of novel features, and parts and combinations of the same, which will be more fully described hereinafter and then pointed out in the claims.

A practical embodiment of the invention is represented in the accompanying drawings, forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the views.

Figure 1 is a longitudinal central sectional elevation of the improvement; Fig. 2 is a sectional plan view of the same; Fig. 3 is an enlarged cross section of the same on the line 3—3 of Fig. 2, Fig. 4 is a similar view of the same on the line 4—4 of Fig. 2. Fig. 5 is a diagrammatic view showing the positions of the pistons and valves at the end of the first two thirds of the stroke of the pistons; and Fig. 6 is a diagrammatic view showing the positions of the pistons and valves at the beginning of the return stroke of the pistons.

The high pressure cylinder A is in axial alinement with the low pressure cylinders B and C, arranged adjacent to the ends of the high pressure cylinder A, and in the said cylinders A, B and C are mounted to reciprocate the pistons A′, B′ and C′ having a common piston rod D attached at its outer end to a cross head E connected by a pitman F with a crank arm G′ of the main driving shaft G, so that when the engine is running the pistons A′, B′ and C′ reciprocate in unison in their respective cylinders A, B and C. The ends of the high pressure cylinder A are connected by admission ports *a* and *b* with a steam chest H connected by a steam pipe H′ with a boiler or other suitable source of motive agent supply, and in the said steam chest H are mounted to slide up and down admission valves I and I′ controlling the admission of the motive agent from the steam chest H by way of the ports *a* and *b* into the ends of the high pressure cylinder A. The valve mechanisms for operating the admission valves I and I′ are alike in construction, so that it suffices to describe but one in detail, special reference being had to Fig. 3. The valve stem I^2 of the admission valve I or I′ is connected at its lower end with the rod J′ of a dash pot J of any approved construction, and on the said dash pot rod J′ is fulcrumed a lever K carrying at the front a weight K′ and provided at the rear with an angular arm K^2. The lower end of the lever K is pivotally connected by a link K^3 with a bell crank lever K^4 carrying a friction roller K^5 engaging a cam K^6 secured on the cam shaft L extending longitudinally and carrying at one end (see Fig. 1) a bevel gear wheel L′ in mesh with a bevel gear wheel L^2 having a spur wheel L^3 in mesh with an intermediate spur wheel L^4 meshing with a spur wheel L^5 secured on the main driving shaft G, so that when the engine is running a continuous rotary motion is given to the cam shaft L from the main driving shaft G. The gearing between the shafts G and L is so proportioned that the shafts G and L rotate in unison.

The arm K^2 on the lever K previously mentioned is adapted to engage a friction roller K^7 journaled on a lever K^8 having its free end connected with a link K^9 adjustably engaging a bracket K^{10} to allow of adjusting the lever K^8 to bring the friction roller K^7 in proper relation to the arm K^2. Now when the engine is running and the cam shaft L turns and with it the cam K^6, then a swinging motion is given to the bell crank lever K^4 which by its connection with the lever K raises the rod J^1 and consequently the stem I^2, to move the corresponding valve I or I′ into an open position as illustrated in Fig. 3. During the upward movement of the lever K the arm K^2 causes the lever K to swing outward, to finally allow the valve I or I′ to drop and close suddenly at the time the piston A′ is near the end of its stroke, it being understood that the weight K′ returns the lever K to a normal vertical position so as to bring the arm K^2 again in proper relation relative to the friction roller K^7. The cams K^6 for the two valves I and I′ are alike in construction but are arranged in opposite directions so that when the valve I is opened the other valve I′ is closed and vice versa.

The ends of the high pressure cylinder A are also provided with exhaust ports *c* and *d* (see Figs. 1, 3 and 4) leading to chests N and N′ having valves O and O′ and controlling

passages *e*, *e'* leading to chests P, P' connected by ports *f* and *f'* with the inner ends of the low pressure cylinders B and C, as plainly indicated in Fig. 1. The mechanisms for actuating the valves O and O' are alike in construction and each has its valve stem O^2 (see Fig. 4) connected by a link O^3 with a bell crank lever O^4 carrying a friction roller O^5 engaging a cam O^6 secured on the cam shaft L, so that when the engine is running the valves O and O' are alternately actuated to open and close the passages *e*, *e'* with a view to connect the exhaust end of the high pressure cylinder A with the inner or adjacent ends of the low pressure cylinders B and C. Thus as shown in the drawings, for instance, the left hand end of the high pressure cylinder A is the exhaust end at the time and is connected by the port *d* with the chest N' in which the valve O' is open to connect the chest H with the chest P' by way of the passage *e'*, and as the chest P' is connected at all times by the port *f'* with the inner end of the low pressure cylinder C it is evident that the exhaust motive agent from the left hand end of the high pressure cylinder A can pass directly into the right hand end of the low pressure cylinder C, to expand therein, and to exert pressure against the piston C' in the same direction in which the live active agent acts on the piston A' in the high pressure cylinder A, that is, in the direction of the arrow *a'*. It is understood that during the time this takes place the valve O is closed so that communication between the right hand end of the high pressure cylinder A and the inner or left hand end of the low pressure cylinder B i cut off.

The chests P and P' are provided with exhaust ports *g*, *g'* leading to the atmosphere and controlled by exhaust valves P^2, P^3 actuated from the cam shaft L by means of cams P^4 and intermediate connection similar to the ones connecting the valves O, O' with the cams O^6, so that further description of the same is not deemed necessary. The outer ends of the low pressure cylinders B and C are provided at their bottoms with exhaust ports f^2, f^3 (see Fig. 1) leading to the chests Q and Q' containing valves Q^2, Q^3 similar to the valves P^2, P^3, and controlling exhaust ports g^2, g^3 leading to the atmosphere. The valves Q^2, Q^3 are actuated from the cam shaft L by cams Q^4, and intermediate connections similar to the ones for the valves O, O', so that further description of the same is not deemed necessary.

The low pressure cylinders B and C are also provided at their ends with ports *h h'* and h^2, h^3, of which the ports *h*, h^2 lead to chests R, R' and the ports *h'*, h^3 to chests R^2, R^3 adjacent to the chests R, R' respectively. The chest R is adapted to be connected with the chest R^2 by a valve S, and a similar valve S' is used to connect the chest R' with the chest R^3, and the chests R^2, R^3 are connected by pipes T', T^2 with a reservoir T. The ports *h'* and h^3 are controlled by valves U, U', and the said valves S and U, S', U' are actuated from the cam shaft L by the use of cams S^2, U^2, S^3, U^3 and the connections between the cams and valves being similar to the ones connecting the valves I, I' with the cams K^6 (see Fig. 3), further description is not deemed necessary.

The operation is as follows: When the engine is running and the several parts are in the position illustrated in the drawings, then the piston A' in the high pressure cylinder A is propelled forward in the direction of the arrow *a'* by the action of the live steam passing from the steam chest H by way of the open valve I and port *a* into the right hand end of the cylinder A. At the same time the exhaust steam from the left hand end of the cylinder A passes by way of the port *d* (see Fig. 1), the open valve O', the passage *e'*, the chest P' and the port *f'* into the right hand end of the low pressure cylinder C, so that the steam expands and acts on the piston C' to propel the same forward in the direction of the arrow *a'*. At the same time this takes place steam from the reservoir T passes by way of the pipe T' into the chest R^2, by the open valve U and port *h'* into the right hand end of the low pressure cylinder B to exert pressure on the piston B', with a view to propel the same forward in the direction of the arrow *a'*. Thus from the foregoing it will be seen that the three pistons A', B' and C' are acted on simultaneously by the motive agent, to force the same forward in the direction of the arrow *a'*. During this time the ports *g* and g^3 are open, so that the exhaust steam in front of the forwardly moving pistons B' and C' can escape from the low pressure cylinders B and C by way of the ports *f*, f^3 and the valves P^2, Q^3 in open position over the ports *g* and g^3. When the piston A' in the high pressure cylinder A has traveled about two-thirds of its stroke, see Fig. 5 then the valve S' (see Fig. 2) is moved into an open position to allow a portion of the exhaust steam in the rear end of the low pressure cylinder C to pass from the chest R' into the chest R^3 and from the latter by way of the pipe T^2 into the reservoir T to replenish the same. When the piston A' reaches the end of its forward stroke in the high pressure cylinder A, see Fig. 6, then the valves I and I' are shifted so that the valve I' moves into an open position to allow the steam to pass from the chest H into the left hand end of the cylinder A, by way of the open valve I' and the port *b*, to act on the piston A' to push the same in the inverse direction of the arrow *a'*. When the valves I and I' are shifted, the valves O and O' are changed, so that the valve O' closes the passage *e'* while the valve O opens the passage *e*, to allow the steam in

the right hand end of the high pressure cylinder A to pass by way of the port *c*, open valve O, the passage *e*, the chest P and port *f* into the inner or left hand end of the low pressure cylinder B, to act on the piston B′ therein, with a view to move the same in the inverse direction of the arrow *a′*. It is understood that when the valves O, O′ are shifted the valves P^2, P^3, Q^2 and Q^3 are moved, and likewise the valves U and U′, so that the motive agent from the reservoir T can pass by way of the pipe T^2 into the chest R^3 and by way of the now open valve U′ and port h^3 into the left hand end of the low pressure cylinder C, to act on the piston C′ therein, so as to push the same in the inverse direction of the arrow *a′*. The valve S′ moves into a closed position as soon as the piston A′ reaches the end of its forward stroke, and when the piston A′ reaches two-thirds of its return stroke in the inverse direction of the arrow *a′* then the valve S is opened (the valve U being in a closed position), so that a portion of the motive agent in the left hand end of the low pressure cylinder B can pass by way of the chest R and open valve S into the chest R^2 and from the latter by way of the pipe T′ into the reservoir T, so as to replenish the same. When the pistons A′, B′ and C′ reach the end of their return strokes then the valve S closes and the valves I, I′, U, U′, O, O′, P^2, P^3 and Q^2, Q^3 change their position back to the one illustrated in the drawings, and the above described operation is then repeated.

From the foregoing it will be seen that the exhaust steam from the high pressure cylinder A is used in the adjacent ends of the low pressure cylinders B and C for actuating the pistons B′ and C′ therein until the piston A′ has traveled about two-thirds of its stroke, and then a portion of the exhaust steam from this high pressure cylinder A is utilized to replenish the reservoir T. It will also be noticed that the steam in the reservoir T is used in the outer ends of the low pressure cylinders B and C only, and a free exhaust is had from the high pressure cylinder to the atmosphere, and the pistons B′ and C′ are relieved of all back pressure on the third expansion of the steam.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. A triple expansion engine comprising a high pressure cylinder, low pressure cylinders on opposite ends of the high pressure cylinder and in axial alinement therewith, connected pistons moving in unison in the said cylinders, admission valves for controlling the admission of the motive agent to the said high pressure cylinder, exhaust valves controlling the exhaust motive agent from the high pressure cylinder to the adjacent or inner ends of the said low pressure cylinders, a reservoir, and valves for connecting the exhaust side of the high pressure cylinder with the said reservoir.

2. A triple expansion engine comprising a high pressure cylinder, low pressure cylinders on opposite ends of the high pressure cylinder and in axial alinement therewith, connected pistons moving in unison in the said cylinders, admission valves for controlling the admission of the motive agent to the said high pressure cylinder, exhaust valves controlling the exhaust motive agent from the high pressure cylinder to the adjacent or inner ends of the said low pressure cylinders, a reservoir, valves for connecting the exhaust side of the high pressure cylinder with the said reservoir, and valves connecting the reservoir with the outer ends of the said low pressure cylinders.

3. A triple expansion engine comprising a high pressure cylinder, low pressure cylinders on opposite ends of the high pressure cylinder and in axial alinement therewith, connected pistons moving in unison in the said cylinders, admission valves for controlling the admission of the motive agent to the said high pressure cylinder, exhaust valves controlling the exhaust motive agent from the high pressure cylinder to the adjacent or inner ends of the said low pressure cylinders, a reservoir, and valves for connecting the exhaust side of the high pressure cylinder with the said reservoir at the time the pistons in the cylinders are in an approximately two-third stroke position.

4. A triple expansion engine comprising a high pressure cylinder, low pressure cylinders on opposite ends of the high pressure cylinder and in axial alinement therewith, connected pistons moving in unison in the said cylinders, admission valves for controlling the admission of the motive agent to the said high pressure cylinder, exhaust valves controlling the exhaust motive agent from the high pressure cylinder to the adjacent or inner ends of the said low pressure cylinders, a reservoir, and valves operating in unison with the admission valves for connecting the reservoir with the outer ends of the low pressure cylinders.

5. A triple expansion engine comprising a high pressure cylinder, low pressure cylinders on opposite ends of the high pressure cylinder and in axial alinement therewith, connected pistons moving in unison in the said cylinders, admission valves for controlling the admission of the motive agent to the said high pressure cylinder, exhaust valves controlling the exhaust motive agent from the high pressure cylinder to the adjacent or inner ends of the said low pressure cylinders, a reservoir, valves for connecting the exhaust side of the high pressure cylinder with the said reservoir at the time the pistons in the cylinders are in an approximately two-third stroke position,

and valves operating in unison with the said admission valves for connecting the said reservoir with the outer ends of the low pressure cylinders.

6. A triple expansion engine comprising a high pressure cylinder, low pressure cylinders on opposite ends of the high pressure cylinder and in axial alinement therewith, connected pistons moving in unison in the said cylinders, admission valves for controlling the admission of the motive agent to the said high pressure cylinder, exhaust valves controlling the exhaust motive agent from the high pressure cylinder to the adjacent or inner ends of the said low pressure cylinders, a reservoir, valves for connecting the exhaust side of the high pressure cylinder with the said reservoir at the time the pistons in the cylinders are in an approximately two-third stroke position, valves operating in unison with the said admission valves for connecting the said reservoir with the outer ends of the low pressure cylinders, and exhaust valves controlling the exhaust motive agent from the outer ends of the said low pressure cylinders.

7. A triple expansion engine comprising a high pressure cylinder, low pressure cylinders on opposite ends of the high pressure cylinder and in axial alinement therewith, connected pistons moving in unison in the said cylinders, admission valves for controlling the admission of the motive agent to the said high pressure cylinder, exhaust valves controlling the exhaust motive agent from the high pressure cylinder to the adjacent or inner ends of the said low pressure cylinders, a reservoir, valves for connecting the exhaust side of the high pressure cylinder with the said reservoir at the time the pistons in the cylinders are in an approximately two-third stroke position, valves operating in unison with the said admission valves for connecting the said reservoir with the outer ends of the low pressure cylinders, exhaust valves controlling the exhaust motive agent from the outer ends of the said low pressure cylinders, a main driving shaft connected with the said pistons, a cam shaft driven from the said driving shaft, cams on the said cam shaft, and connections between the said cams and the said valves for actuating the same.

8. In a triple expansion engine, low pressure cylinders, a high pressure cylinder between the low pressure cylinders, connected pistons moving in unison in the cylinders, a steam chest having ports leading into the high pressure cylinder, valves in the steam chest and controlling the ports thereof, and valve mechanisms for alternately opening and closing the valves, each valve mechanism closing its valve suddenly at the time the piston of the high pressure cylinder is near the end of its stroke.

9. In a triple expansion engine, low pressure cylinders, a high pressure cylinder between the low pressure cylinders, connected pistons moving in unison in the cylinders, a main drive shaft, a cam shaft driven from the main shaft, a steam chest having ports leading into the high pressure cylinder, valves in the steam chest and controlling the ports thereof, and valve mechanisms for the valves, operated by the cam shaft, said valve mechanisms alternately opening and closing the valves and each suddenly closing its valve at the time the piston of the high pressure cylinder is near the end of its stroke.

10. In a triple expansion engine, low pressure cylinders, a high pressure cylinder between the low pressure cylinders, connected pistons moving in unison in the cylinders, a main drive shaft, a cam shaft operating in unison with the main shaft, a live steam chest having ports leading into the high pressure cylinder, valves in the steam chest and controlling the ports thereof, and exhaust steam chest having ports leading into the high pressure cylinder, valves in the exhaust steam chest and controlling its ports, and means for operating the said valves from the cam shaft.

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

WILLIAM SHIELDS LYCAN.

Witnesses:

W. F. TAYLOR,

REUBEN LOVELL.