No. 889,460.

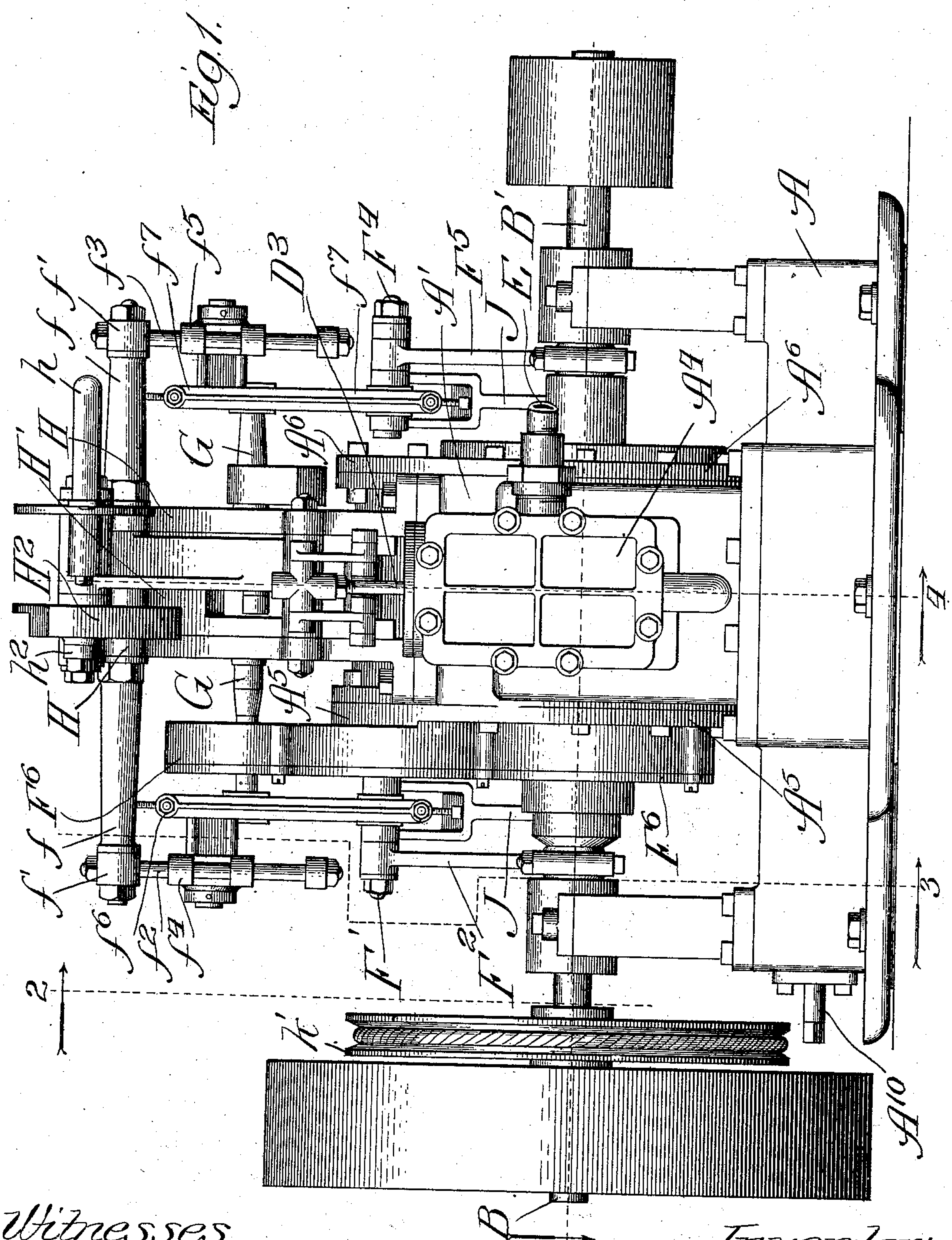
PATENTED JUNE 2, 1908.

M. L. HARRIS.

ENGINE.

APPLICATION FILED APR. 10, 1907.

12 SHEETS—SHEET 1.



Witnesses

E. E. Gaylord,

Chas. H. Bull.

Inventor:

Malcolm L. Harris,

By Dyrenforth, Lee, Chritton and Wiles,

Att'ys.

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

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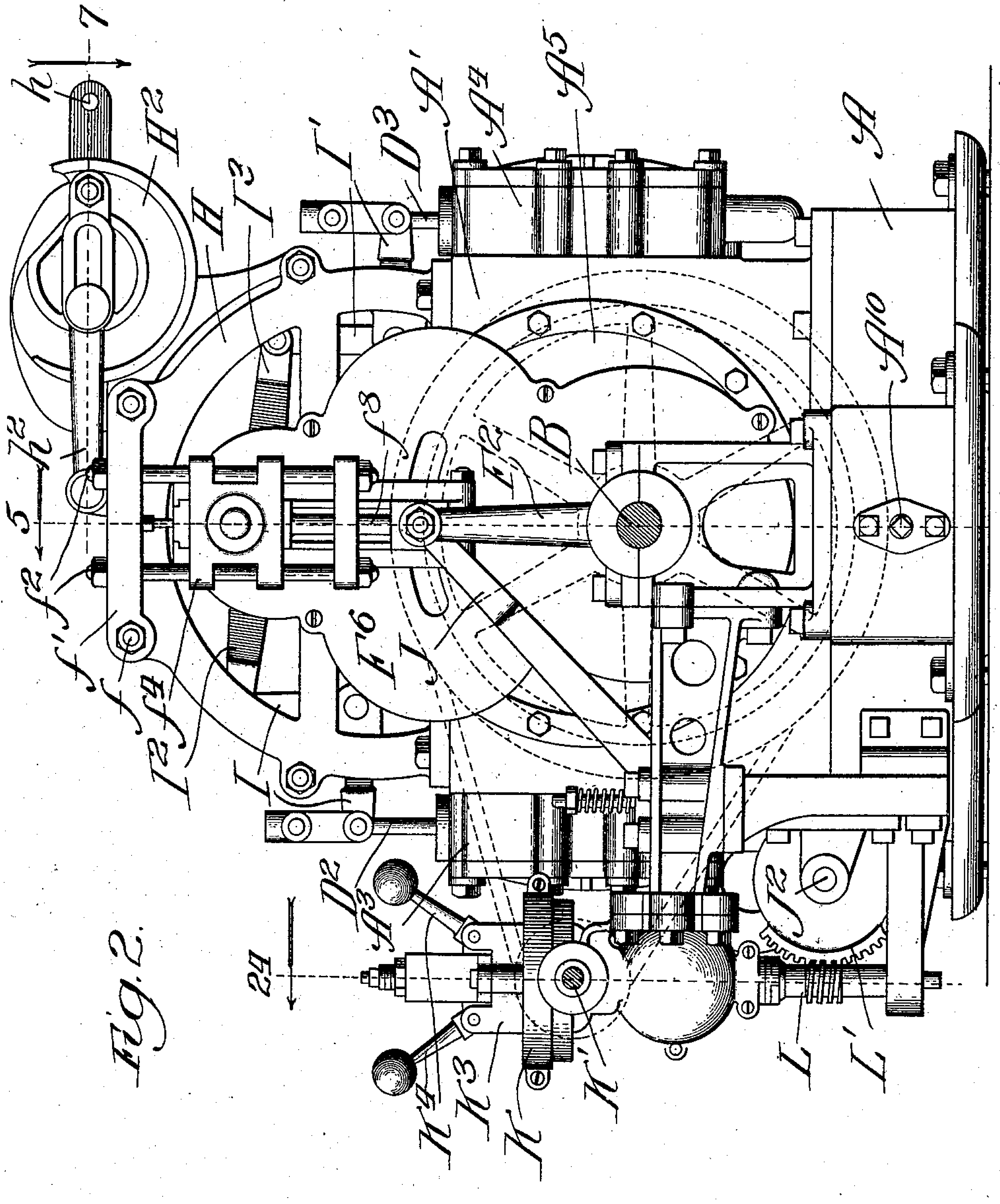

Fig. 2.

Witnesses:
[illegible] Gaylord,
Chas. H. Bull.

Inventor:
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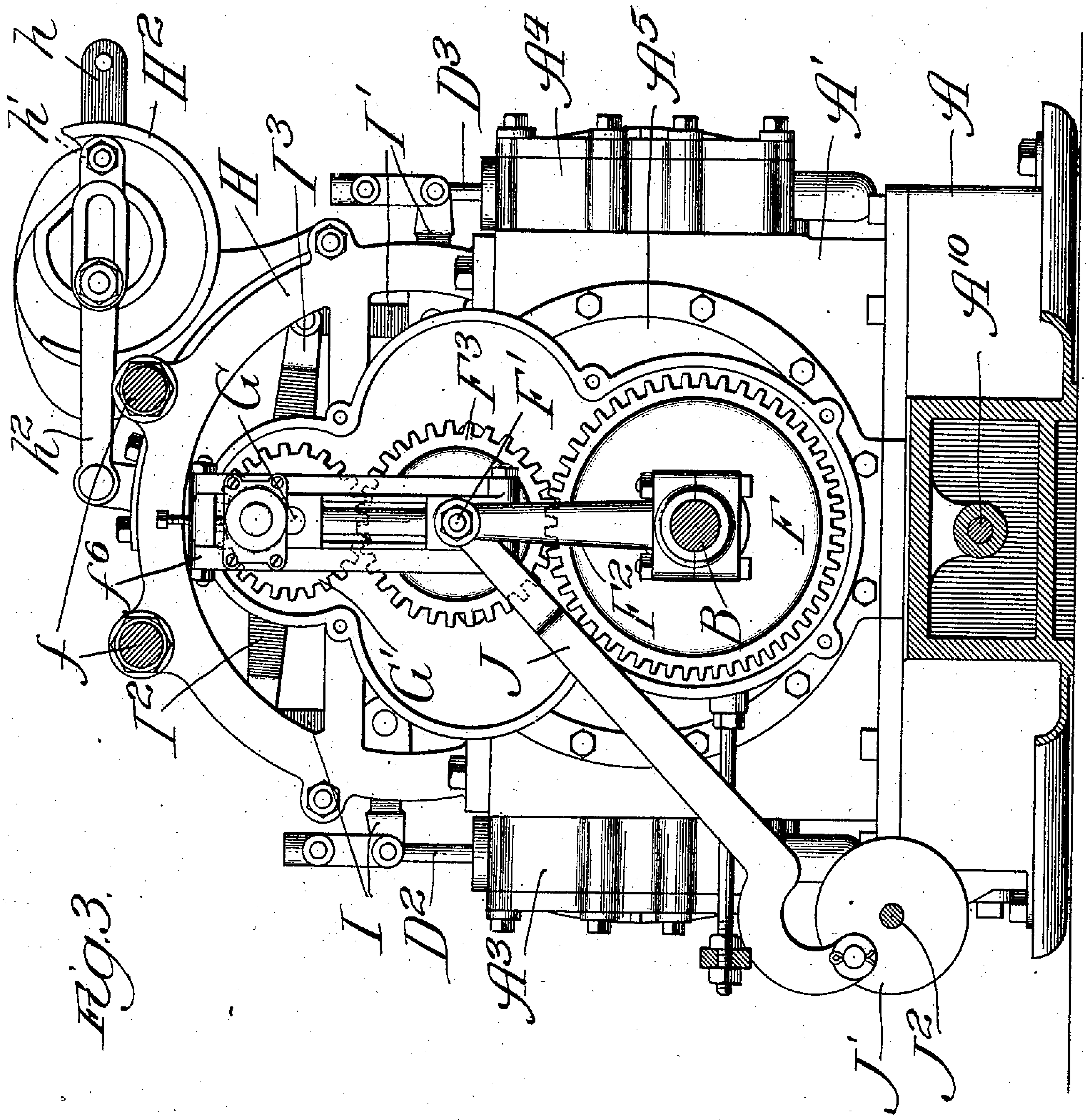

Fig. 3.

Witnesses:

Chas. E. Gaylord,

Chas. H. Buell.

Inventor:

Malcolm L. Harris,

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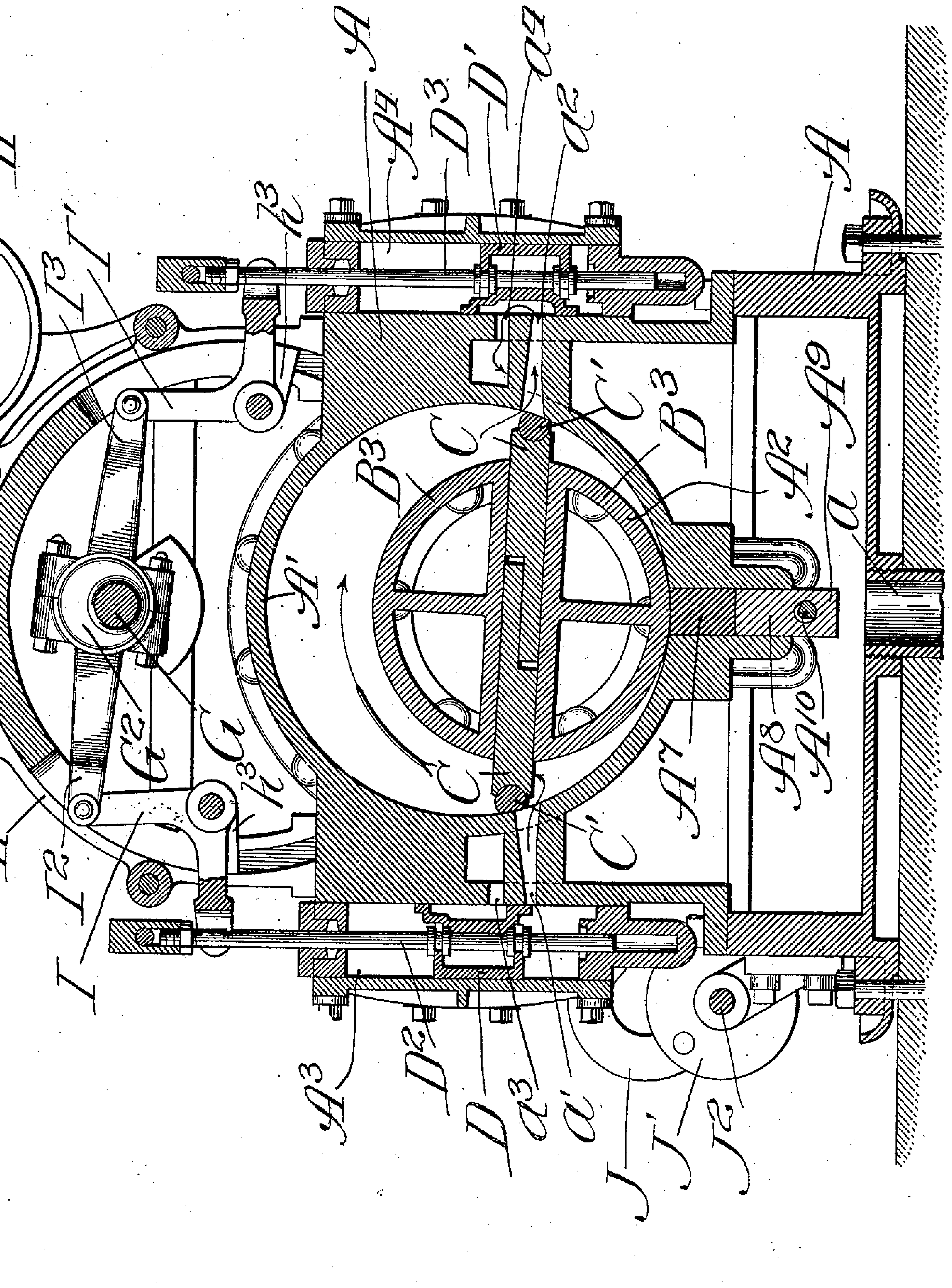

Fig. 4

Witnesses:
Chas. E. Gaylord.
Chas. H. Buell.

Inventor:
Malcolm L. Harris,
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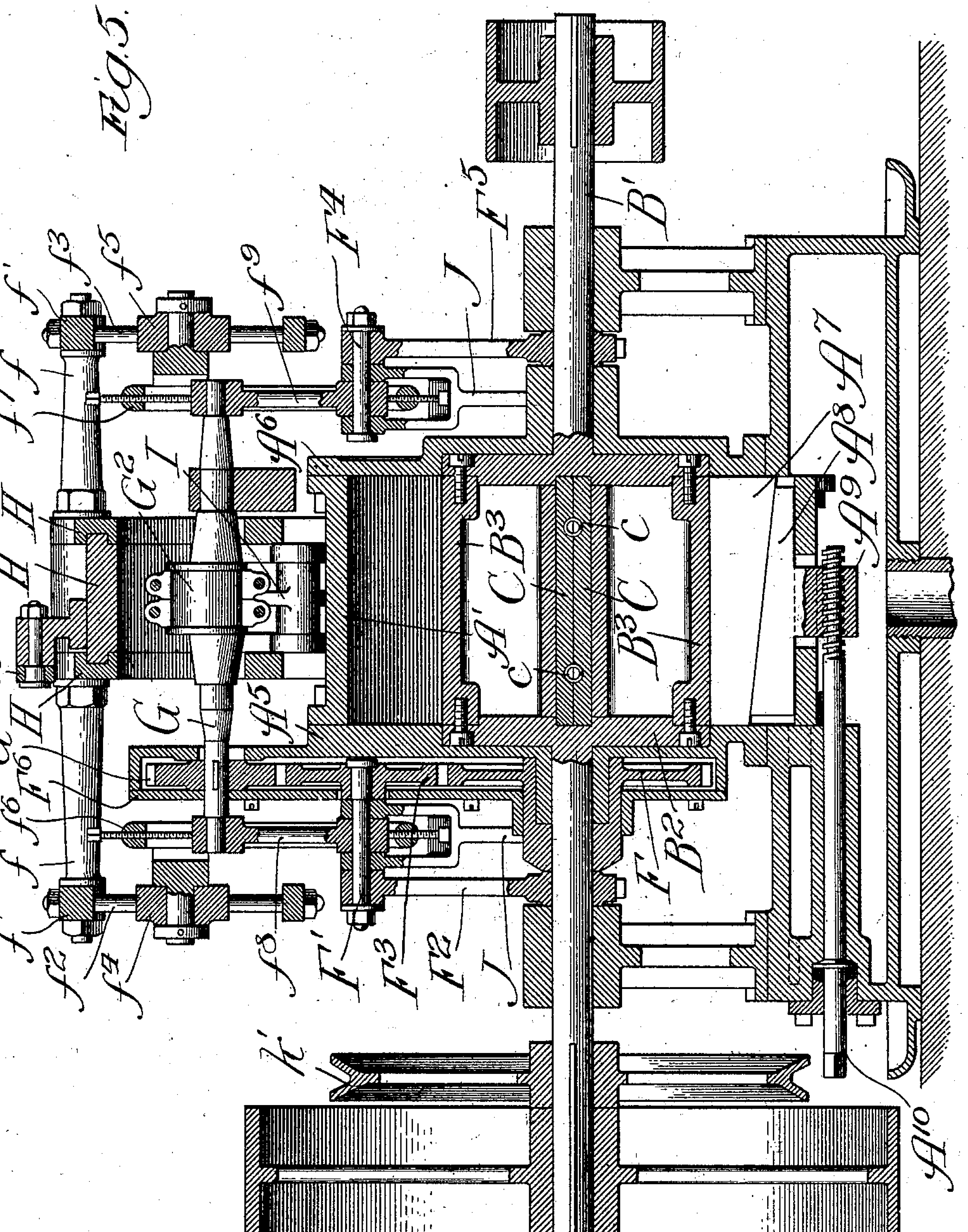
Fig. 5.



Witnesses:
C. E. Gaylord.
Chas. H. Bull.

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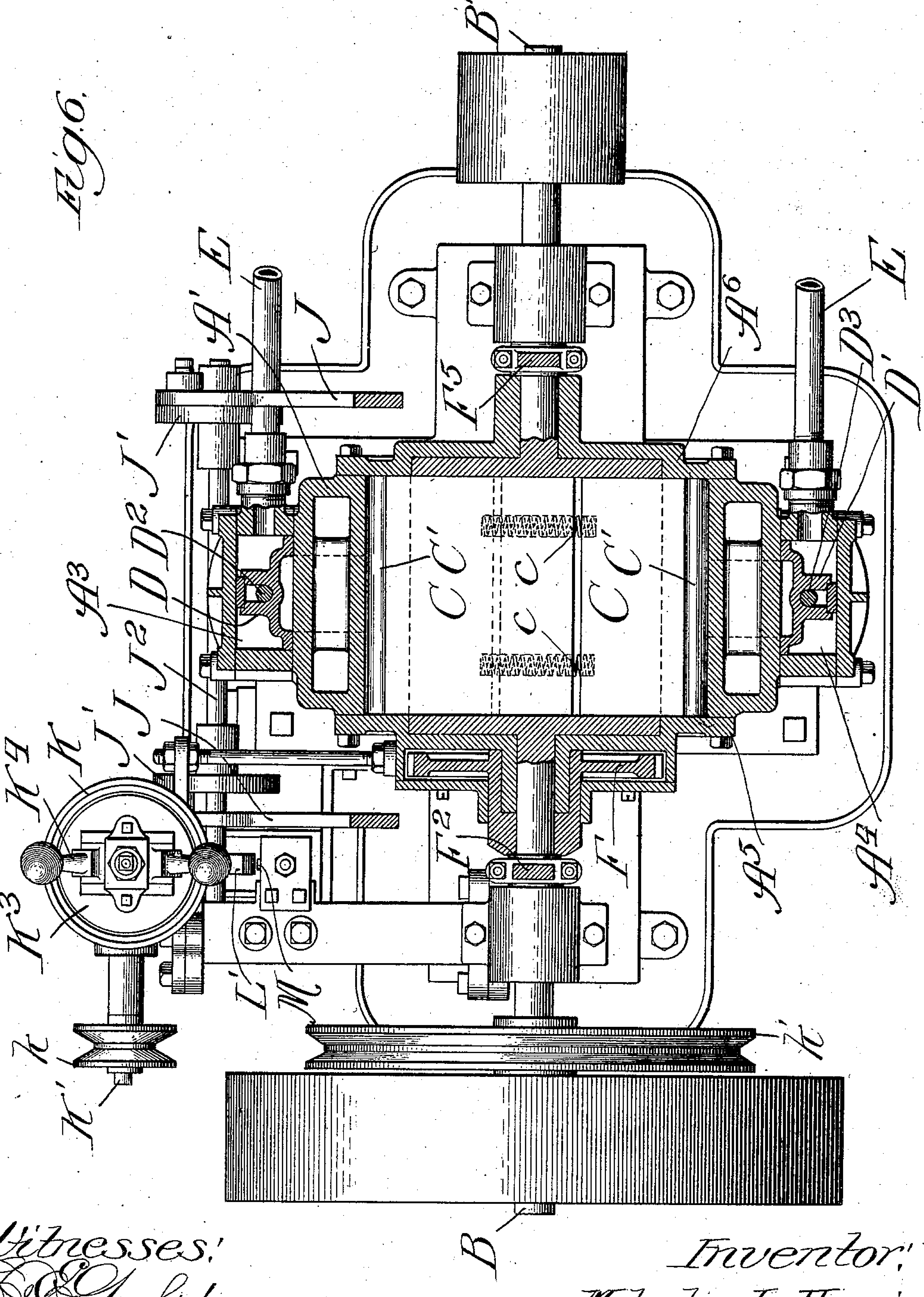

Fig. 6.

Witnesses:

Chas. E. Gaylord.

Chas. H. Bull.

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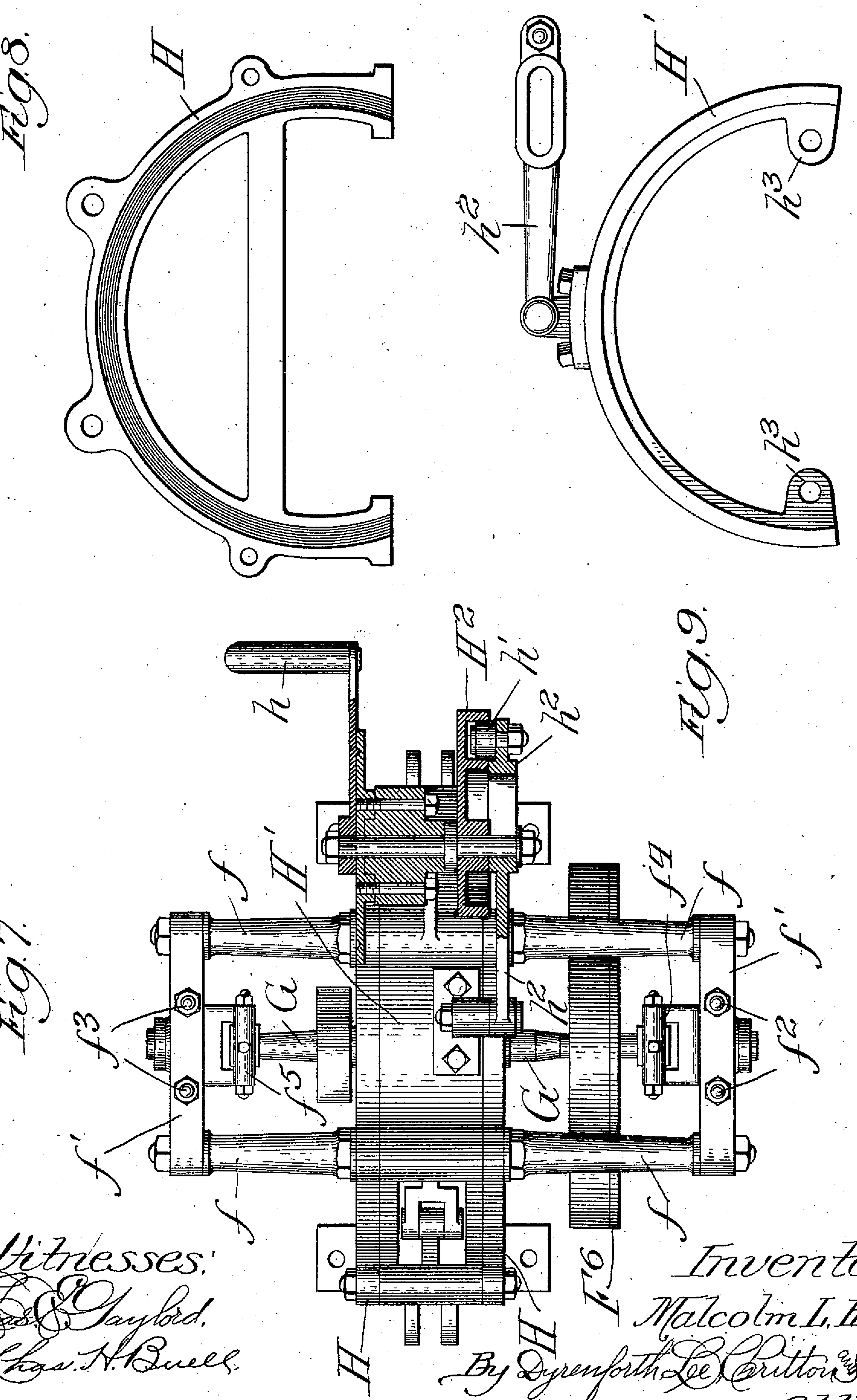

Witnesses:
Chas. E. Gaylord.
Chas. H. Buell.

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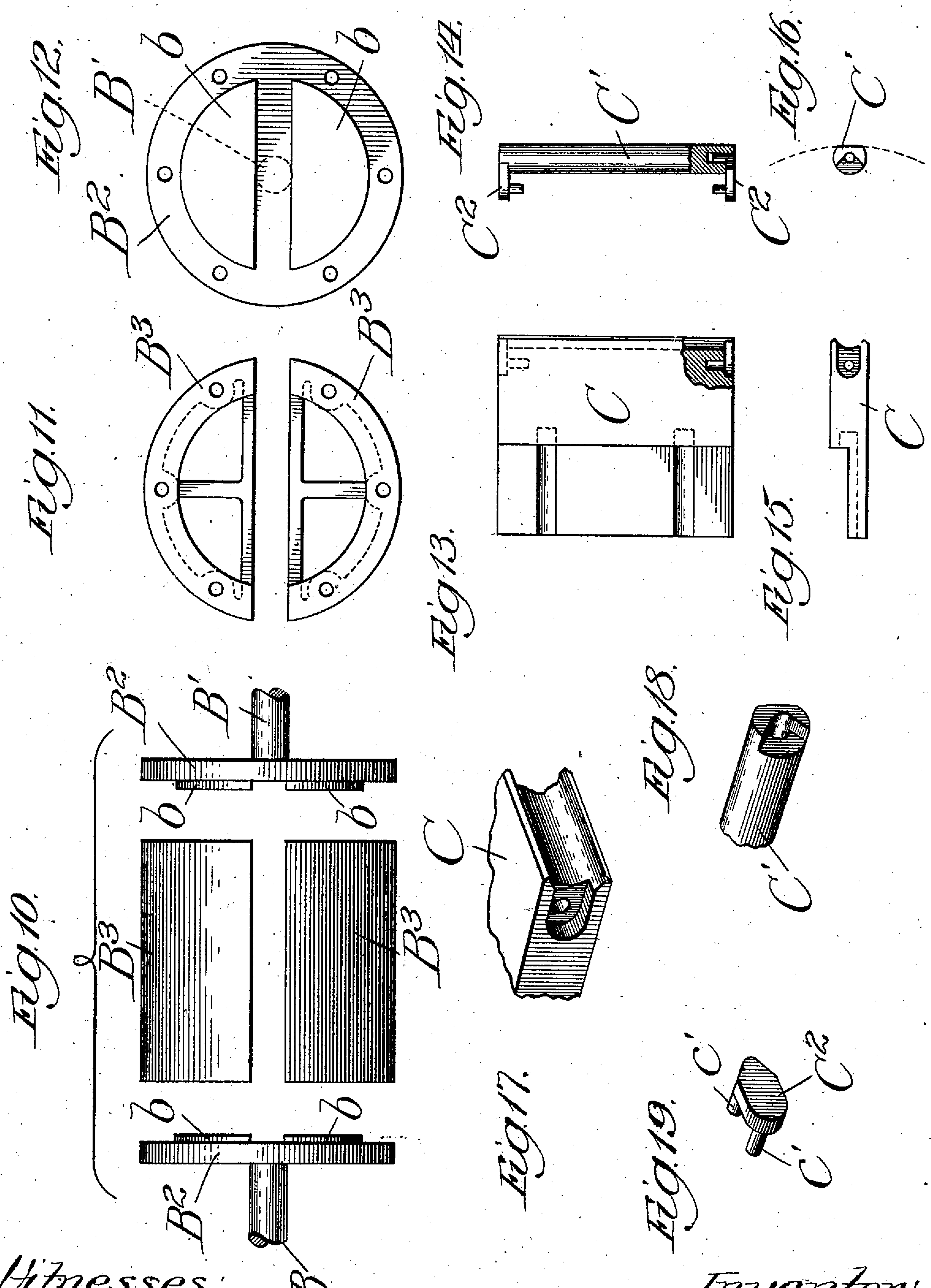

Witnesses:
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Inventor:
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12 SHEETS—SHEET 9.

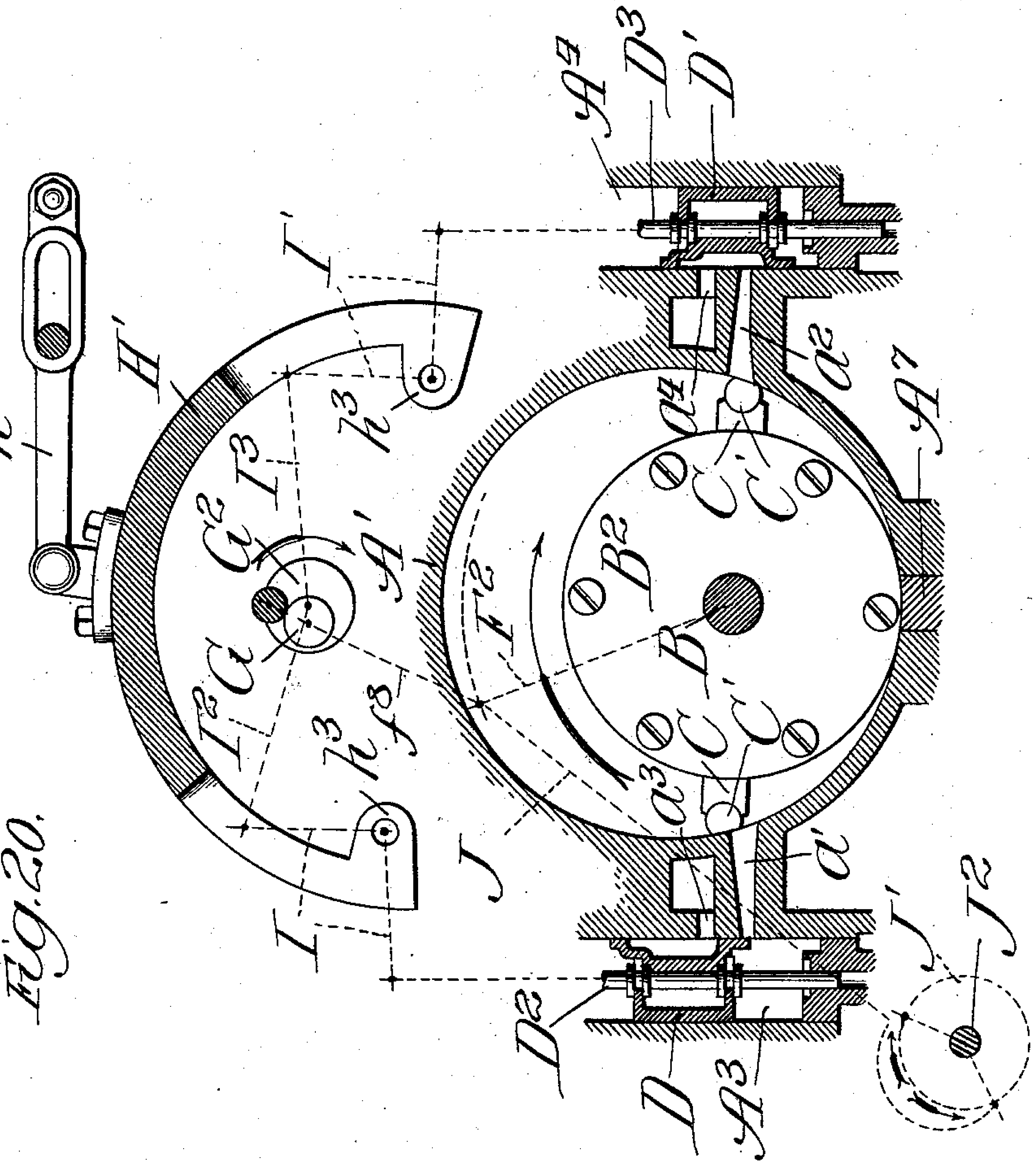

Fig. 20.

Witnesses:
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Chas. H. Buell.

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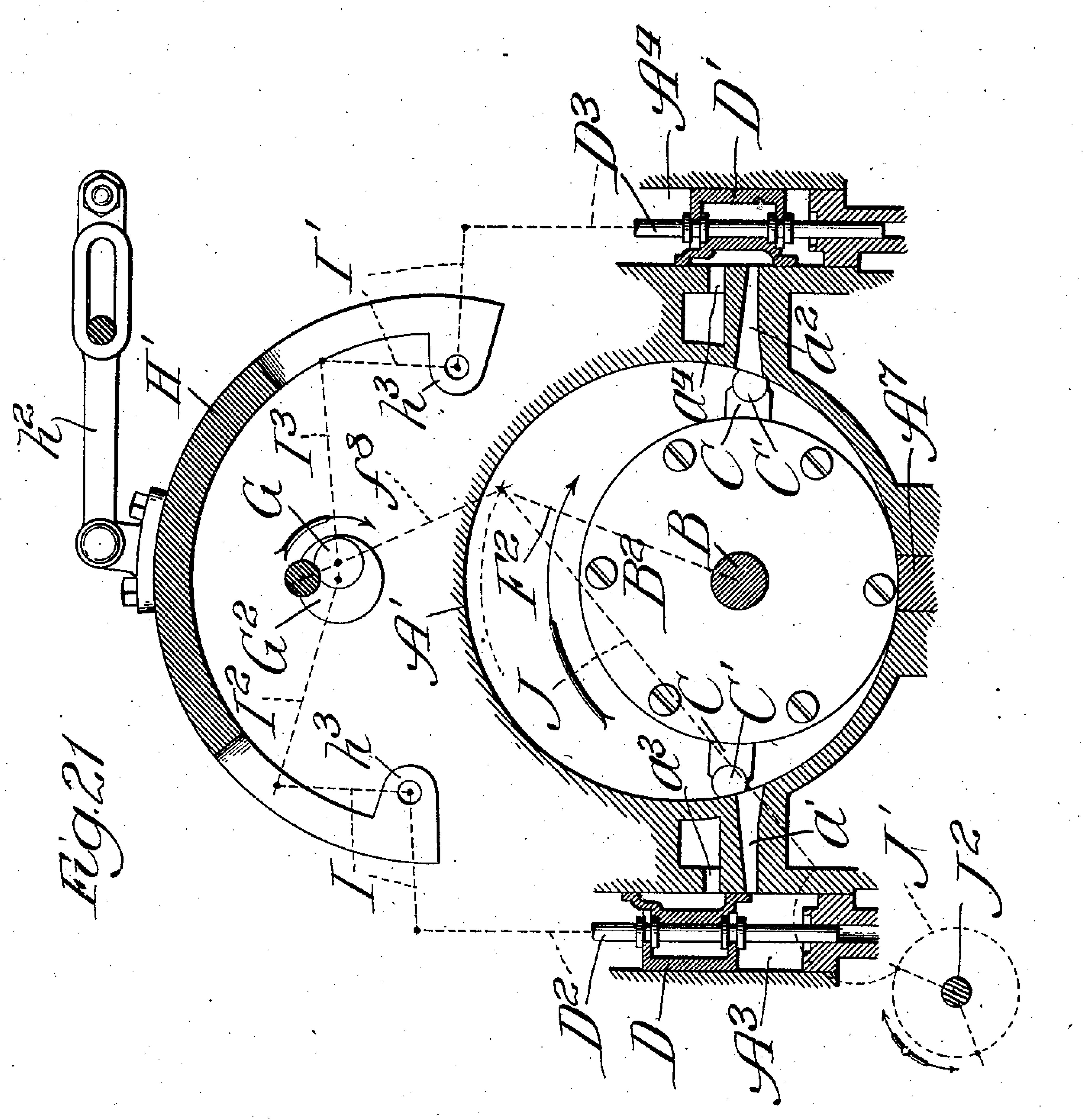
APPLICATION FILED APR. 10, 1907.

12 SHEETS—SHEET 10.



Witnesses:

C. E. Gaylord.

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Inventor:

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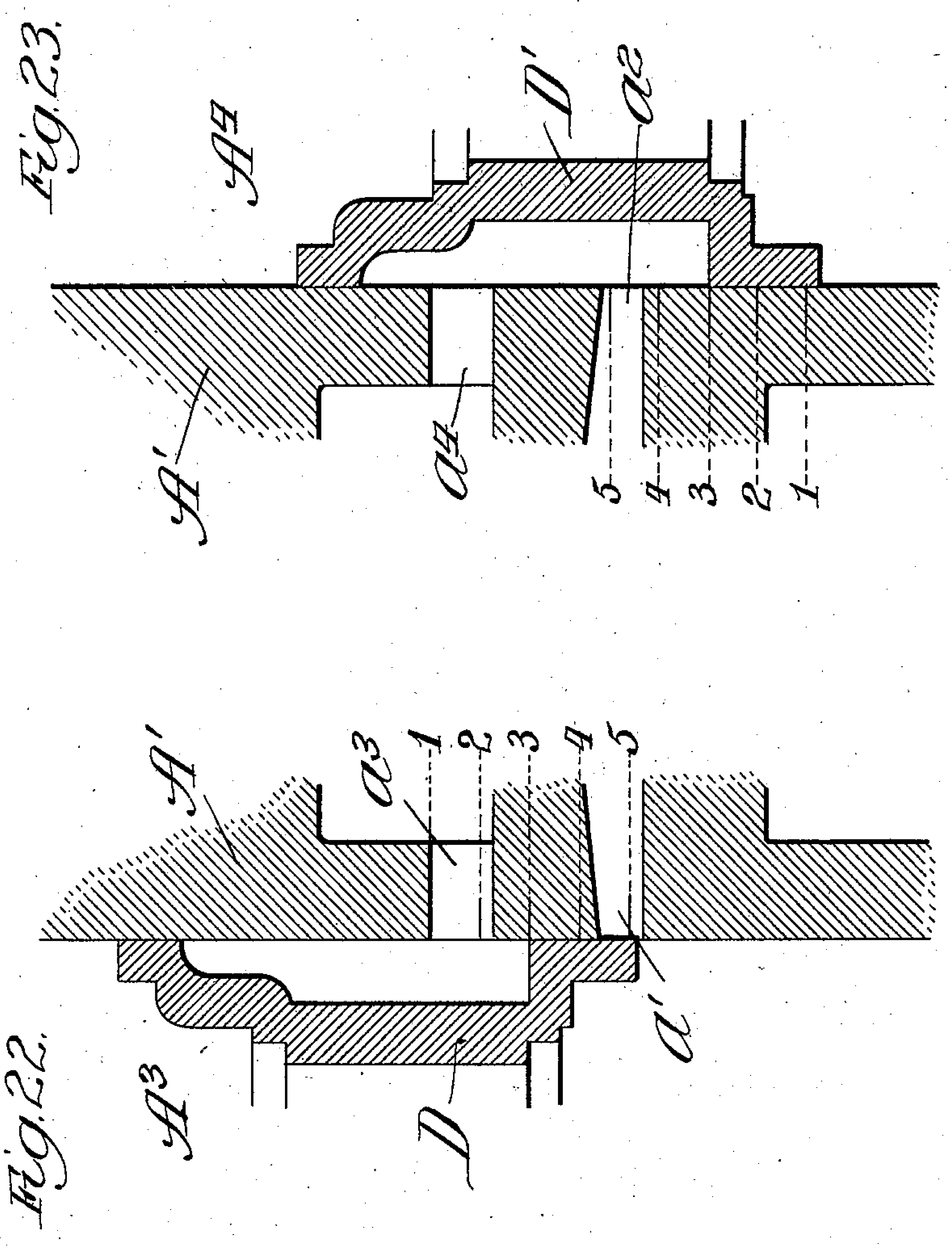
12 SHEETS—SHEET 11.



Witnesses:
Chas. E. Gaylord.
Chas. H. Buell.

Inventor:
Malcolm L. Harris,
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THE NORRIS PETERS CO., WASHINGTON, D. C.

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12 SHEETS—SHEET 12.

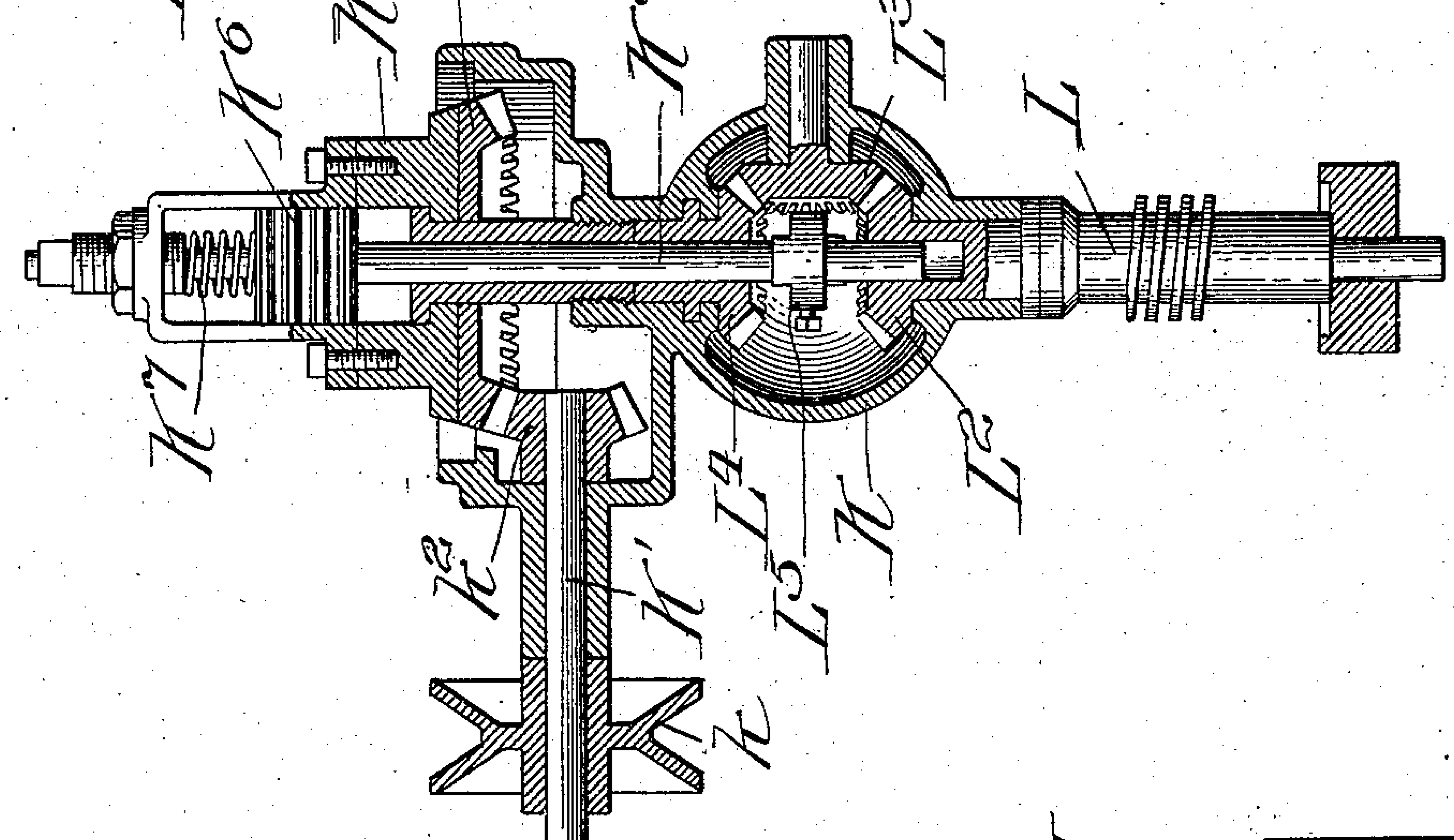

Fig. 25.

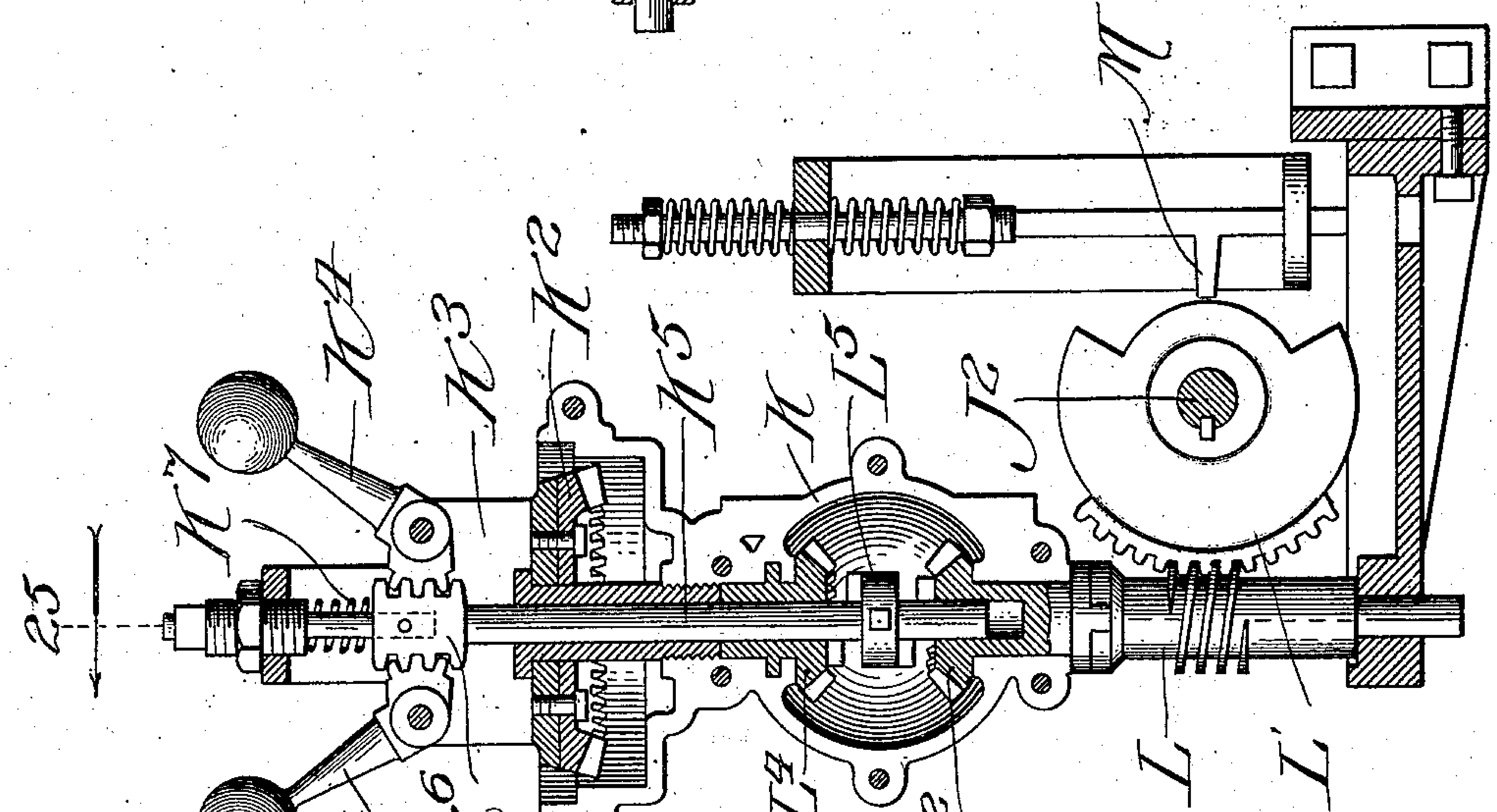

Fig. 24.

Witnesses:

[signature]

Chas. H. Buell

Inventor:

Malcolm L. Harris,

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Att'ys.

UNITED STATES PATENT OFFICE.

MALCOLM L. HARRIS, OF CHICAGO, ILLINOIS.

ENGINE.

No. 889,460. Specification of Letters Patent. Patented June 2, 1908.

Application filed April 10, 1907. Serial No. 367,364.

To all whom it may concern:

Be it known that I, MALCOLM L. HARRIS, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a new and useful Improvement in Engines, of which the following is a specification.

My invention relates to certain new and useful improvements in engines and is fully described and explained in the specification and shown in the accompanying drawing, in which:—

Figure 1 is a side elevation of my engine; Fig. 2 is a vertical transverse section on the line 2 of Fig. 1 looking in the direction indicated; Fig. 3 is a vertical transverse section on the broken line 3 of Fig. 1, the gear-inclosing cover being removed to show the gear arrangement; Fig. 4 is a vertical transverse section on the line 4 of Fig. 1 looking in the direction of the arrow; Fig. 5 is a central longitudinal section in the line 5 of Fig. 2 looking in the direction of the arrow; Fig. 6 is a horizontal section in the line 6 of Fig. 1 looking downwards; Fig. 7 is a horizontal section in the line 7 of Fig. 2 looking downwards, the upper portion only of the structure being shown; Fig. 8 is an elevation of one of the tracks at the upper portion of the engine which guide the movable segment; Fig. 9 is a similar view of the movable segment with its actuating links; Fig. 10 is a plan view of the portion making up the rotating drum and of portions of the main shaft of the engine; Fig. 11 is an end view of the two central drum sections; Fig. 12 is an elevation of one of the drum heads; Fig. 13 is an elevation of one of the blade sections, a portion of the blade being broken away to show the packing arrangement; Fig. 14 is an elevation of the packing element and the links by which it is attached to the corresponding blade sections; Fig. 15 is an elevation of one of the edges of the blade shown in Fig. 13; Fig. 16 is an elevation of one of the ends of the packing element shown in Fig. 14, the links being removed from place; Fig. 17 is a perspective view of a portion of one of the blade sections; Fig. 18 is a perspective view of an end of one of the packing elements; Fig. 19 is a perspective view of one of the links by which the packing elements are secured to the blade sections; Fig. 20 is a diagrammatic view showing the parts when the engine is running under the maximum cut-off; Fig. 21 is a view similar to Fig. 20 except that the parts are shown running without any cut-off, the steam being admitted during the full stroke; Fig. 22 is a diagrammatic view of one of the valves and the parts adjacent thereto when operating as an inlet valve; Fig. 23 is a similar view showing a valve operating as an exhaust valve; Fig. 24 is a longitudinal vertical section on the line 24 of Fig. 2 showing portions of the governor; and Fig. 25 is a transverse section on the line 25 of Fig. 24 looking in the direction of the arrow.

Referring to the drawings, A indicates a hollow base provided at its center, (Fig. 4), with a pipe, *a*, for the exit of vapor. Upon the base, A, and secured thereto is mounted a casing, A^1, in which is a longitudinally-extending cylinder, A^2. To the two sides of the casing, A^1, are secured hollow steam-chests, A^3 and A^4, said steam-chests having communication with the cylinder, A^2, by cylinder ports, a^1 and a^2 respectively. The lower portion of the casing, A^1, is cored out and communicates with the hollow of the base, A, and exhaust ports, a^3 and a^4, connect the steam-chests, A^3 and A^4, above the ports, a^1 and a^2, with the hollow of the casing A, as illustrated in Fig. 4. Thus it is possible for steam to pass either from the steam-chests into or out of the cylinder, A^2, and also between the steam-chests and the hollow of the base, A, and the exhaust pipe, in either direction.

The particular construction of the steam-chests is immaterial and it may be modified as desired without affecting my invention substantially, the steam-chests of the engine as herein shown having top and bottom portions and front and rear plates and side plates all bolted together and to the casing, A^1.

The casing, A^1, is closed at its front and rear ends by heads, A^5, A^6, respectively, provided with eccentric bosses, through which extend front and rear shaft sections, B and B^1 respectively, the said shaft sections being provided with suitable pulleys at their extreme ends for the transmission of power, and being provided at their adjacent ends with drum-heads, B^2, in the form of substantially flat circular plates. The drum-heads, B^2, are illustrated in Figs. 10 and 12, from which it will be seen that each has projecting from its inner face, or the face turned toward the center of the cylinder, two segment-shaped projections, *b*, which are adapted to engage with corresponding openings in two substantially semi-cylindrical drum sections, B^3. The drum-heads, B^2, and the drum sections, B^3, (Fig. 10), are assembled by bringing the drum-heads toward the drum sections until the parts take the position shown in Fig. 5, when the drum-heads are secured to the drum sections by means of screws, the heads of which enter countersunk depressions in the outer faces of the drum-heads. Thus the two shaft sections are secured together against relative rotation and the shaft, drum-heads and drum sections together form a single unitary structure having an enlarged central cylindrical portion which is slotted transversely through its diameter. This enlarged cylindrical portion or drum is of such size as to just touch the inner surface of the cylinder at its bottom, *i. e.*, the portion immediately below the line of the shafts.

In order to take up any wear which may occur between the drum and the cylinder at the point where the two contact, a movable plate, A^7, is let into the lower face of the cylinder, (Figs. 4 and 5), the upper edge of said plate touching the drum and the lower edge thereof being beveled as illustrated. The plate, A^7, rests upon a corresponding movable plate, A^8, beveled on its upper edge and having on its lower portion an extension or lug, A^9, through which runs a screw, A^{10}. Thus, by rotating the screw, A^{10}, the plate, A^7, can be raised or lowered as desired, so that a constant abutment is maintained between the drum and the lower portion of the cylinder wall.

Through the slot in the drum project two overlapping blades, C, the adjacent ends of which are cut to one-half of their thickness throughout their width so as to overlap as shown in Fig. 4. Springs, *c*, (Figs. 5 and 6), lie in grooves cut in said blades so as to press the same normally apart and into contact with the walls of the cylinder. The extreme edges of the blades, which are adjacent to the walls of the cylinder, are grooved longitudinally and in these grooves lie packing members, C^1, the major portions of whose surfaces are cylindrical to conform with the curve of the grooves in the edges of the blades, C, while a portion of the surfaces of the packing members is cylindrical, with a curvature equal to that of the interior of the cylinder wall, (Fig. 16). The packing members are held in place in the grooves provided to receive them by means of links, C^2, upon the ends of which are pins, c^1, which enter corresponding openings in the blades and in the packing members, both the blades and the packing members being cut away, (Figs. 17 and 18), to receive the links. By this construction it will be seen that the blades are given a firm and tight bearing at all times against the walls of the cylinder, so that as the shaft and drum are rotated the blades which move them will at all times maintain the contact necessary to the successful operation of a rotary engine or pump of any sort.

It will be seen from Fig. 4 of the drawing that the main shaft is at substantially the same height as are the inlet ports, a^1, a^2, entering the cylinder, A^2, so that when the blades are horizontal they will simultaneously cover the two ports. Thus as the drum is rotated the two blades will cross the ports simultaneously.

In the steam-chests, A^3, A^4, are vertically reciprocable slide valves, D, D^1, carried by valve stems, D^2, D^3, which extend upwards from the tops of the steam-chests. The slide valves may be constructed in any desired form and are hollowed out on the surfaces adjacent to the walls of the casing, A^1, to such an extent that they more than inclose both ports of said steam-chests. The slide valves are made of sufficient size from front to rear of the chest to give accurate guidance to the valves therein. The steam-chests themselves are supplied with live steam under pressure by means of pipes, E, (Fig. 6). It will thus be obvious that when a valve is in the position of the valve, D, Fig. 4, or in any higher position, live steam will be admitted through the corresponding cylinder port to the cylinder so as to operate the drum in the ordinary way common for rotary engines, that when either of the valves is in the position of the valve, D^1, Fig. 4, the port leading from the steam-chest to the cylinder will be thrown into communication with the exhaust port, a^4, and that this will be true even though the valve oscillates for a considerable distance to either side of the position of said valve, D^1, Fig. 4, and that at such times the live steam in the steam-chest will be entirely cut off from entrance to the cylinder.

Having now explained the construction of the cylinder, drum, blades, steam passages and steam-controlling valves, I will set out the mechanism by which these valves are operated.

Upon the forward end of the main shaft section B, just in front of the forward head, A^5, of the cylinder, is mounted a gear, F, (Figs. 3 and 5). Above this shaft section B, is an intermediate shaft, F^1, mounted upon a link, F^2, loosely journaled upon the shaft, B. The intermediate shaft, F^1, carries upon its rear end an intermediate gear, F^3, in mesh with the main shaft gear, F. To the rear of the cylinder and above the main shaft section, B^1, is an intermediate shaft, F^4, carried by a link, F^5, journaled upon said main shaft section, the said links, F^2, F^5, being equal in length, and the intermediate shaft, F^4, being symmetrical in position with the intermediate shaft, F^1. The segmental tracks, which project upward from the casing and which will presently be described in detail, support forwardly and rearwardly the extending horizontal posts, f, connected by cross bars, f^1, at the front and rear, (Figs. 2 and 5). The cross bars, f^1, support depending parallel guide rods, f^2, f^3, in pairs, one pair in front of and one pair at the rear of the engine, (Figs. 1, 2 and 5). These guide rods support vertically movable cross-heads, f^4, f^5, at the front and rear of the engine respectively. Links, f, f^7, are journaled in the cross-heads, f^4, f^5, respectively and depend therefrom as illustrated in Figs. 2 and 5, these links being made in the form of rectangular frames with projecting studs near their upper ends, which enter perforations in the cross-heads. Within the links, f^6, f^7, are minor links, f^8, f^9, held in position by set screws at the top and bottom of the links, f^6, f^7. The lower ends of the minor links, f^8, f^9, surround the front and rear intermediate shafts, F^1, F^4, respectively, and the upper ends of the minor links, f^8, f^9, support a rotatable countershaft, G, carrying a countershaft gear, G^1, in mesh with the intermediate gear, F^3. The gears are all inclosed by a cover, F^6, which is slotted for the passage of the countershaft, G, and the intermediate shaft, F^1, so as to permit a limited movement of said shaft.

From the above description of the gears, shaft, countershaft and connected parts, it will be seen that when the main shaft and the drum are rotated the countershaft will be rotated in the same direction. The main gear, F, and countershaft gear, G^1, are so proportioned that the countershaft will make two revolutions for each revolution of the main shaft and drum. The intermediate shaft and the intermediate gear can be moved laterally to either side of the position shown in Fig. 3, when they will swing in an arc of a circle determined by the link, F^2, and during such movement the countershaft gear will move bodily downward for a very slight distance and will move sidewise for a short distance, determined by the swing of the link, f^6, about its pivot. It will be understood that the link arrangement at the rear of the engine is exactly the same as the arrangement at the front, excepting that the gears are omitted at the rear of the engine, and thus the countershaft will receive support from both ends and its two supports will be moved simultaneously and symmetrically in the manner above described.

Bolted to and projecting upward from the engine casing are two segmental tracks, H, in the form of arcs of circles. The constructions of these tracks are best illustrated in Fig. 8, from which figure it will be seen that each of the tracks has an inwardly-facing grooved slideway. Between these tracks and in the slideways thereof runs a segment, H^1, having on its edges ribs adapted to run in the grooved slideway of the track, H, the segment, H^1, being of such length that it can be rotated to a limited extent in the tracks which hold it. A cam, H^2, rotatable by means of a handle, h, engages a roller, h^1, upon a link, h^2, connected with the segment, H^1, whereby the segment can readily be rocked and whereby it can also be fixed in either extreme position, *i. e.*, either the position shown in Fig. 4 or a position symmetrical therewith but upon the opposite side of the center of the structure. The segment, H^1, is cut away at its lower ends, (Fig. 4), and at its lower ends has inwardly-projecting ears, h^3, which afford pivotal support for bell crank levers, l, l'. The bell cranks, l, l', have, as seen in Fig. 4, horizontally-projecting arms which have pivotal connection with the valve-stems, D^2, D^3, connected with the slide valves, D, D^1. They have also vertically-projecting arms which are connected pivotally with eccentric arms, l^2, l^3, which engage an eccentric, G^2, upon the countershaft, G, through the medium of the usual eccentric straps common in engine construction. It will thus be seen that rotation of the countershaft with its eccentric will simultaneously and oppositely move the eccentric rods, l^2, l^3, thus imparting upward movement to the horizontal arm of one bell crank lever and simultaneous and equal downward movement to the horizontal arm of the other bell crank. Thus the two valves are moved simultaneously and equally in opposite directions at all times.

I shall now set out the operation of so much of the engine as has already been described, in order that the operation and purpose of the remaining portions will be more readily understood.

When the movable segment and the bell crank levers carried thereby occupy the position shown in the drawing, the engine will run in the direction indicated by the arrow in Fig. 4. Assuming that the gears occupy the position shown in Fig. 3, the eccentric will occupy the position shown in Fig. 4 at the time when the ends of the blades are passing the cylinder ports, and at such time the valve, D, which is the intake valve during the rotation of the engine in the direction in question, will be in upward motion and just uncovering the cylinder port to admit live steam from the corresponding steam-chest into the space within the cylinder behind the blade. The valve, D^1, which is then an exhaust valve, will also occupy the position shown in Fig. 4, and the cylinder space will be in communication through said valve with the exhaust port from the steam-chest and thus the vapor within the cylinder in advance of the oncoming blade will be ejected. In this position of the parts, (Fig. 4), the eccentric is in mid-position, *i. e.*, each of the valves is midway between its extreme upper and lower positions. The various possible positions of the valves are diagrammatically illustrated in Figs. 22 and 23, and, when the parts are as shown in Fig. 4, each of the valves occupies the position marked 3 in said Figs. 22 and 23. In operation, the intake valve reaches the lowest position possible with the gears in the position shown in Fig. 3, (*i. e.*, the position marked 4 in Fig. 22), when the drum is 45° behind the position shown in Fig. 4. From that point it will begin to rise, reaching the position 3 in Fig. 22 when the drum reaches the position shown in Fig. 4, and reaching its extreme upper position, (*i. e.*, the position marked 2 in Fig. 22), when the drum has rotated another 45°. It will then begin to descend and will again reach the position marked 3 in Fig. 22 when the drum has rotated 90° from position shown in Fig. 4, and at this point the cut-off will take place, no further steam being admitted to the cylinder until the drum rotates 180° from the position shown in Fig. 4, when the next succeeding blade passes the port. Thus in this position of the gears the intake valve oscillates between the positions 2 and 4 in Fig. 22, admitting steam just as the blade passes the cylinder port and cutting off at half stroke. Meantime the exhaust valve, whose various positions are shown in Fig. 23, is similarly oscillated between the positions 2 and 4 in Fig. 23 and it will be seen that during its oscillations the cylinder port and the exhaust port are continuously connected by the slide valve and are continously cut off from the live steam in the steam-chest. The movement of the exhaust valve is therefore an idle movement, performing no function. If now for any reason it is desired to decrease the amount of steam admitted and to shorten the period of operation during which the valve is admitting live steam from the steam-chest to the cylinder, the intermediate gear, F^3, will be drawn to the left as viewed in Fig. 3. If it be assumed that during such movement the drum and main shaft gear remain stationary, then the intermediate gear, F^3, will rotate to the left and the countershaft gear will rotate to the right, thus advancing the position of the countershaft with reference to the main shaft. If the main shaft and drum were in rotation when this movement of the intermediate gear took place, the parts would of course continue in motion, but the countershaft would be given an additional portion of a turn so as to take a position relatively in advance of the drum and main shaft. Simultaneously with this right hand rotary movement the countershaft will be drawn bodily to the left a short distance by swinging about the pivot of its supporting link as heretofore described. The throw of the eccentric and the distance which the countershaft moves bodily are so proportioned that when the countershaft and eccentric are rotated forward from the position shown in Fig. 4, the shaft moves to the left a sufficient distance to keep the center of the eccentric in exactly the same position, so that the valves occupy the same positions when the blades are passing the cylinder ports.

The extreme position which the ports reach when the intermediate gear is drawn to the left is shown diagrammatically in Fig. 20, where the drum is shown in the same position as in Fig. 4 and where it will be seen that the center of the eccentric is in exactly the same position as in Fig. 4, so that the valves occupy the same position, *i. e.*, the intake valve occupying a position where it is just a trifle above the lower edge of the port opening to the cylinder. However, in Fig. 4 the eccentric is in mid-position, while in Fig. 20 it is in one of its extreme positions and the only movement which the intake valve can take from the position thus shown is a downward movement. Thus the valve will start in position 3 of Fig. 22, the same as before, but it will move downward through the position 4 to the position 5. It will then rise until it again reaches the position 3 just as the next blade passes the port, so that the steam will practically be cut off throughout the entire stroke of the valve and throughout the entire movement of the drum. The exhaust valve in Fig. 20 also occupies the position 3 in Fig. 22 but it is in its lowest position and will rise from that position through the positions marked 4 and 5 and will eventually return to the position marked 3. During this stroke the exhaust valve maintains continuous connection between the cylinder port and the exhaust port, although the cylinder port is constricted at one time to considerable extent, but this constriction occurs at a time when there is no steam in the cylinder and it is therefore of no consequence. It will be seen that the exhaust valve in this type of action is also entirely idle and performs no useful function.

It will be readily understood that corresponding results will be produced by placing the intermediate gear in any position between that diagrammatically illustrated in Fig. 20 and that illustrated in Fig. 3, the amount of swing of the intermediate gear to the left determining the relative positions of the countershaft and the eccentric, and thus determining at what point the cut-off will occur. At all positions the cylinder port will be opened at the same time, but whether it will oscillate between the points 2 and 4, as it does when the intermediate gear is in its normal position in Fig. 3, or between the points 3 and 5, as it does when the intermediate gear is in the extreme position shown in Fig. 20, or whether it will oscillate between some other pair of points between the points 2 and 5 in Fig. 22, will depend on the amount to which the intermediate gear is swung to the left. The same is true of the exhaust valve. If now it is desired to increase the effective length of the stroke, the intermediate gear is moved in the opposite direction, *i. e.*, to the right in Fig. 3. This movement will produce relative left hand rotation between the drum and countershaft and eccentric thereon, and will swing the countershaft to the right so that as before when the drum is in the position shown in Fig. 4 the position of the center of the eccentric will be immediately above the center of the drum, and thus the valves will always occupy the same position at that time. The position of the parts when the intermediate gear is swung to its extreme position to the right is shown in Fig. 21, where the drum is shown in the same position as in Fig. 4, and therefore the valves are in the same position. It will be readily observed that in this position the intake valve is in its lowest position, while the exhaust valve is in its highest position. Thus starting with the parts as shown in Fig. 21, both valves will be in the positions 3 indicated diagrammatically in Figs. 22 and 23, and will move successively through the positions 2 and 1 and back to positions 3. In other words steam will be admitted continuously from the left hand steam-chest to the cylinder and will only be restrained slightly just as the blade is passing the port. As a result the engine will run under full stroke. It will readily be understood that in any intermediate position between that shown in Fig. 3 and that shown in Fig. 21 corresponding results will be produced, so that any effective length of stroke greater than half stroke can be obtained by shifting the intermediate gear to the right.

It will be observed in connection with the operation thus far described that the valve which is operating as an exhaust valve performs a purely idle movement at all times and that this valve could properly be omitted from the engine without in anyway interfering with its action, were it only desired to run the engine in one direction. When, however, it is desired to reverse the engine, the movable segment, H^1, is rocked about the center of the guides provided for it, so that it takes a position to the opposite side of the center of the engine symmetrical with respect to the position which it originally occupied. Inasmuch as all parts of the engine are symmetrical on the two sides, as illustrated in Fig. 4, this rocking of the segment will shift the valve which was formerly the exhaust valve into the position of the intake valve and will shift the valve which was formerly the intake valve into the position of the exhaust valve, so that the engine will run in either direction with perfect facility by merely shifting the position of the segment. It will be evident that when the engine is reversed the lateral movement of the intermediate gear must also be reversed in order to secure corresponding results. Thus, in whichever direction the engine is running, it will run at half stroke when the intermediate gear is in the position shown in Fig. 3; it will decrease its effective stroke when the gear is moved toward the valve which is the inlet valve for the direction in question, and it will increase its stroke when the gear is moved away from the intake valve.

For the purpose of moving the intermediate shaft as set out, I provide two links, J, (Figs. 5 and 6), the upper ends of which are bifurcated and journaled upon the intermediate shafts, F^1, F^4, at the front and rear of the engine. These links run diagonally downward, (Fig. 3), and are pivotally connected to disks, J^1, upon a regulating shaft, J^2, the said links being arched near their lower ends, in order that they may clear the said shaft as the same rocks. The said links, J, are shown in an intermediate position in Fig. 3, and are diagrammatically shown in extreme positions in Figs. 20 and 21. It will be obvious from these drawings and the description of the construction that rotation of the shaft, J^2, will produce the variations in the cut-off already described. For certain uses of the engine the shaft, J^2, could be manually operated with perfect success, or other means might be adopted for moving the links, J, to produce the requisite movement of the intermediate gear and of the countershaft. On the other hand for certain other purposes it is desirable to have the regulating done automatically and for this purpose I utilize the governor illustrated in Figs. 24 and 25. K in these figures represents a governor casing, the form of which is plainly illustrated. A shaft, K^1, extends forward from the governor casing and bears upon its forward end a pulley, k, which is belted to a pulley, k^1, upon the forward main shaft section. Thus the speed of the shaft, K^1, will at all times be proportionate to the speed of rotation of the drum and other moving parts of the engine. The shaft, K^1, bears on its rear end, within the governor casing a gear, k^2 in mesh with a gear, K^2, to the upper face of which is secured a rotating bracket, K^3, in which are pivoted two governor arms, K^4, weighted at their outer ends in the usual manner. A vertical shaft, K^5, passes through the center of the gear, K^2, and carries on its upper portion a block, K^6, having rack teeth on opposite sides in mesh with gears on the governor arms, K^4, so that when these governor arms are thrown outwards by centrifugal force said block, K^6, will be raised against the force of a spring, K^7, bearing downward upon the block, K^6.

Projecting from the lower portions of the governor frame is a rotatable vertical shaft, L, provided with a worm in mesh with a segmental gear, L^1, fast upon the shaft, J^2, which it is desired to move by means of the governor. The shaft, L, has at its upper end a lower miter gear, L^2, in mesh with an intermediate miter gear, L^3, which in turn is in mesh with an upper mitered gear, L^4, which surrounds the shaft, K^6. The adjacent faces of the gears, L^2, L^4, are provided with clutch teeth and the shaft, K^5, carries between said gears a clutch collar, L^5, adapted to engage with the clutch teeth upon either of said gears.

The operation of this governor will be readily understood. When the engine is running in the direction in which it will run with the parts in the position shown in the drawings, the shaft, K^1, and pulley, k, will rotate in a right hand direction as seen in Fig. 2. Thus the gear, K^2, the bracket, K^3 and the shaft, K^5, together with the governor arms, will all rotate in a left hand direction. The side of the gear, K^2, which is the side seen in Figs. 24 and 25, will thus move to the left. Now if the engine runs too fast the shaft, K^5, will be raised, throwing the clutch members into engagement with the upper miter gear, L^4, and rotating that gear in the same direction as gear K^2. This rotation will, through the medium of the intermediate miter gear, rotate the lower miter gear, L^2, and the shaft, L, with the worm thereon, in the opposite direction and such rotation will move downward the segmental pinion, L^1, upon the shaft, J^2, thus drawing the links, J, toward the governor and increasing the cut-off of the engine. The cut-off will be continuously increased until the engine reaches sufficiently slow speed to cause the governor arms to draw the clutch member out of its engagement with the upper miter gear, L^4. Thereupon the engine will run at a normal speed. If the engine should run too slow the spring, K^7, would force the shaft, K^5, downwards, so the clutch member, L^5, would engage with the lower miter gear, L^2, causing reverse rotation of the shaft, L, and its worm, with a consequent rise in the segmental pinion, L^1, and motion of the intermediate gear in the direction to increase the length of time steam is admitted. When the engine is running in a reverse direction the same action of the clutch takes place, but, inasmuch as the moving parts of the governor necessarily revolve in the opposite direction, the links will move in the opposite direction, which will produce corresponding effects upon the motion of the engine when running reversed. A stop, M, movable against the spring resistance in opposite directions, is provided for the pinion, L^1, in order to prevent undue movement of the regulating shaft in either direction and to cause the worm and gear to mesh at all times, even if the worm rotates enough to run off the gear.

The advantages of my engine will be readily appreciated from a consideration of its operation. The rotary engine has certain advantages of economy which it is very desirable to utilize, but very great difficulty has heretofore been experienced in adapting a cut-off to a rotary engine, particularly in adapting to a rotary engine a variable cut-off which could be controlled either manually or by a governor, so that expansive working of the steam could be utilized for the sake of economy whenever possible. With my construction I obtain an engine where the cut-off can be varied to any extent and where, also, the intake and exhaust valves are entirely independent, so that there can be no back pressure when the engine is running cut-off. The means whereby these results are accomplished are particularly advantageous in that they give continuous regular movement to such parts and enable me to use an eccentric of ordinary form, which is a particularly simple and durable means for transmitting motion. Furthermore, the arrangement is such that the valves are always opened at the same point in the movement of the blades, so that the maximum pressure of the steam occurs immediately behind the blades in all cases and there is no back pressure of any kind or premature opening of the ports. Furthermore the entire engine can be reversed at any point in its operation and at any given stroke of the valve without in any way altering the extent of cut-off. For instance, should the engine be running full stroke and without the governor attached, as it might be doing in vehicle construction, the whole engine can be reversed and run full stroke backwards without passing through any intermediate position. Furthermore the cut-off is so complete that when the engine is operated without a governor no throttle whatever is necessary. The entire regulation of the engine can be done with the cut-off, which is obviously the most efficient and economical manner of regulating the speed of the engine.

When used for vehicle purposes, as, for instance, in an automobile, my engine can be regulated in speed by providing means whereby the vertical governor shaft can be moved vertically by manual control. Thus, if this shaft be raised by hand, the vehicle will accelerate its speed until the shaft is released, while if the shaft be pressed down the vehicle will decrease its speed until the shaft is released. In this way, by very simple manipulation, the engine can be varied in speed wholly through the medium of the cut-off and it can be stopped entirely by cutting off to the maximum.

I realize that considerable variation is possible in the details of construction without departing from the spirit of my invention, and I do not intend, therefore, to limit myself to the specific form herein shown and described.

I claim as new and desire to secure by Letters Patent:—

1. The combination with a casing having a port, of a vapor propelled rotary member movable within the casing, valve gearing embodying a rotating valve-actuating device driven by said vapor-propelled rotary member, and connecting devices running therefrom to the valve, and means for shifting one portion of said valve gearing to alter the movement of the valve with reference to the port, and means for moving another portion of the valve gearing to cause said valve to uncover said port at a fixed time with reference to the movement of said vapor-propelled rotary member.

2. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a valve adapted to control the port, valve gearing embodying a rotating valve-actuating device driven by the vapor-propelled rotary member, and connecting devices running therefrom to the valve, and means for giving one movement to a portion of the valve gearing to alter the movement of the valve with reference to the port and for also rotating said rotating valve-actuating device with reference to the vapor-propelled rotary member, to cause the valve to uncover the port at the same time with reference to the movement of the vapor-propelled rotary member and to cover the port at different times with reference thereto.

3. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a reciprocating valve adapted to control the port, a valve-operating eccentric driven by said vapor-propelled rotary member, connections between said eccentric and said valve and means for rotating said eccentric with reference to said vapor-propelled rotary member and for shifting the position of parts of the valve mechanism to bring the valve into position to uncover the port at the same time, but to cover it at different times.

4. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a reciprocating valve adapted to control the port, means for reciprocating the valve through a constant stroke, means for shifting the position of the stroke of the valve with reference to the port, and means for so varying the timing of the reciprocations of the valve with reference to the vapor-propelled rotary member as to cause it to open the port at the same time with reference to the movement thereof, but to close the port at different times with reference to the movement thereof.

5. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a reciprocating valve adapted to control the port, valve gearing embodying an eccentric rotated by the vapor-propelled member, and means for imparting movement having two components to parts of the valve gear, one component of said motion operating to shift the limits of the reciprocations of the valve and the other component being a rotary movement of the eccentric with reference to the vapor-propelled rotary member, whereby the valve is made to uncover the port at the same time with reference to the movement of said vapor-propelled rotary member, whatever be the limits of movement of the valve.

6. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a reciprocating valve adapted to control the port, valve gear embodying an eccentric rotated by the vapor-propelled rotary member, and means for shifting the eccentric bodily to shift the limits of reciprocation of the valve and for rotating the eccentric with reference to the vapor-propelled rotary member, whereby the valve will open the port at the same time with reference to the movement of the vapor-propelled rotary member and will close the port at varying times with reference thereto.

7. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a reciprocating valve adapted to control the port, valve gear embodying an eccentric rotated by the vapor-propelled rotary member, means for shifting portions of the valve gear to vary the limits of the reciprocation of the valve with reference to the port, and means for correspondingly and conversely rotating the eccentric with reference to the vapor-propelled rotary member, whereby, when the valve is moved to vary the length of time during which the port will be opened thereby, its timing is varied in an opposite direction to cause it to open the port at the same time with reference to the movement of the vapor-propelled rotary member.

8. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a reciprocating valve adapted to control the port, valve gear embodying an eccentric rotated by the vapor-propelled rotary member, said valve gear serving as means of connection between the vapor - propelled rotary member and the valve, means for adjusting the valve gear to vary the position of the stroke of said valve with reference to the port without changing the length of said stroke, and means for varying the relative angular position between the eccentric and the vapor - propelled rotary member to cause the valve to open the port at the same time with reference to the movement of the vapor-propelled rotary member.

9. The combination with a casing having a port, of a vapor-propelled rotary member

movable within the casing, a countershaft provided with an eccentric, connections between the countershaft and the vapor-propelled rotary member, connections between the eccentric and the valve, and means for simultaneously moving the countershaft bodily and rotating said countershaft with reference to the vapor-propelled rotary member to vary the position of the stroke of the valve and maintain the relative time when the port is uncovered with reference to the movement of the vapor-propelled rotary member constant.

10. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a reciprocating valve, a bell crank lever having connection with the valve, an eccentric, an eccentric strap connected with the bell crank, means of connection between the eccentric and the vapor-propelled rotary member, and means for shifting the eccentric bodily in one direction and rotating it in the opposite direction to vary the length of time the port is uncovered by the valve without changing the time when the port is first uncovered by the valve.

11. The combination with a casing having a port, of a vapor-propelled rotary member movable within the casing, a shaft having connection with said vapor-propelled rotary member, a gear on the shaft, a link movable about the center of said shaft, an intermediate gear carried by the link, a second link pivoted to the first at the axis of said intermediate gear, a countershaft having an eccentric, a guide for the upper end of said second link, a journal on said second link for said countershaft, a valve controlling said port, and means of connection between said eccentric and valve, and means for shifting said intermediate gear.

12. The combination with a casing having a port and a vapor-propelled rotary member movable within the port, of a shaft having connection with the vapor-propelled rotary member, a gear on the shaft, a vertical guide above the shaft, a cross-head on the guide, links pivoted together and to the cross-head and shaft, the countershaft carrying a gear pivoted to the upper link, and below the pivot thereof to the cross-head, an eccentric upon the countershaft, a valve and means of connection between the valve and the eccentric, and an intermediate gear journaled at the pivot between said two links and having engagement with said two first-named gears.

13. The combination with a casing having a port, a shaft thereon and a vapor-propelled rotary member having connection with the shaft, of a gear upon the shaft, a cross-head guided to move vertically, a link pivoted to the cross-head, an intermediate shaft to which the free ends of said two links are pivoted, an intermediate gear on the intermediate shaft, gears on said two first-named shafts engaging with the intermediate gear, a valve, an eccentric upon the countershaft and connections between said eccentric and said valve, and means for shifting the intermediate shaft laterally.

14. The combination with a casing having a port, means for supplying steam to the port, a valve for controlling the port, and a vapor-propelled rotary member movable within the casing, of a shaft having connection with the vapor-propelled rotary member, a gear upon the shaft, vertical guides at the front and rear of the machine, cross-heads movable upon said guides, links pivoted to the cross-heads, a countershaft journaled between said links below their pivots, an eccentric on said counter-shaft having connection with said valve to operate the same, links pivoted to the first-mentioned shaft at the front and rear of the machine and pivoted also to said first-named links, an intermediate gear journaled at the pivot between the forward pair of links, a gear on the forward end of the countershaft, the three gears being in engagement.

15. The combination with a casing having a port and a valve for controlling the port, of a vapor-propelled rotary member movable within the casing, a shaft to which said vapor-propelled rotary member is attached, a countershaft having an eccentric, connection between the eccentric and the valve, connection between said countershaft and said first-named shaft embodying a movable intermediate gear, and means whereby, when the gear is moved to rotate the countershaft with reference to the first-named shaft, the countershaft will be bodily moved in an opposite direction.

16. The combination with a casing, steam-chests on the sides thereof, ports communicating from the steam-chests to the atmosphere and from the steam-chests to the interior of the casing, valves controlling the ports, a vapor-propelled rotary member within the casing and a shaft to which said vapor-propelled rotary member is secured, of a countershaft having connection with said first-named shaft, an eccentric upon the countershaft, an oscillating segment, valve-operating levers pivoted to the segments, connections between the valve-operating levers and the valves and between the valve-operating levers and the eccentric, whereby the valves are simultaneously and oppositely oscillated, connections between the countershaft and the first-named shaft, means for shifting the countershaft laterally and rotating it with reference to the first-named shaft, and means for oscillating the segment to reverse the relative positions of the valves in their steam-chests.

17. In an engine a main-shaft, a countershaft, means of connection between said

shafts embodying an intermediate gear, means for shifting the position of the journal of said intermediate gear to vary the relative angular positions between said shafts while in motion, and means for bodily shifting the position of the counter-shaft simultaneously with its angular movement.

18. In an engine, a main shaft, a counter-shaft, means of connection between said shafts embodying an intermediate gear, means for shifting the position of the journal of said intermediate gear to vary the relative angular positions between said shafts while in motion, and means for bodily shifting the counter-shaft in an opposite direction from its angular movement.

MALCOLM L. HARRIS.

In presence of—

RALPH A. SCHAEFER,

J. H. LANDES.