(No Model.) 6 Sheets—Sheet 1.

F. M. RITES.

METHOD OF STEAM DISTRIBUTION IN MULTIPLE EXPANSION ENGINES.

No. 502,140. Patented July 25, 1893.

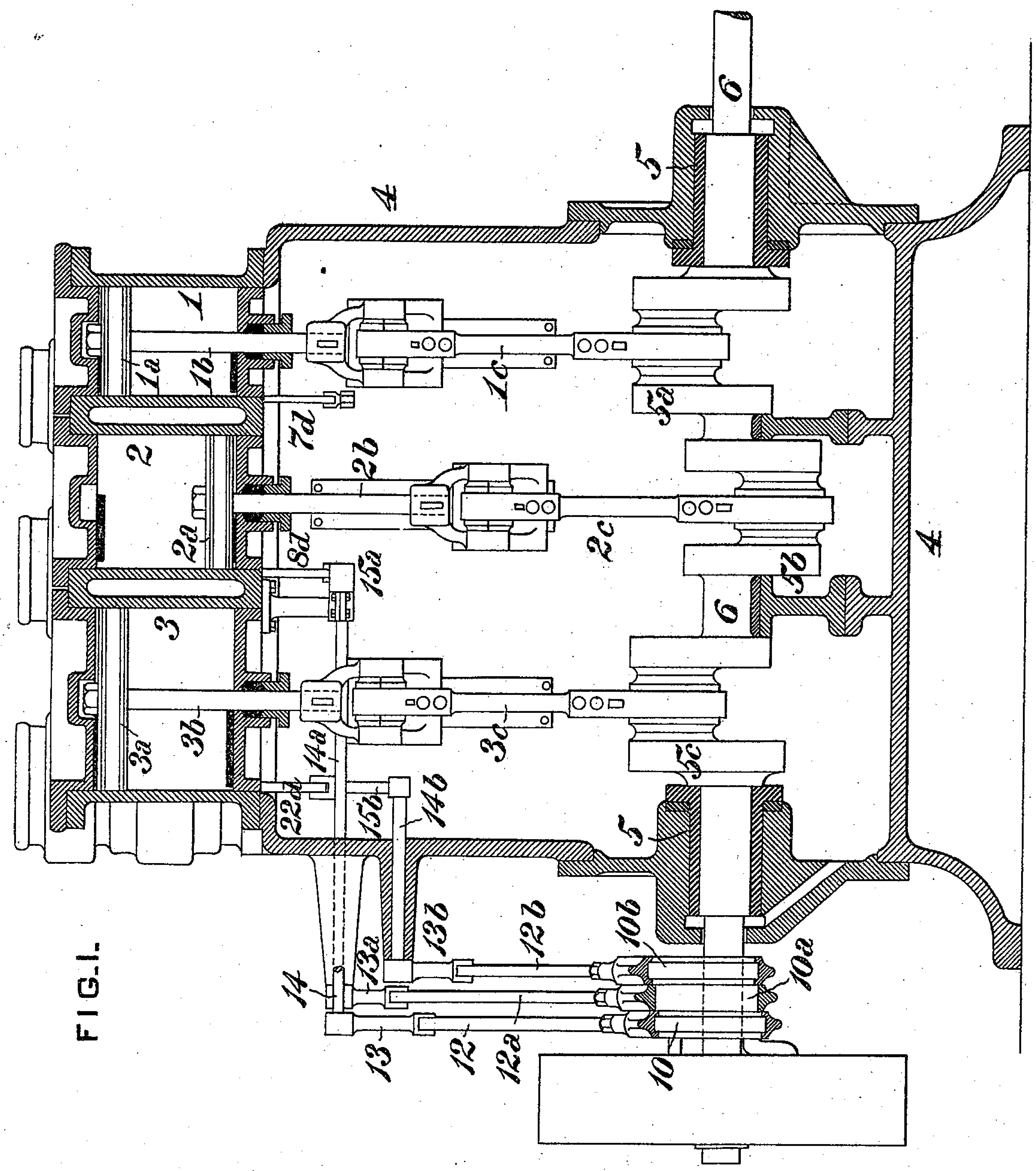

FIG. I.

WITNESSES:

E. Newell.
F. E. Gaither.

INVENTOR,

Francis M. Rites,
By J. Snowden Bell, Att'y.

(No Model.)

6 Sheets—Sheet 2.

F. M. RITES.

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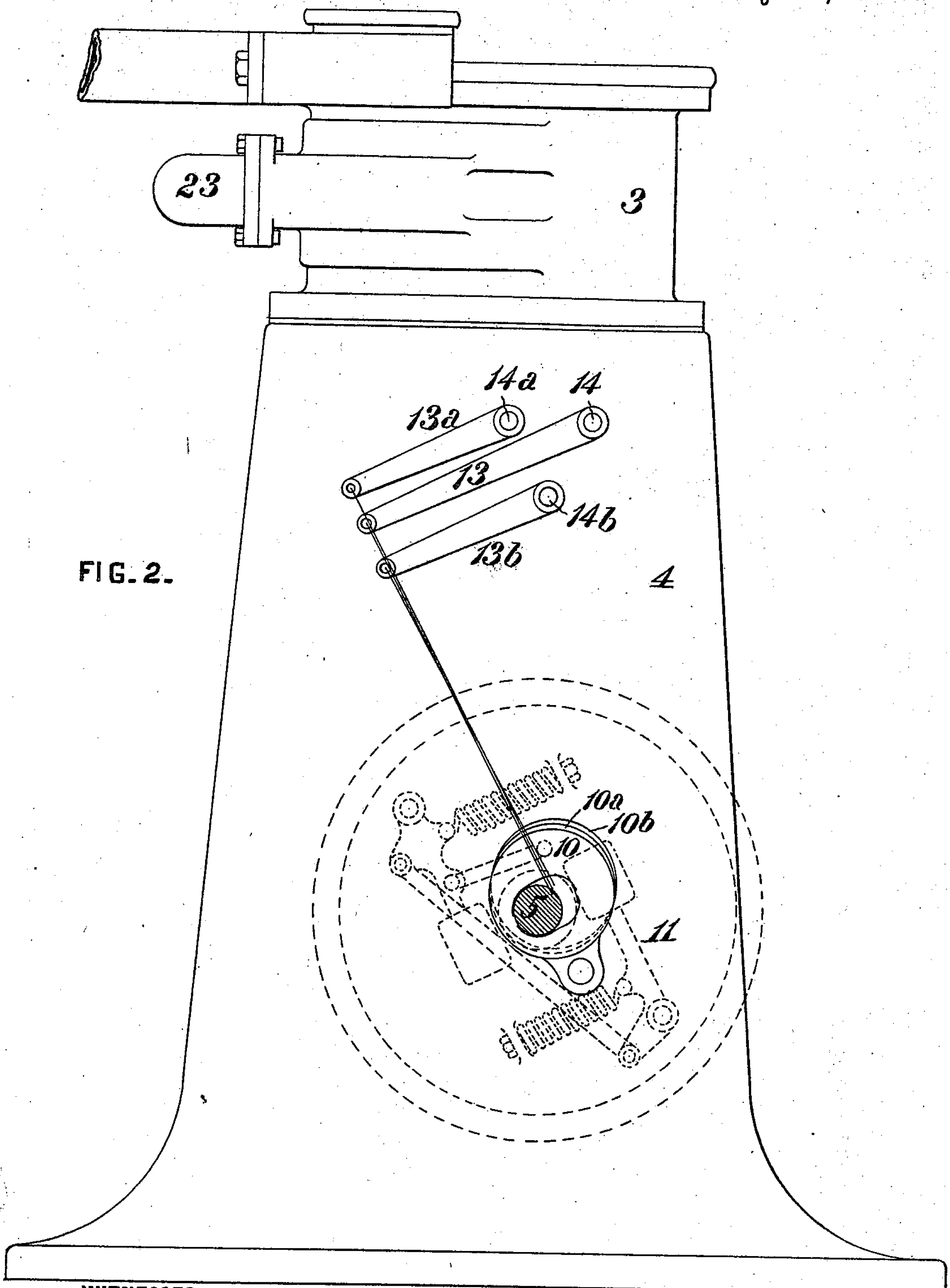

FIG. 2.

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6 Sheets—Sheet 3.

F. M. RITES.

METHOD OF STEAM DISTRIBUTION IN MULTIPLE EXPANSION ENGINES.

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FIG. 3.

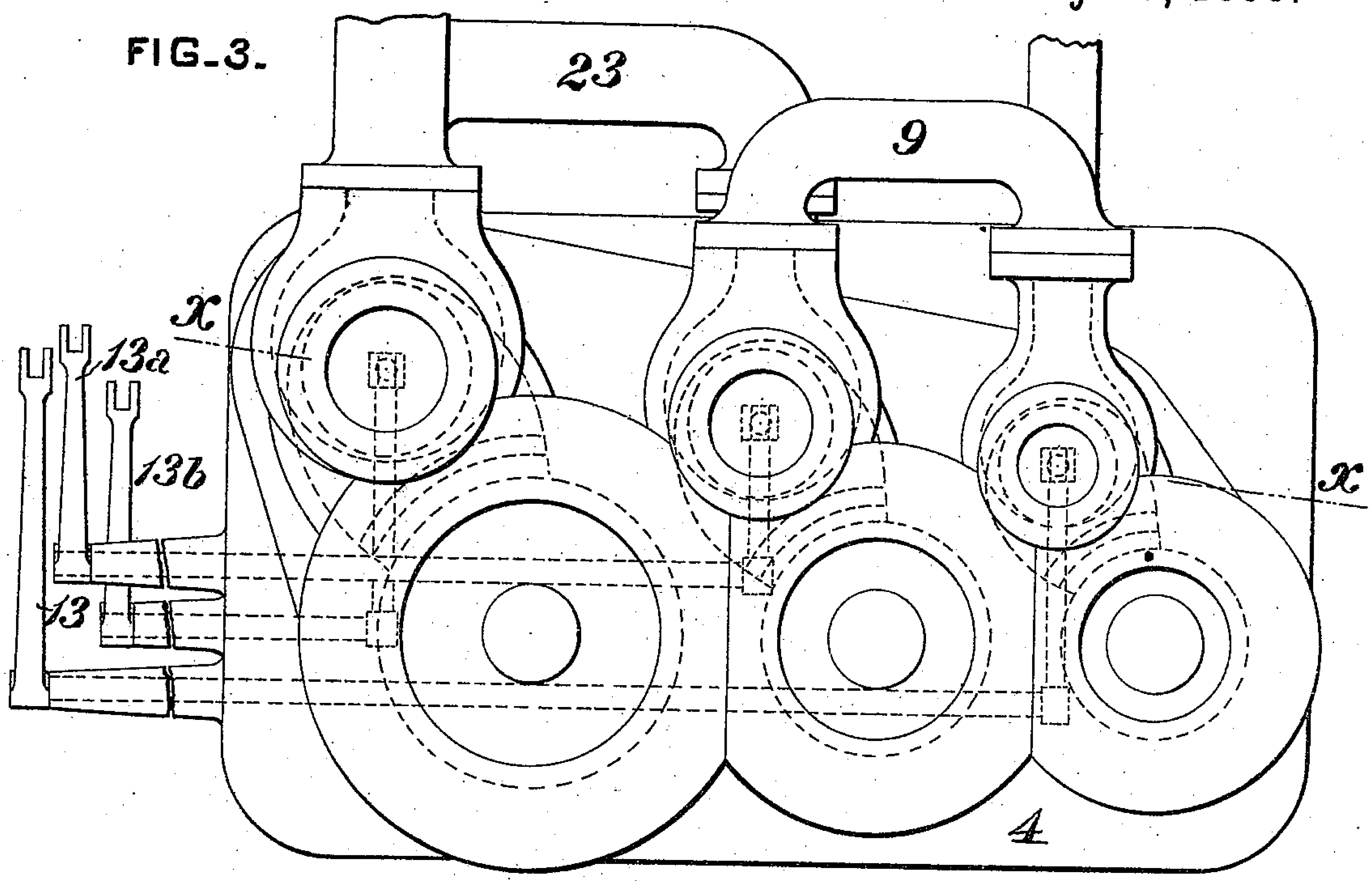
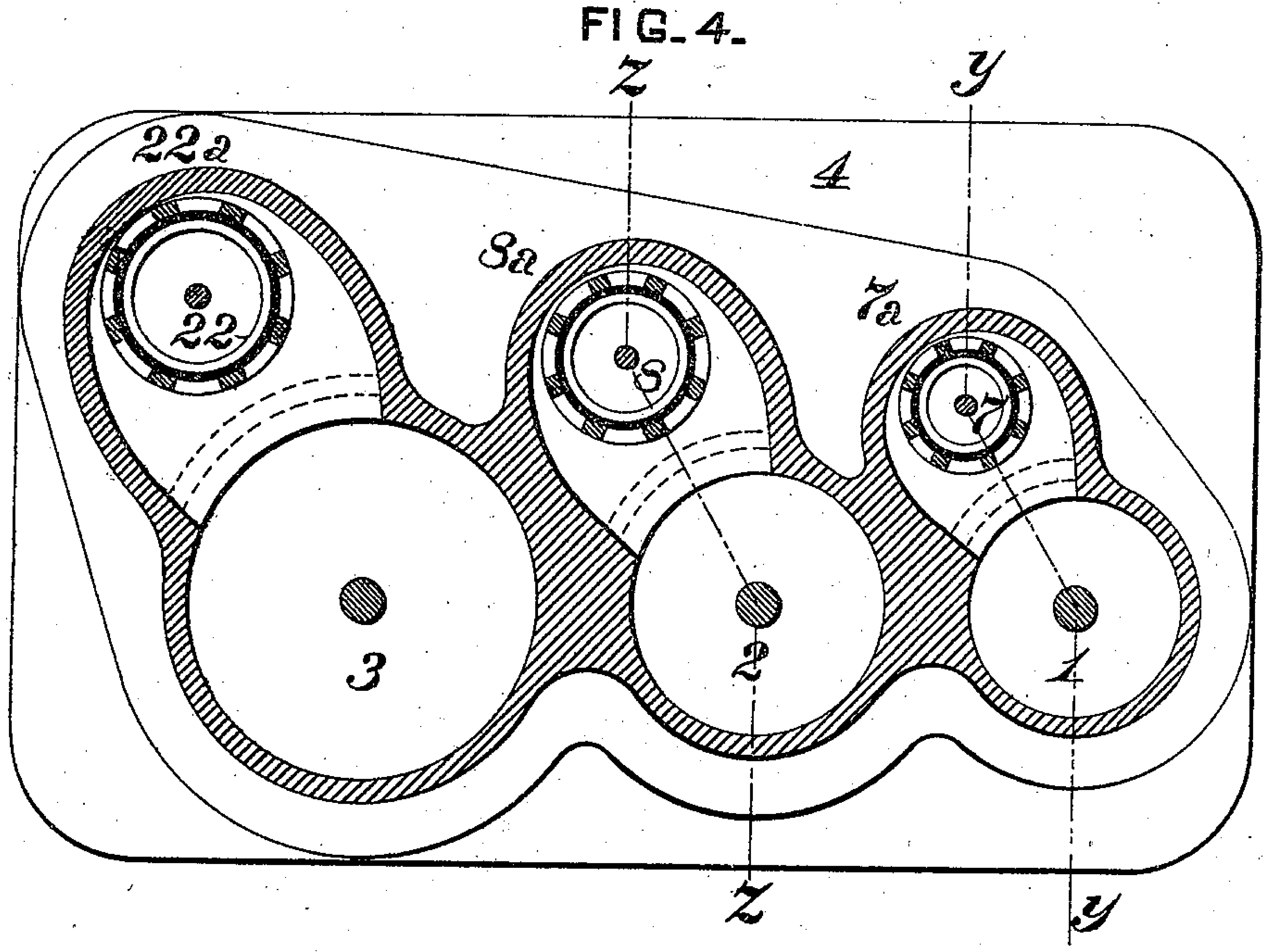


FIG. 4.



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6 Sheets—Sheet 4.

F. M. RITES.

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FIG-5.

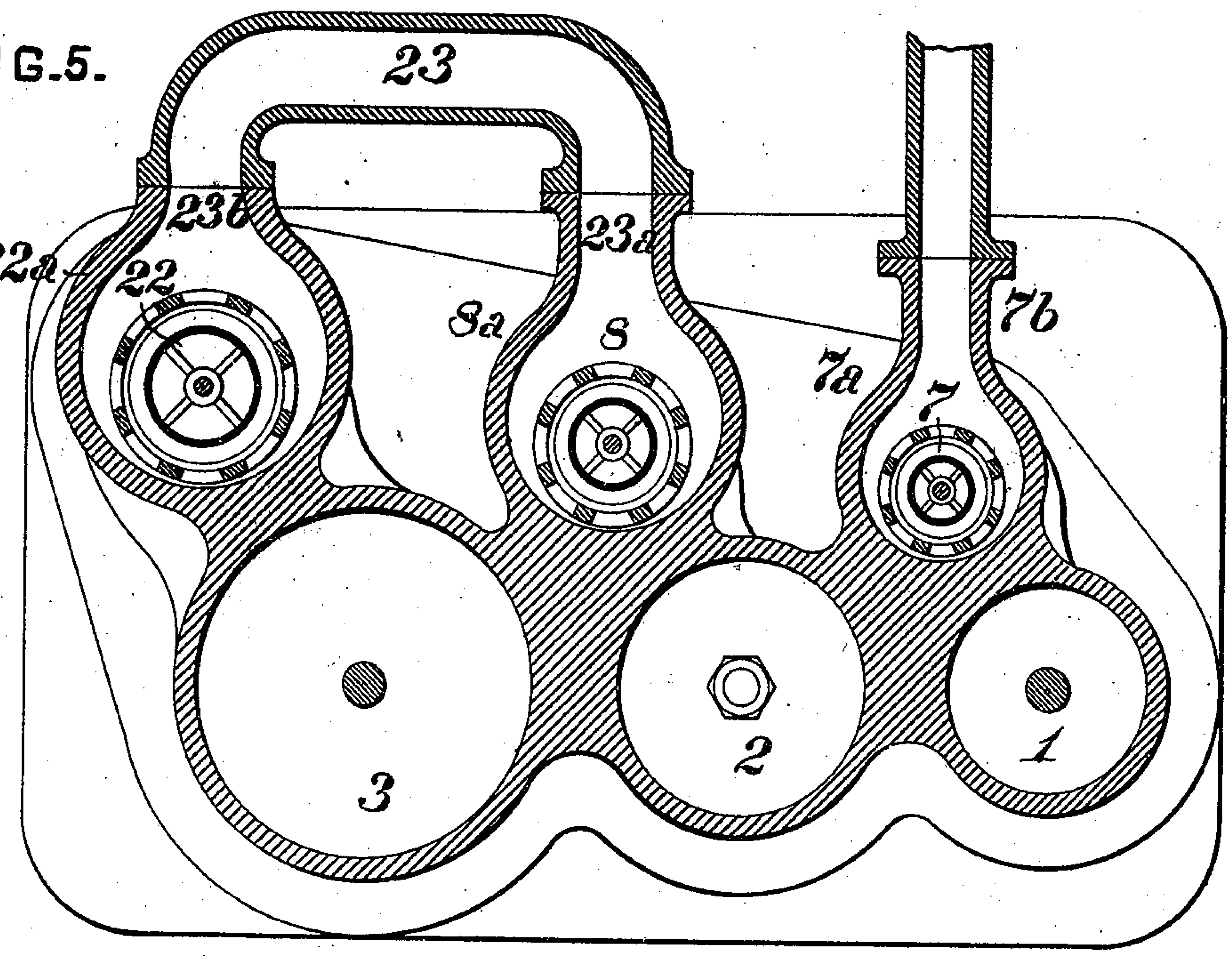
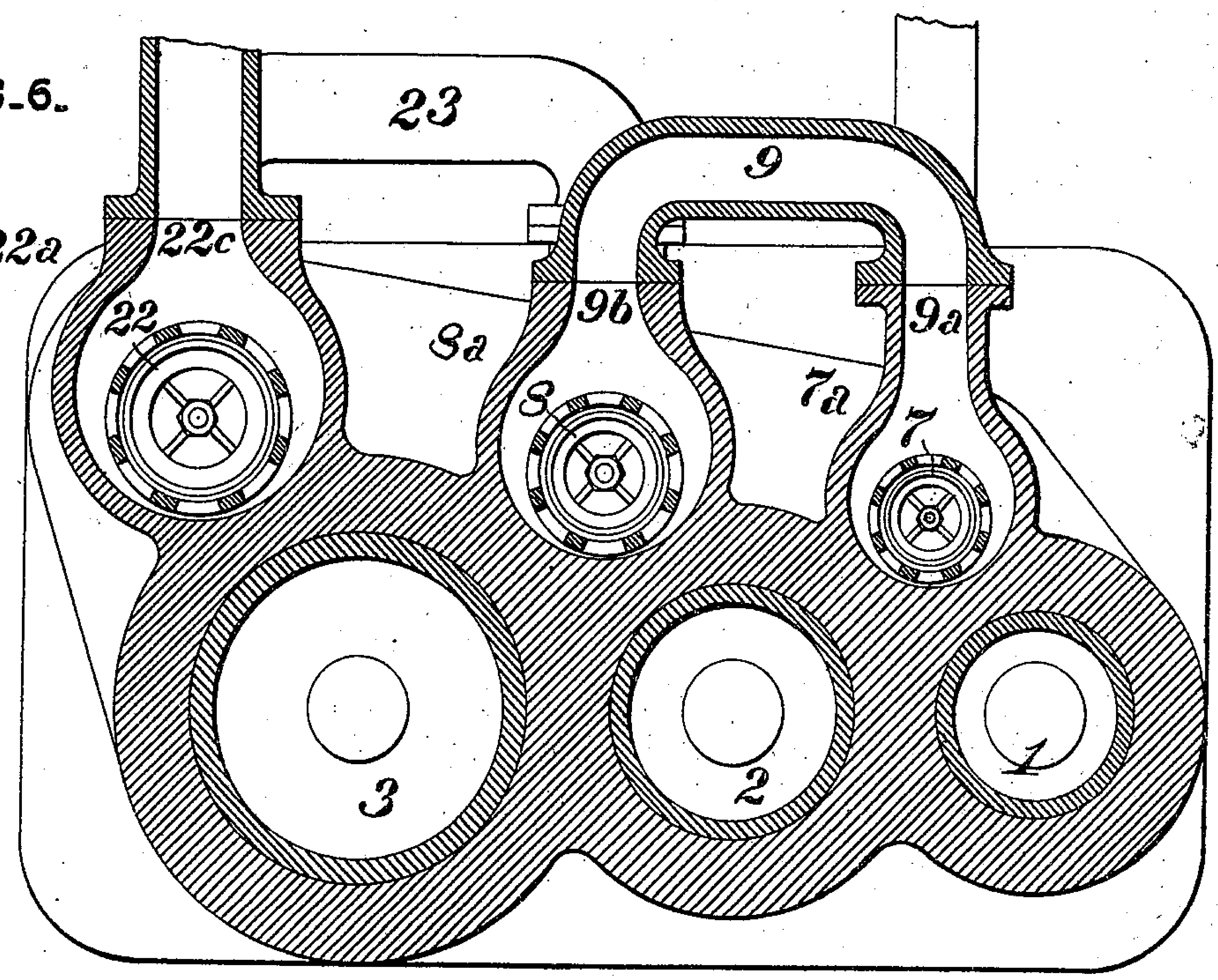


FIG-6.



WITNESSES:

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(No Model.)

6 Sheets—Sheet 5.

F. M. RITES.

METHOD OF STEAM DISTRIBUTION IN MULTIPLE EXPANSION ENGINES.

No. 502,140.

Patented July 25, 1893.

FIG_7.

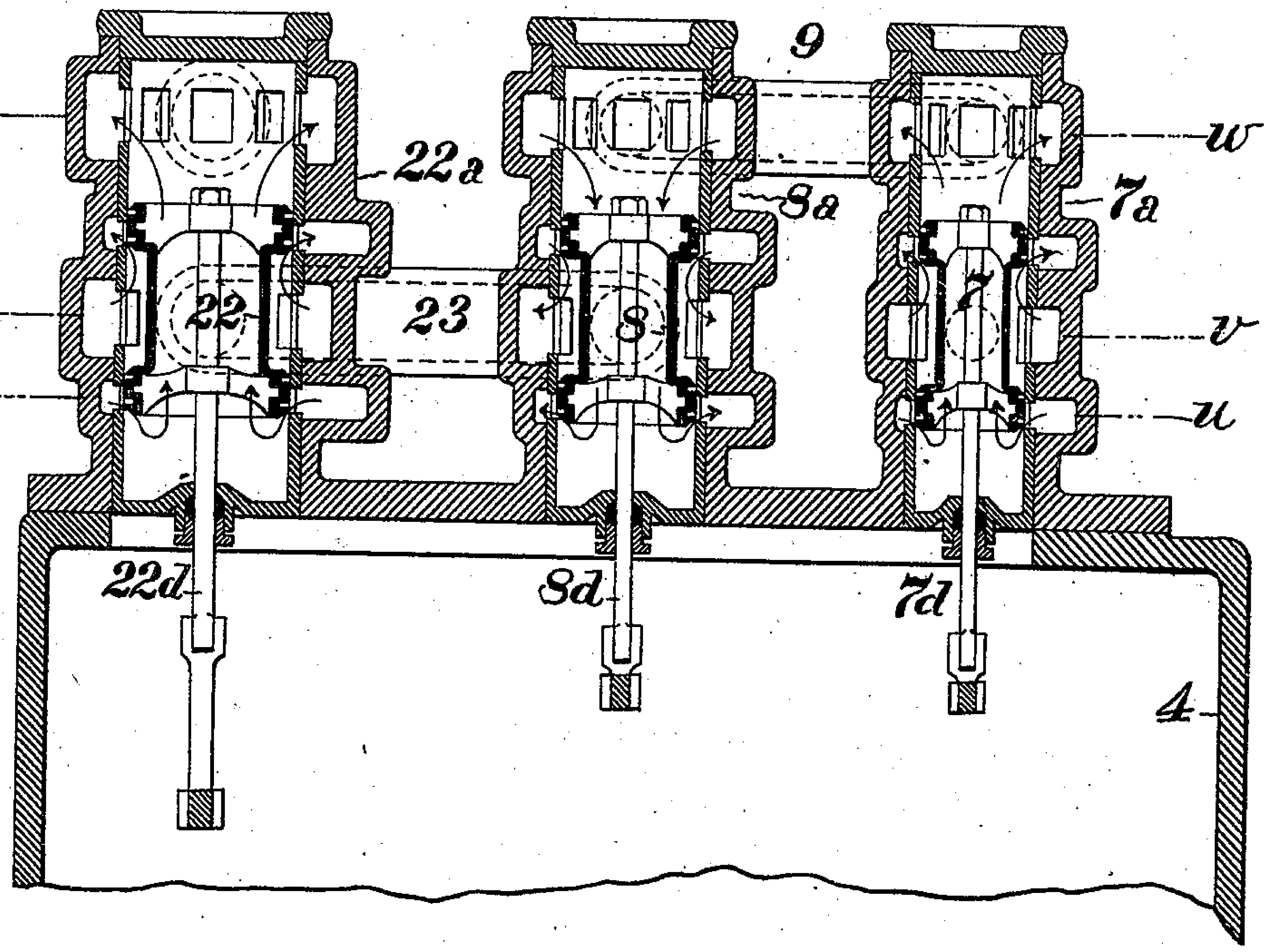


FIG_9.

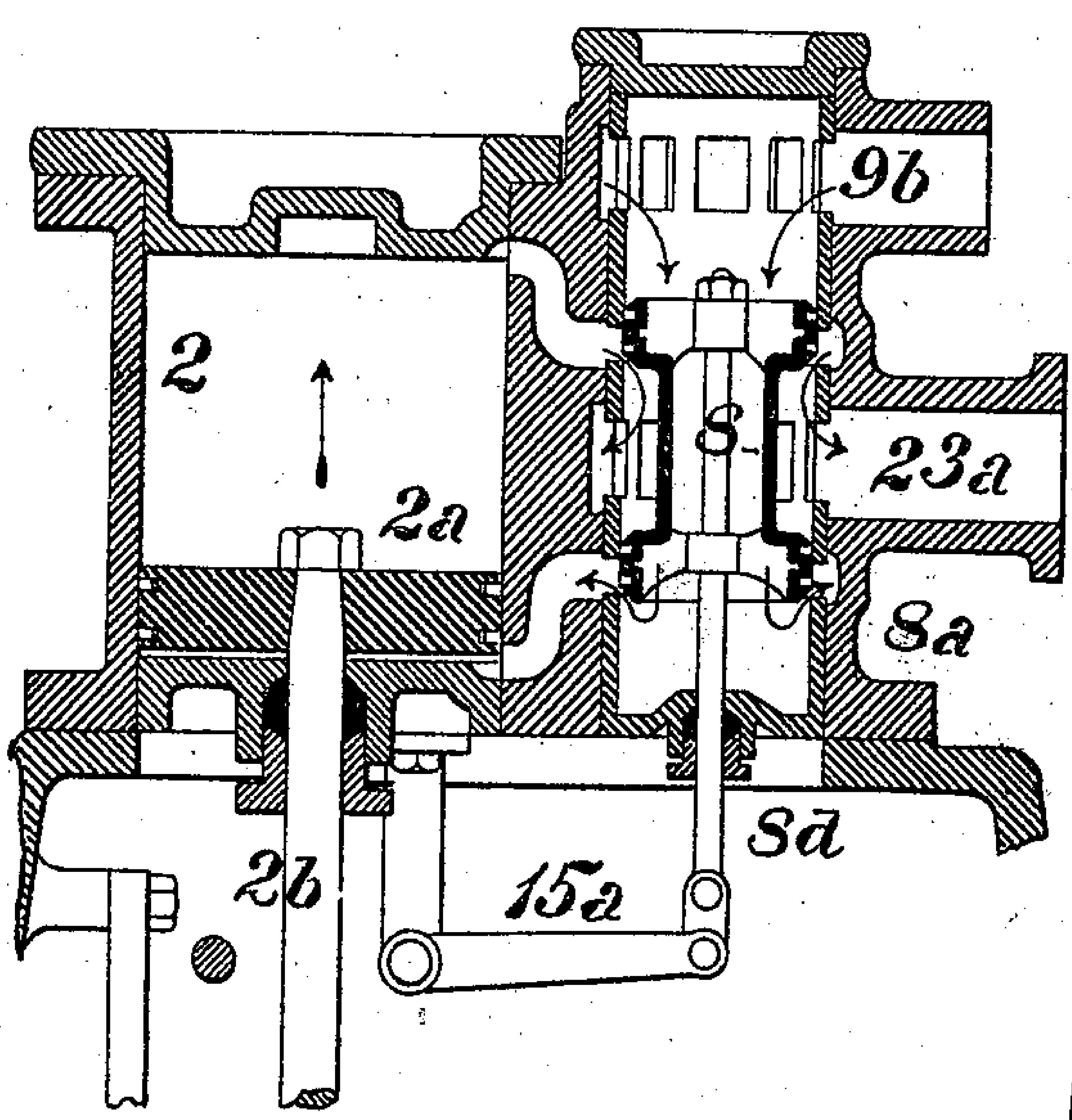
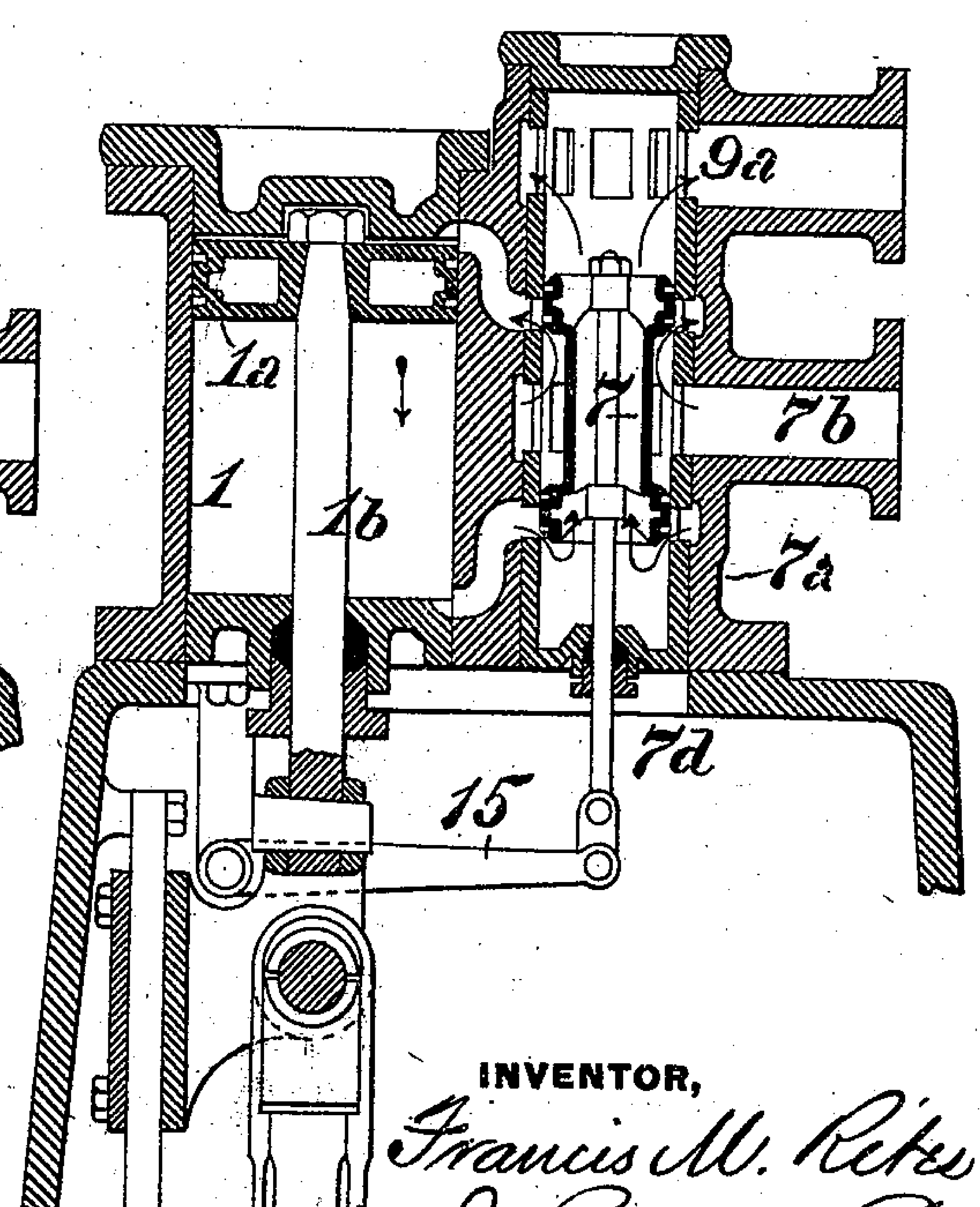


FIG_8.



WITNESSES:

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FIG. 10.

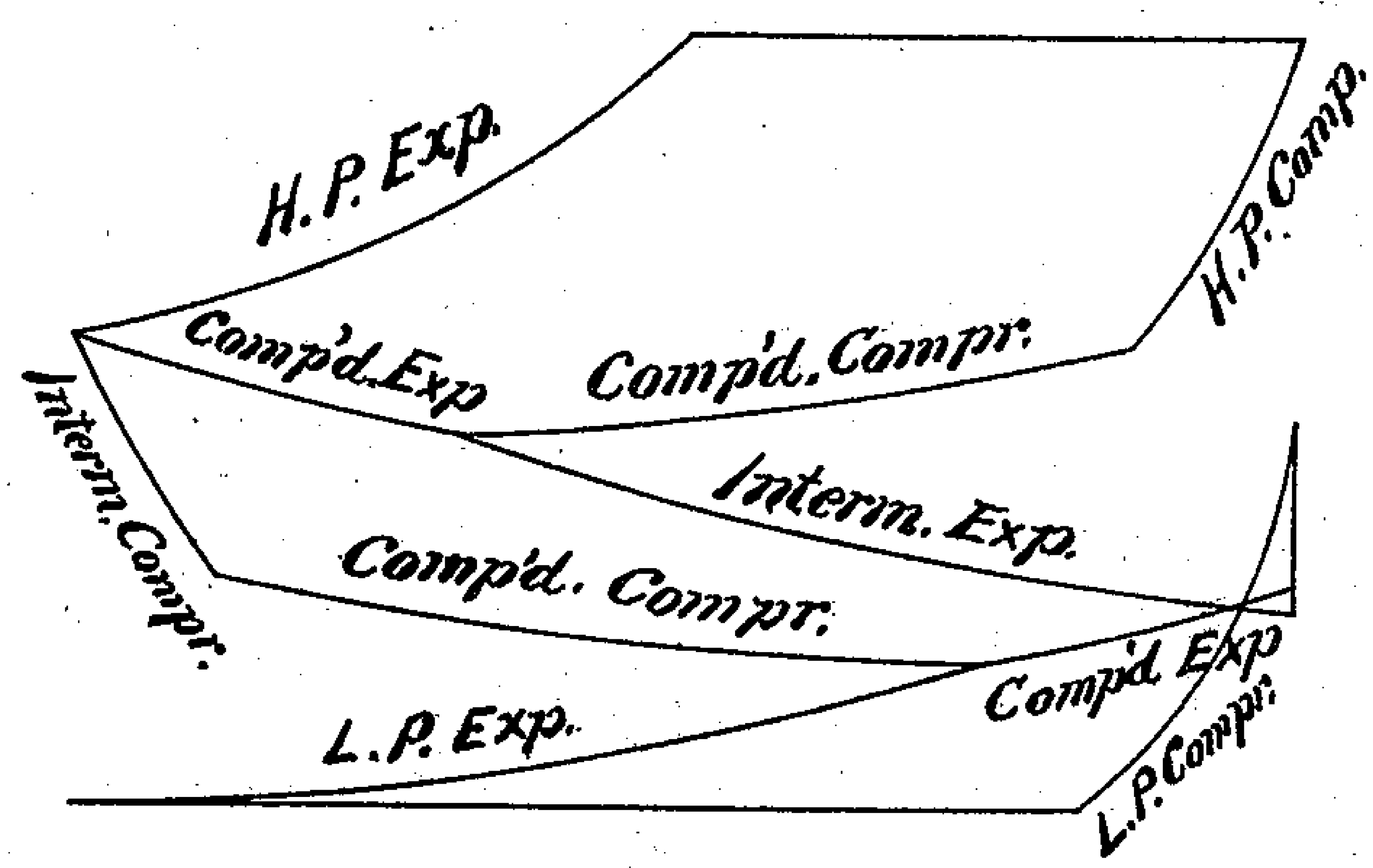
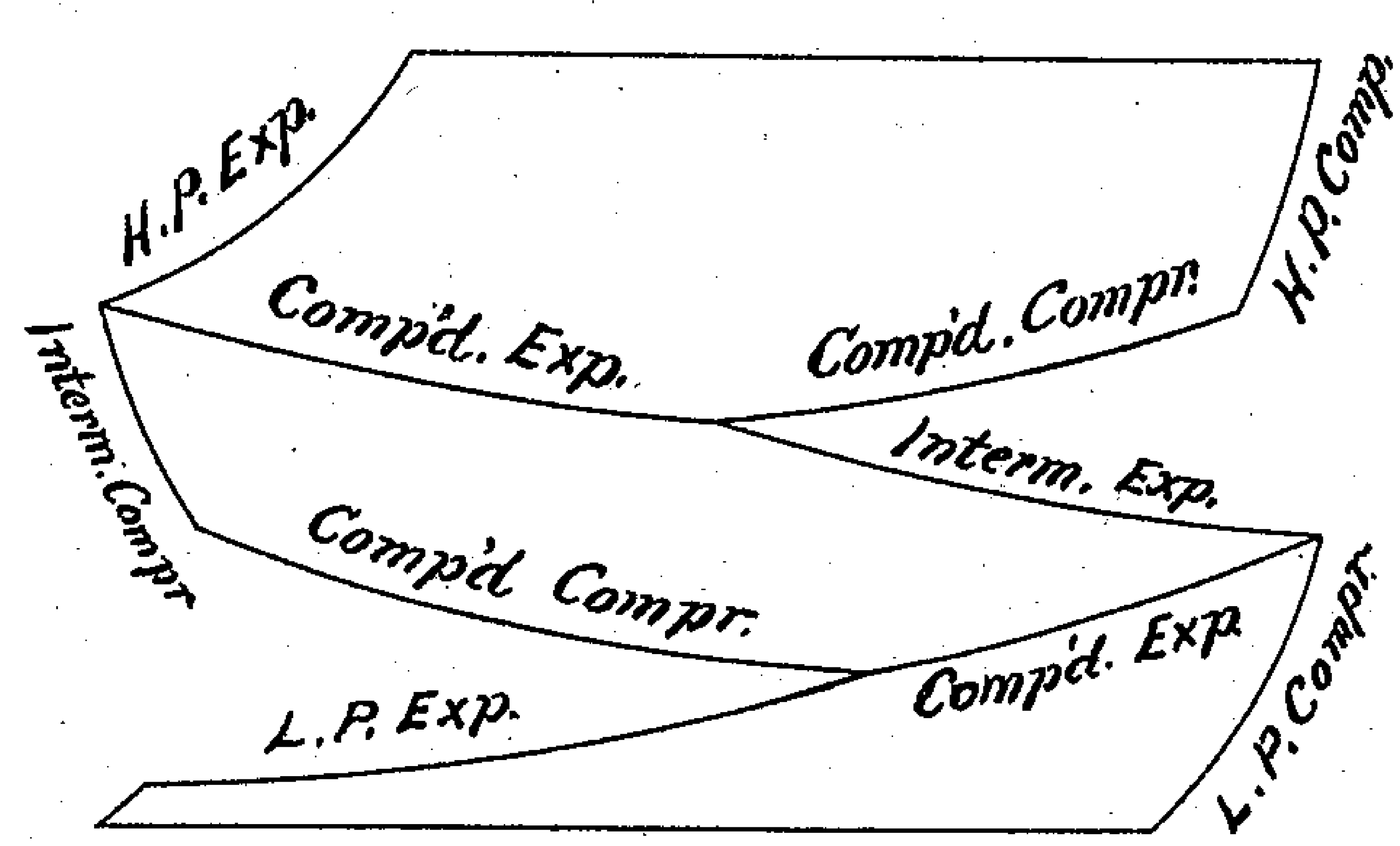


FIG. 11.



WITNESSES:

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F. E. Gaither.

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UNITED STATES PATENT OFFICE.

FRANCIS M. RITES, OF ALLEGHENY, PENNSYLVANIA.

METHOD OF STEAM DISTRIBUTION IN MULTIPLE EXPANSION ENGINES.

SPECIFICATION forming part of Letters Patent No. 502,140, dated July 25, 1893.

Application filed September 19, 1892. Serial No. 446,247. (No model.)

To all whom it may concern:

Be it known that I, FRANCIS M. RITES, a citizen of the United States, residing at Allegheny, in the county of Allegheny and State of Pennsylvania, have invented or discovered a certain new and useful Improvement in Methods of Steam Distribution in Multiple Expansion Engines, of which improvement the following is a specification.

The object of my invention is to enable the distribution of steam in the several cylinders of a multiple expansion engine to be so effected that the maximum economical utilization which is attainable under any given operative conditions will be maintained throughout the entire range of variation of the ratio of expansion due to variations of load or pressure or both, by, first, the equalization and maintenance, under all conditions, of the effect of changes of temperature in the several cylinders in condensing and re-evaporating the steam, second, by the prevention of waste of steam in receiver and clearance spaces by effecting compression to initial pressure in the high pressure and intermediate cylinders and receivers and, third, by curtailment of the percentage of waste through radiation to the condenser during low pressure exhaust, by a variable low pressure compression.

To this end, my invention, generally stated, consists in a novel method of effecting the distribution functions of a multiple expansion engine under any desired operative conditions, and maintaining a corresponding performance of such functions under variations of operative conditions, by supplying steam, throughout an automatically varied portion of the stroke of the piston, to a preliminary or high pressure cylinder, expanding the steam in said preliminary cylinder throughout the remaining portion of the stroke, exhausting the steam through an intermediate expansion chamber into a secondary cylinder, expanding the steam between the high pressure and the secondary cylinder throughout a portion of the stroke in the latter, automatically regulated in different degree from that in the high pressure cylinder, compressing steam in the expansion chamber to its initial pressure and afterward compressing it into the high pressure clearance space to its initial pressure, and, coincidently with this double high pressure compression, expanding steam in the secondary cylinder, exhausting the steam from the secondary cylinder through an intermediate expansion chamber into a tertiary cylinder and expanding it between the second and tertiary cylinders throughout a portion of the stroke in the latter automatically regulated in different degrees from that in the high pressure and intermediate cylinders, compressing steam in the intermediate expansion chamber to its initial pressure, and afterward compressing it into the intermediate cylinder's clearance space to its initial pressure, and coincidently with this double intermediate compression, expanding steam throughout the remaining portion of the stroke in the tertiary cylinder, exhausting the steam from the tertiary cylinder, continuing these operations throughout the series of cylinders, and finally exhausting from and effecting compression of steam in the low pressure cylinder, for a period and degree variable in correspondence with the coincident variations of cut off in the several cylinders. The improvement claimed is hereinafter fully set forth.

It has been heretofore and is now readily practicable to design and construct a multiple expansion steam engine which shall operate satisfactorily and develop a comparatively high degree of efficiency under the particular operative conditions for which it is specially designed, and which also will be readily adjustable to meet and provide for minor variations from such normal or designed conditions, but such engines, as heretofore constructed, have not proven capable of automatically adapting themselves to substantial variations from their normal conditions, so as to maintain the maximum attainable economy under each of the variations or conditions to which they may be subjected in practice.

My present invention provides the desired capacity of automatic adaptability to high economical performance under varying conditions, in which prior constructions, so far as my knowledge and information extend, have been deficient, and before proceeding to specifically describe an instance of its application, its leading and essential features may be generally described as follows. The required regulation of speed is effected by corresponding variation of the ratio of expansion by a governor, such ratio being so proportioned in the several cylinders that the range of temperature in each cylinder shall, at all times, be equalized, in respect to its effect on condensation and re-evaporation, while all functions of distribution are proportioned with the same accuracy under any particular operative conditions, as under the special conditions to meet which, as normal, the distribution mechanism is designed. A receiver or expansion chamber is located between each cylinder and the next succeeding cylinder.

The varying rapidity of recovery at different changes of temperatures, renders it necessary to unequally vary the point of cut off and consequent ratio of expansion in the several cylinders, always, however, to the end of equalizing the condensation and subsequent re-evaporation therein. The theoretical indicator diagram (Figs. 10 and 11) serve to illustrate the action desired and result accomplished in the operation of my invention under material variations of load. It will be seen that the greater range of variation of the ratio of expansion is in the preliminary or high pressure cylinder, while the ratio of expansion is similarly variable, although in a less degree, in each of the succeeding cylinders.

By the employment of different valve motions the cut off in the primary cylinder is variable within a considerable range, as in the instance indicated from three-fourths to one-half of the stroke while the cut off in the secondary cylinder is variable within a less range as from one-half to five-sixteenths, and the tertiary cylinder cut off is variable a still shorter range, as from three-eighths to one-fourth. By reason of such relative variation, while the relative range of temperatures varies slightly in the several cylinders, the corresponding relative rapidity of recovery counteracts the otherwise injurious effect of unequal condensation and re-evaporation. The constant quantities illustrated by these diagrams are, (first) compression in the receivers to their initial pressure; and (second) compression in the high pressure and intermediate cylinders to their initial pressure. For these constant quantities, proper relative proportions in the capacity of each clearance space and of receiver volumes are necessary, and these proportions are, in turn, dependent on the relative proportions of the cylinders. The variable quantities are, first, the points of cut off in the several cylinders and, second, the period and degree of low pressure compression. The low pressure clearance is made of as small volume as is consistent with other requirements, and equalizes the percentage of loss due to radiation to the condenser.

With a view to simplification a single governor and a connected series of eccentrics is herein shown, each of which eccentrics actuates an independent distribution valve for one of the cylinders of the engine, but it would be equally admissible if preferred, or deemed better adapted to a special design of the engine, to employ any number of valves, actuated by any number of eccentrics, provided that the governor or governors control the varying distributions in the manner hereinafter set forth.

In the accompanying drawings, which illustrate one form of multiple expansion engine adapted to the practice of my invention, Figure 1 is a vertical, longitudical central section; Fig. 2, an end view, as seen from the left; Fig. 3, a plan or top view; Figs. 4, 5, and 6, horizontal sections, at the lines u, u, v, v, and w, w, respectively, of Fig. 7; Fig. 7, a vertical longitudinal section, at the line x, x, of Fig. 3; Figs. 8 and 9, vertical transverse sections, at the lines y, y and z, z, respectively, of Fig. 4; and, Figs. 10 and 11, diagrams illustrating forms of indicator curves developed in the operation of an engine in accordance with my invention.

In the form herein described, the engine is shown as of the double acting vertical triple expansion type, and is provided with a preliminary or high pressure cylinder 1, a secondary or intermediate cylinder 2, and a tertiary or low pressure cylinder 3, all of which are secured to the top of a suitable crank case or housing 4, in the lower portion of which are located the bearings 5 of a main or crank shaft 6. The pistons 1^a, 2^a, and 3^a, of the primary, secondary, and tertiary cylinders are secured, respectively, to piston rods 1^b, 2^b, and 3^b, which are coupled, respectively, by connecting rods, 1^c, 2^c, and 3^c, to the pins of double cranks 5^a, 5^b, and 5^c, on the crank shaft 5.

The distribution functions of the primary cylinder 1 are effected by a distribution valve 7, of the piston type, which is fitted to reciprocate in a valve chest 7^a adjacent to the primary cylinder, and the distribution functions of the secondary and the tertiary cylinders are effected, respectively, by independent distribution valves 8 and 22, also of the piston type, and fitted, respectively, to reciprocate in valve chests 8^a and 22^a, located adjacent to, and communicating by ports with, the secondary and the tertiary cylinders respectively. Steam is admitted to the primary valve chest 7^a through a supply pipe connected to an inlet nozzle 7^b, and is finally exhausted from the tertiary valve chest 22^a, through an exhaust pipe connected to an outlet or discharge nozzle 22^c near the upper end of said valve chest. A receiver or expansion chamber 9 communicates, by ports 9^a, with the primary valve chest 1^a, and, by ports 9^b, with the secondary valve chest 8^a. Another receiver or expansion chamber 23, communicates, by ports 23^a, with the secondary valve chest 8^a, and by ports 23^b, with the tertiary valve chest 22^a.

The distribution valves 7, 8, and 22 which are of relatively different angular advance are actuated, respectively, by adjustable eccentrics 10, 10^a, and 10^b, which are mounted on the crank shaft 5 in positions of relatively different angular advance, with the capacity of movement transversely thereto, and are coincidently varied and controlled in position, relatively to the axial line of the crank shaft, by an automatic cut off governor 11, of any suitable and preferred construction, which is mounted on the crank shaft and coupled to the eccentrics, as indicated in Fig. 1, and (in dotted lines) in Fig. 2. In the instance shown, the eccentric rods 12, 12^a, 12^b, are, respectively, coupled at their upper ends to arms 13, 13^a, 13^b, of relatively different lengths, and fixed on horizontal rock shafts 14, 14^a, 14^b, respectively, said rock shafts being journaled in bearings in the upper portion of the housings or crank case, and having secured, upon their opposite ends, arms 15, 15^a, 15^b, differing relatively in length, proportionately to the lengths of the arms 13, 13^a, 13^b, and respectively coupled to the stems 7^d, 8^d, and 22^d, of the primary, secondary, and tertiary distribution valves 7, 8, and 22, respectively.

Under the above construction, the strokes of the several valves will be of different relative lengths and the centers of the eccentrics will be moved through unequal angles across the shaft and into positions of relatively different angular advance, in the adjustments effected by the governor.

Any other preferred construction of valve mechanism having the capability of effecting cut off at different desired portions of the stroke, as, for example, the well known Corliss valve gear, might be applied in lieu of that shown, if, as in the present instance, the distribution functions of the valves are controlled by a single governor, in such manner as to vary the points of cut off unequally in the several cylinders, as in the construction described and shown herein.

In the operation of a multiple expansion engine provided with a distribution valve system embodying the same or substantially the same essential and characteristic features as that hereinbefore described, and assuming the moving members to be initially in the several positions shown in the drawings, steam from the boiler is admitted to the chest of the primary distribution valve 7, between the two end pistons of said valve, and passes into the primary cylinder through the upper induction port thereof, effecting the downward stroke of the piston 1^a, and being cut off at the desired point in the stroke by the governor. The steam which has effected the preceding upward stroke of the piston 1^a of the primary cylinder, passes out of the cylinder through the lower induction port, thence into the valve chest 7^a below the valve 7, and into the receiver 9, through which it passes under compound expansion, through the ports 9^b, through the body of the valve 8, and through the lower induction passage, into the secondary cylinder 2, effecting the upward stroke of its piston 2^a, and being cut off at a point of the stroke bearing the desired relation to the ratio of expansion in the primary cylinder, by the governor. The continued downward movement of the piston 1^a, of the primary cylinder after cut off in the secondary cylinder, compresses the steam in the receiver 9 to its initial pressure, when the lower piston of the valve 7 cuts off communication between the upper induction passage and the receiver, and thereupon, the residue of the downward movement of the piston 1^a, compresses steam in the clearance space of the primary cylinder to initial pressure. The steam which has effected the preceding downward stroke of the piston 2^a of the secondary cylinder, passes out of said cylinder through the upper induction passage into the valve chest 8^a, and around the body of the valve 8, to the receiver 23, and through the receiver 23 into the valve chest 22^a of the tertiary cylinder 3, around the body of the valve 22. From the valve chest 22, the steam passes into the tertiary cylinder through the upper induction port thereof, effecting the downward stroke of the piston 3^a, and being cut off at the desired point in the stroke, different from those in the preceding cylinders, by the governor. The continued upward movement of the piston 2^a, of the secondary cylinder, after cut off in that cylinder, compresses steam in the receiver 23 between the secondary and tertiary cylinders, to its initial pressure, whereupon the upper piston of the valve 8 cuts off communication between the upper induction passage of the secondary cylinder and the receiver 23, and the residue of the upward movement of the piston 2^a, compresses steam in the clearance space of the secondary cylinder to its initial pressure. The steam which has effected the preceding upward stroke of the piston 3^a of the tertiary cylinder, passes out of said cylinder, through the lower induction passage and through the body of the valve, to the condenser or to the atmosphere, as the case may be, until the valve 22 cuts off communication from the lower induction passage of the tertiary cylinder to the exhaust outlet, from which period until the end of the stroke, the remainder of the steam below the tertiary piston is compressed into its clearance space, the degree and period of such low pressure compression varying correspondingly with variation of the points of cut off in the several cylinders.

The operations described as to the primary and secondary cylinders would be similarly repeated with any number of cylinders beyond the secondary cylinder, and may be completed at that cylinder, with a variable low pressure compression as described, or they may be carried through any desired number of additional cylinders, a variable low pressure compression being effected in the ultimate cylinder.

I claim as my invention and desire to secure by Letters Patent—

1. The improvement in the method of steam distribution in multiple expansion engines, which consists in coincidently and automatically varying all the distribution functions in all the cylinders of the engine, similarly and in respectively different degrees, substantially as set forth.

2. The improvement in the method of steam distribution in multiple expansion engines which consists in coincidently and automatically varying the expansion in all the cylinders, similarly and in respectively different degrees, substantially as set forth.

3. The improvement in the method of steam distribution in multiple expansion engines which consists in coincidently and automatically varying the expansion in all the cylinders, the degree of variation in the primary cylinder being different from that in the succeeding cylinders or either of them, substantially as set forth.

4. The improvement in the method of steam distribution in multiple expansion engines which consists in expanding steam in all the cylinders, effecting high pressure compression and intermediate compression to initial pressure, and effecting a low pressure compression which is variable in period and degree, substantially as set forth.

5. The improvement in the method of steam distribution in multiple expansion engines which consists in coincidently and automatically varying the expansion and period of compression in all the cylinders, effecting high pressure compression and intermediate compression to initial pressure, and effecting a low pressure compression which is varied in period coincidently with and proportionately to variations of expansion, substantially as set forth.

In testimony whereof I have hereunto set my hand.

FRANCIS M. RITES.

Witnesses:
J. SNOWDEN BELL,
R. H. WHITTLESEY.