(No Model.) 5 Sheets—Sheet 1.

F. M. RITES.

METHOD OF STEAM DISTRIBUTION IN TRIPLE EXPANSION ENGINES.

No. 502,501 Patented Aug. 1, 1893.

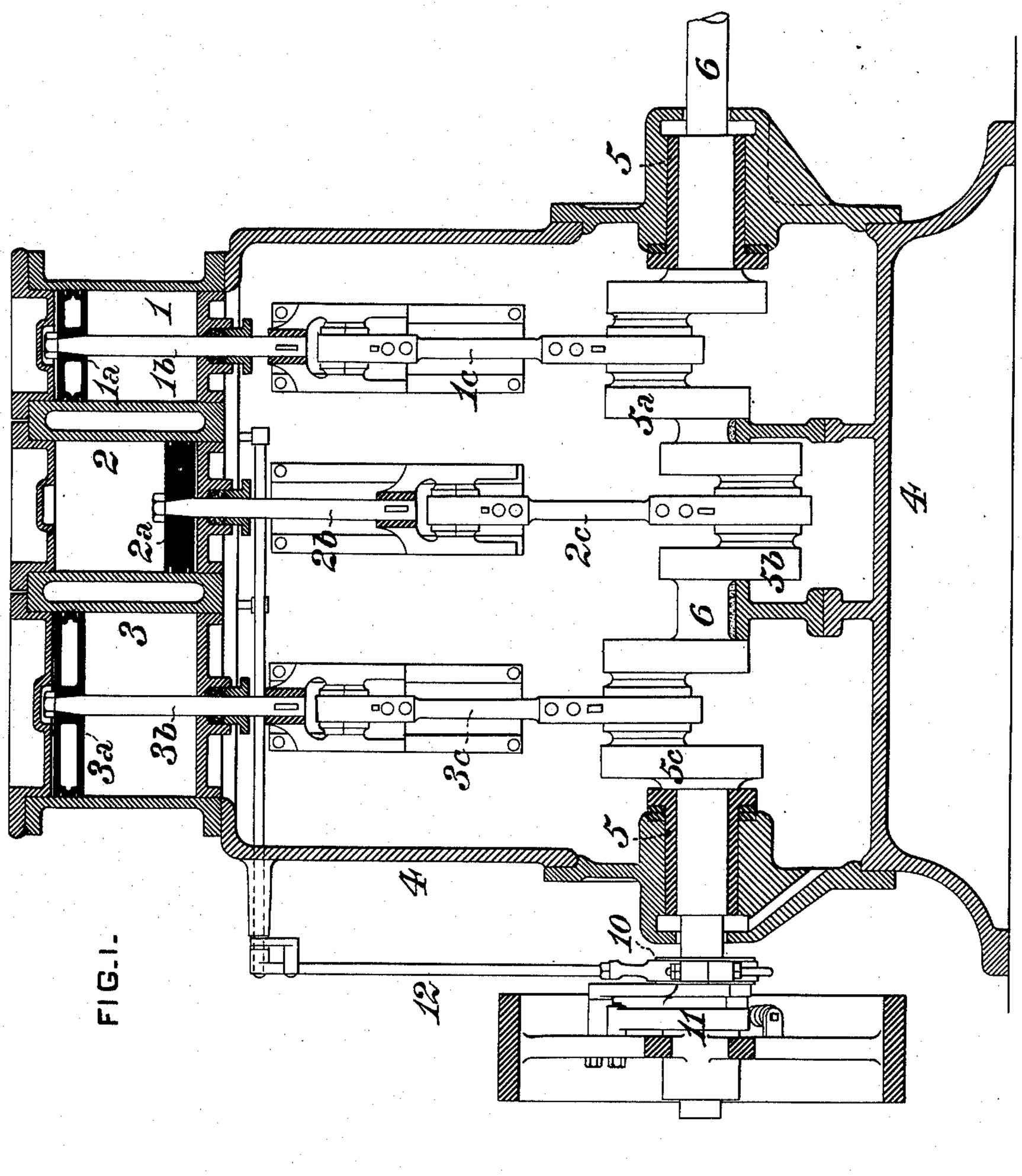


FIG. 1.

WITNESSES:

T. J. Hogan.

F. E. Gaither.

INVENTOR,

Francis M. Rites,

by J. Howden Bell,

Att'y.

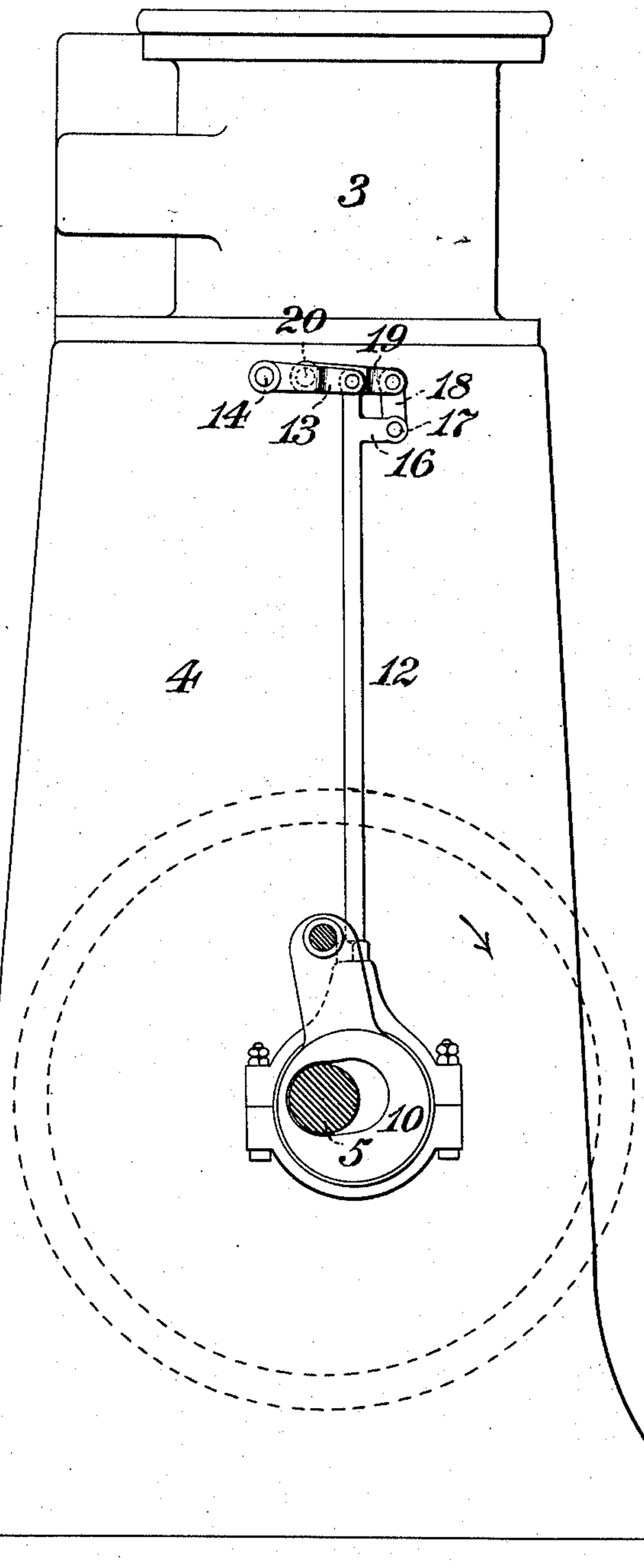
(No Model.) 5 Sheets—Sheet 2.

F. M. RITES.

METHOD OF STEAM DISTRIBUTION IN TRIPLE EXPANSION ENGINES.

No. 502,501. Patented Aug. 1, 1893.

FIG. 2.



WITNESSES:

T. J. Hogan.

F. E. Gaither

INVENTOR,

Francis M. Rites,

by J. Thorndew Bell,

Att'y.

(No Model.) 5 Sheets—Sheet 3.

F. M. RITES.

METHOD OF STEAM DISTRIBUTION IN TRIPLE EXPANSION ENGINES.

No. 502,501. Patented Aug. 1, 1893.

FIG. 3.

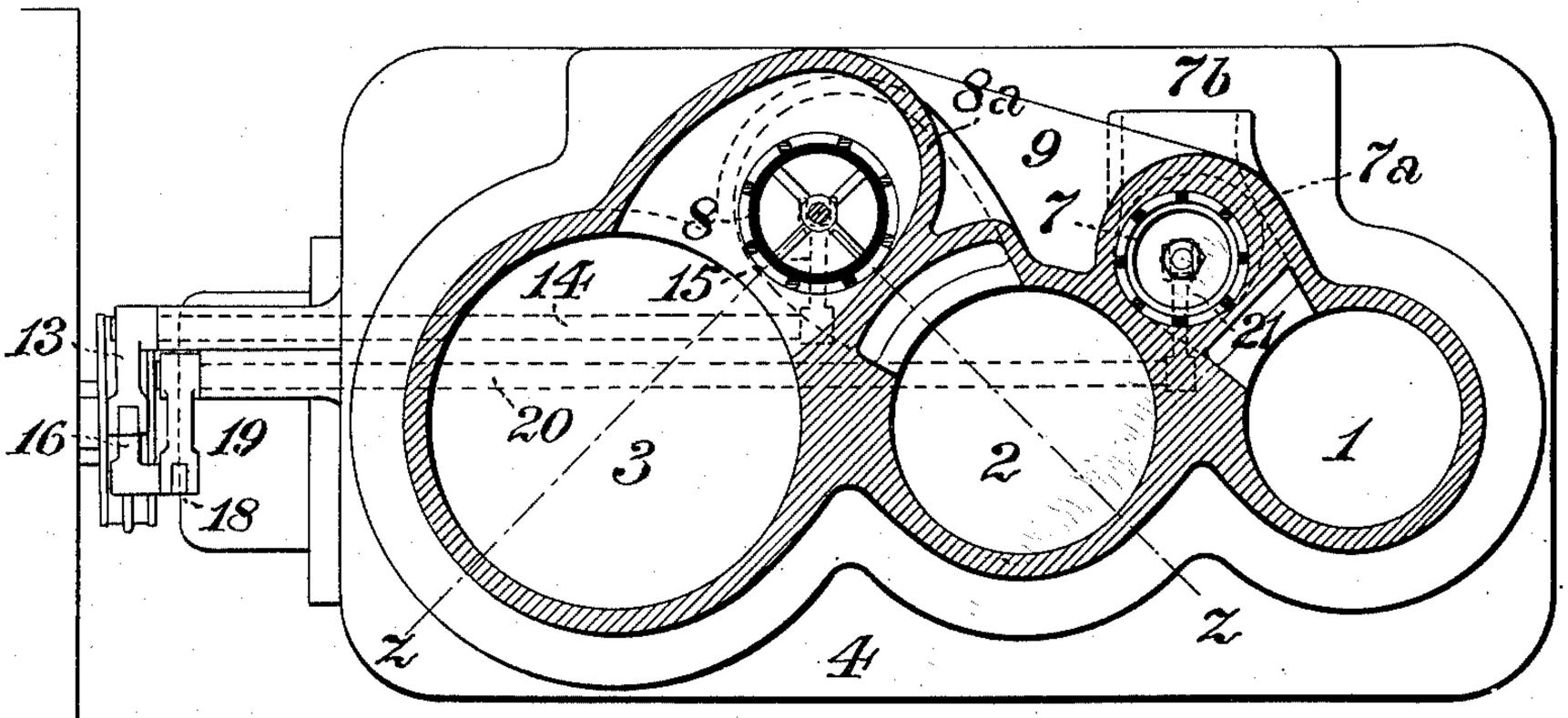
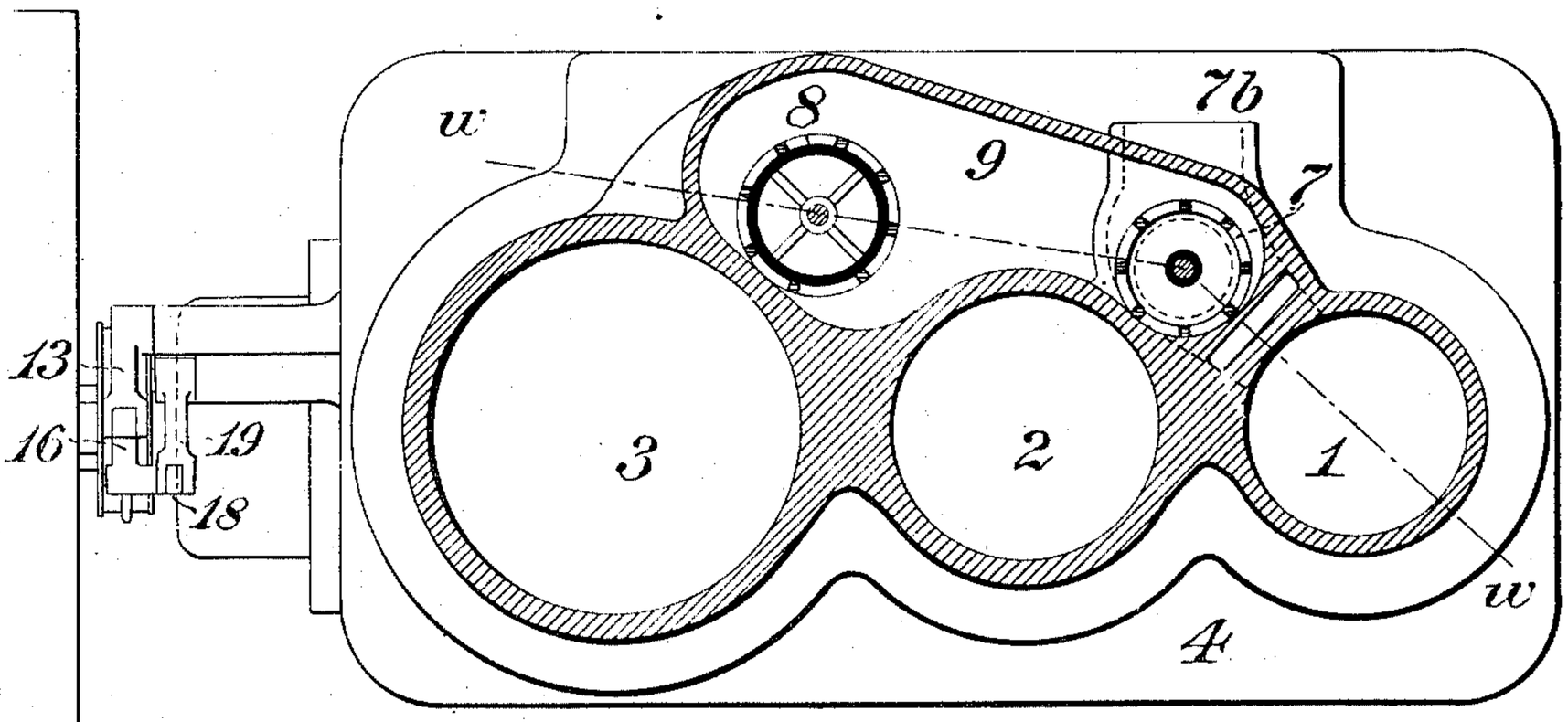


FIG. 4.



WITNESSES:
T. J. Hogan.
F. E. Gaither

INVENTOR.
Francis M. Rites,
by J. Hamilton Bell, Att'y.

(No Model.) 5 Sheets—Sheet 4.

F. M. RITES.

METHOD OF STEAM DISTRIBUTION IN TRIPLE EXPANSION ENGINES.

No. 502,501. Patented Aug. 1, 1893.

FIG. 5.

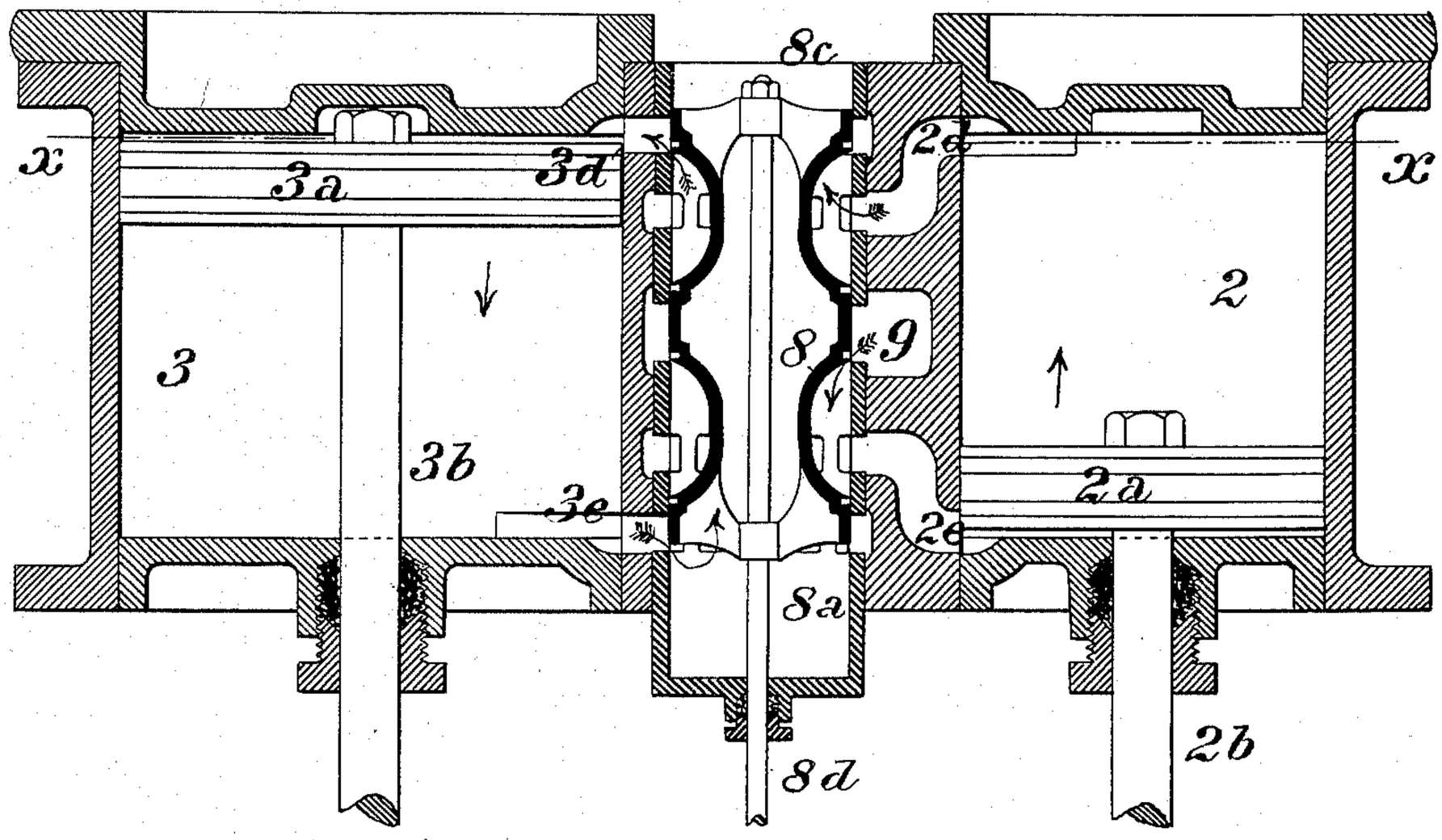
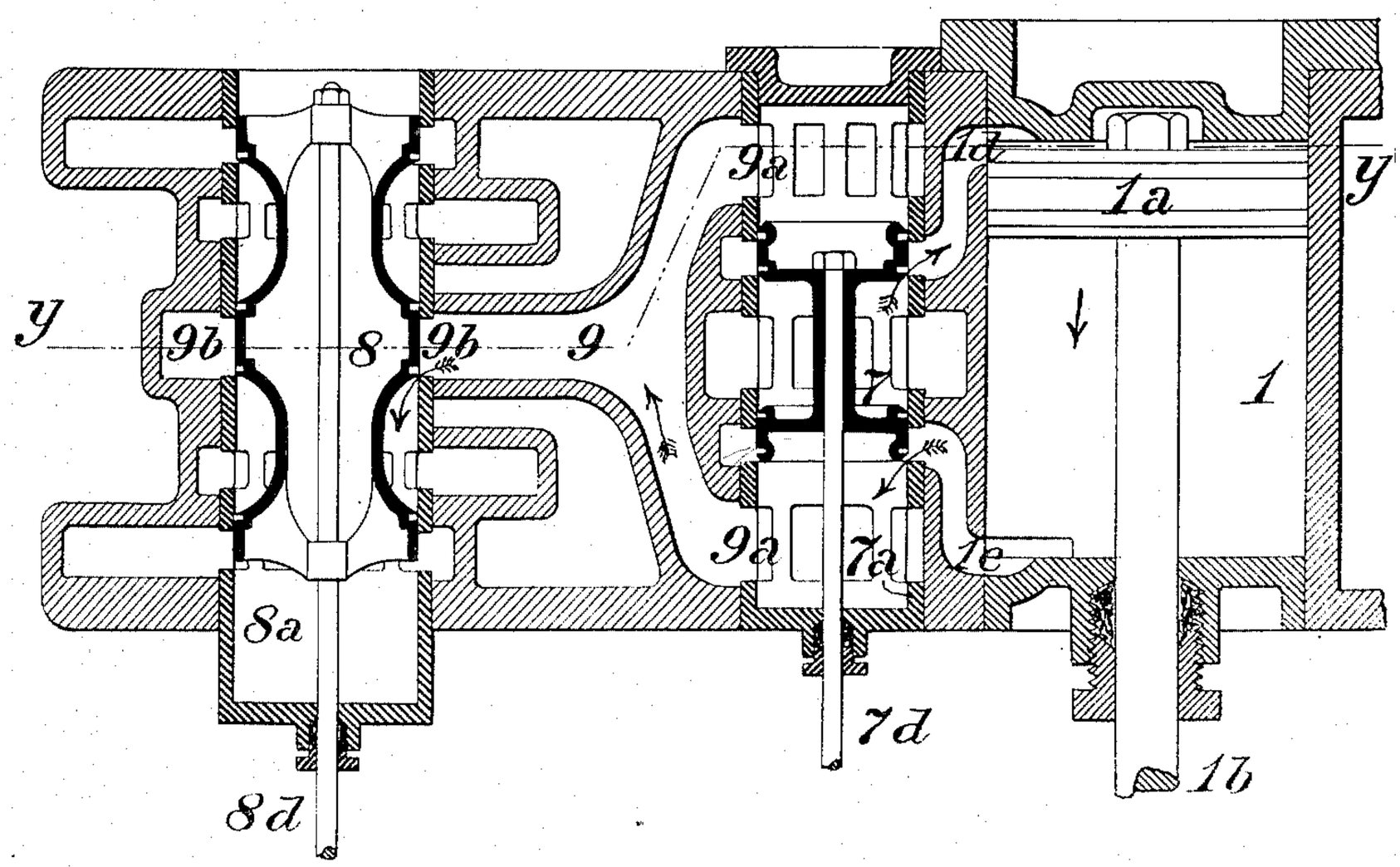


FIG. 6.



WITNESSES:

T. J. Hogan.
F. E. Gaither.

INVENTOR,

Francis M. Rites,
by J. Bowden Pell
Att'y

(No Model.) 5 Sheets—Sheet 5.

F. M. RITES.

METHOD OF STEAM DISTRIBUTION IN TRIPLE EXPANSION ENGINES.

No. 502,501. Patented Aug. 1, 1893.

FIG. 7.

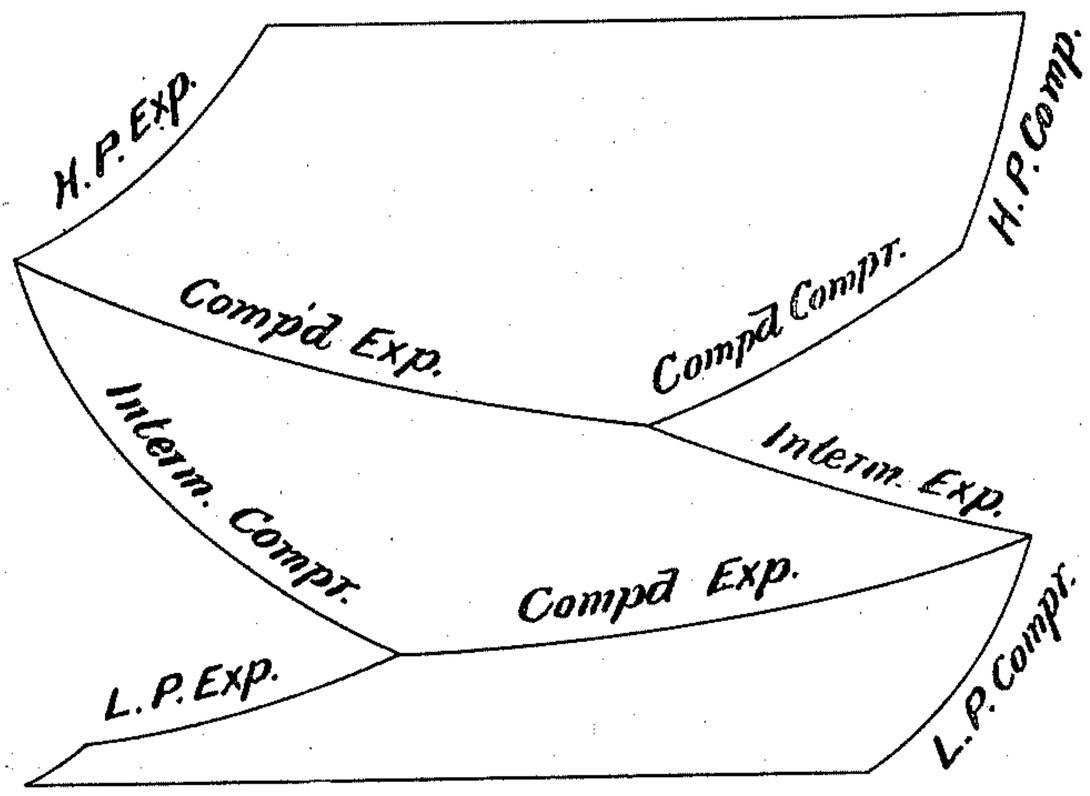
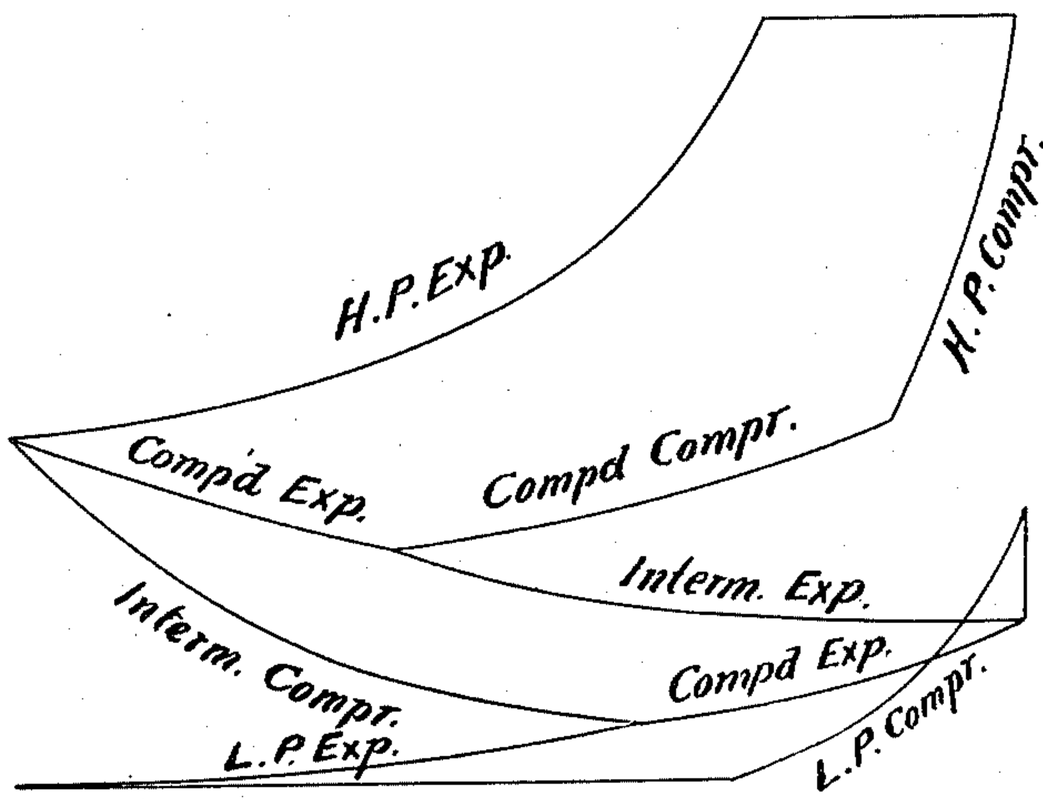


FIG. 8.



WITNESSES:
T. J. Hogan.
W. E. Gaither

INVENTOR,
Francis M. Rites,
by Howson & Sell
Att'y.

UNITED STATES PATENT OFFICE.

FRANCIS M. RITES, OF ALLEGHENY, PENNSYLVANIA.

METHOD OF STEAM DISTRIBUTION IN TRIPLE EXPANSION ENGINES.

SPECIFICATION forming part of Letters Patent No. 502,501, dated August 1, 1893.

Application filed April 14, 1892. Serial No. 429,186. (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 Triple 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 triple 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 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 receiver, and, third, by curtailment of the percentage of waste through radiation to the condenser during low pressure exhaust, by a variable low pressure compression.

The improvement claimed is hereinafter fully set forth.

It has been heretofore and is now readily practicable to design and construct a multiple cylinder 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 of 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. By reason of the rapid fall of pressure, and, incidentally, that of temperature, during compound expansion from higher pressures, it is desirable to employ a receiver or expansion chamber, located between the high pressure and intermediate cylinders, while, on the other hand, the change in the lower pressures during compound expansion being comparatively slight, it is preferable to expand directly from the intermediate into the low pressure 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 diagrams (Figs. 7 and 8) 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 the intermediate and low pressure cylinders.

By reason of the varying angularity of the eccentric rod, the cut off in the high pressure cylinder is variable within a considerable range, as in the instance indicated, from three-fourths to one-fourth of the stroke, while

the cut off in the intermediate and low pressure cylinders is variable within a comparatively short range only, as, from five-eighths to three-eighths of the stroke. 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, (1) compression in the receiver to its initial pressure; (2) compression in the high pressure cylinder to its initial pressure, and, (3) compression in the intermediate cylinder and its continuously communicating clearance chamber to its initial pressure. For these constant quantities, proper relative proportions in the capacity of each clearance space and of receiver volume 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, the employment of two distribution valves only, one of which effects distribution to the high pressure cylinder and the other to the intermediate and low pressure cylinders, as in the construction hereinafter described, is deemed preferable by me, but a separate valve or valves for each cylinder, all actuated by and dependent upon a single eccentric movement controlled by a governor, so that the distribution functions of all the valves are coincidently varied, would be equally admissible if desired. In the instance in which each of the three cylinders is provided with an independent distribution valve or valves, there would be three points of attachment to the actuating arm of the eccentric rod in order to effect a progressive series of ratios of expansion in the several cylinders.

In the accompanying drawings, which illustrate one form of triple expansion engine adapted to the practice of my invention, Figure 1 is a vertical, longitudinal central section; Fig. 2, an end view, as seen from the left; Figs. 3 and 4, horizontal sections, on an enlarged scale, at the lines x, x, of Fig. 5, and y, y, of Fig. 6, respectively; Figs. 5 and 6, vertical sections, on a further enlarged scale, at the lines z, z, of Fig. 3, and w, w, of Fig. 4, respectively, and Figs. 7 and 8, diagrams illustrating forms of indicator curves developed in the operation of a triple expansion engine in accordance with my invention.

In the form herein described, the triple expansion engine is shown as of the double acting vertical type, and is provided with a preliminary or high pressure cylinder 1, an intermediate cylinder 2, and a 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 high pressure, intermediate, and low pressure 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 high pressure 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 high pressure cylinder, and the distribution functions of both the intermediate and low pressure cylinders are effected by a single distribution valve 8, also of the piston type, and fitted to reciprocate in a valve chest 8^a, located adjacent to, and between the center lines of, the intermediate and low pressure cylinders. Steam is admitted to the high pressure valve chest 7^a, through a supply pipe connected to an inlet nozzle 7^b, and is finally exhausted from the intermediate and low pressure valve chest 8^a, through an exhaust pipe connected to an outlet or discharge nozzle 8^c, at the upper end of said valve chest. A receiver or expansion chamber 9 is formed in the cylinder casting, and communicates by ports 9^a with the high pressure valve chest 7^a, and, by ports 9^b, with the intermediate and low pressure valve chest 8^a.

The distribution valves 7 and 8 are actuated by a single adjustable eccentric 10, which is mounted on the crank shaft 5 with the capacity of movement transversely thereto, and is 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 eccentric. In the instance shown the eccentric rod 12 is coupled, at its upper end, to an arm 13, on a horizontal rock shaft 14, journaled in bearings in the upper portion of the housings or crank case, and having secured upon its opposite end an arm 15, shown in dotted lines in Fig. 3, which is coupled to the stem 8^d, of the intermediate and low pressure distribution valve 8. A lateral arm or projection 16 is formed upon the eccentric rod 12 near its upper end, substantially at right angles to the center line of the rod, and carries, upon its outer end, a pin 17, which is coupled, by a link 18, to an arm 19, on one end of a horizontal rock shaft 20, journaled in bearings parallel with the rock shaft 14. An arm 21, on the opposite end of the rock shaft 20, which arm, as well as said rock shaft, are shown in dotted lines in Fig. 3, is coupled to the stem 7^d of the high pressure distribution valve.

The means above described for actuating the high pressure distribution valve and the intermediate and low pressure distribution valve by a single adjustable eccentric con-

trolled by a governor are substantially similar in construction and operation to those set forth in Letters Patent of the United States No. 356,376, for improvement in valve mechanism for compound engines, granted and issued to me under date of January 18, 1887, and do not, in and of themselves, form part of my present invention. The effect of the lateral connection of the stem of the high pressure distribution valve to the eccentric rod, is, as in the construction of said Letters Patent, to impart to said valve a movement corresponding to that which it would receive from an eccentric of greater throw and less angular advance than the eccentric 10, and it will be obvious that, if desired, the two valves might be actuated by separate eccentrics, of different throw and angular advance respectively, and both adjusted and controlled by a governor, such alternative construction being, in the engine herein set forth, and for the purposes of my present invention, the mechanical equivalent of that herein shown and described. Further, 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, all the distribution functions of all the valves are controlled by a single governor.

In the operation of a triple 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 high pressure distribution valve 7, between the two end pistons of said valve, and passes into the high pressure cylinder through the upper induction port 1^d 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 high pressure piston 1^a, passes out of the cylinder through the lower induction port 1^e, thence into the valve chest 7^a below the valve 7, and into the receiver 9, from which it passes under compound expansion, through the ports 9^b, around the body of the valve 8, and through the lower induction passage 2^e, into the intermediate 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 high pressure cylinder, by the governor. The continued downward movement of the high pressure piston 1^a, after cut off in the intermediate 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 passage 1^e and the receiver, and thereupon, the residue of the downward movement of the high pressure piston compresses the steam in the clearance space of the high pressure cylinder to initial pressure. The steam which has effected the preceding downward stroke of the piston 2^a of the intermediate cylinder, passes out of said cylinder through the upper induction passage 2^d into the valve chest 8^a, and, around the body of the valve 8, to and through the upper induction passage 3^d into the low pressure cylinder, effecting the downward stroke of its piston and being cut off at a point of the stroke bearing the desired relation to the ratio of expansion in the high pressure and intermediate cylinders, by the governor.

The continued upward movement of the piston 2^a, of the intermediate cylinder, after cut off in the low pressure cylinder, compresses the steam in the clearance space of the intermediate cylinder, and in the clearance chamber formed by the space between the body of the valve 8 and its valve chest 8^a, to initial pressure. The steam which has effected the preceding upward stroke of the low pressure piston is exhausted through the lower induction passage 3^e, and through the body of the valve 8 and exhaust outlet 8^e, to the condenser or to the atmosphere, as the case may be, until the valve 8 cuts off communication from the lower induction passage 3^e of the low pressure cylinder to the exhaust outlet, from which period until the end of the stroke, the remainder of the steam below the low pressure 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.

I do not claim herein a method of steam distribution which consists in coincidently varying the expansion in all the cylinders, the degree of expansion in the high pressure cylinder being different from that in either of the succeeding cylinders, nor expanding steam in all the cylinders, effecting high pressure compression and intermediate compression to initial pressure and effecting a low pressure compression variable in pressure and degree, nor coincidently varying the expansion and period of compression in all the cylinders, effecting high pressure compression and intermediate compression to initial pressure, and effecting low pressure compression varied in degree coincidently with and proportionately to variations of expansion. Claims for substantially the same subject matter are made by me in a separate application, Serial No. 446,247, filed September 19, 1892.

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

The improvement in the method of steam distribution in triple expansion engines which consists in expanding steam in all the cylinders, intermediately expanding through a receiver from the high pressure to the interme-

diate cylinder, effecting a double high pressure compression, that is to say, a compression in both the receiver and in a high pressure clearance space to initial pressure in each case, effecting intermediate cylinder compression to initial pressure, directly expanding from the intermediate to the low pressure cylinder, and effecting a low pressure cylinder compression which is variable both in period and degree, substantially as set forth.

In testimony whereof I have hereunto set my hand.

FRANCIS M. RITES.

Witnesses:
J. SNOWDEN BELL,
J. L. RALPH.