(No Model.) 2 Sheets—Sheet 1.

M. Mac MAHON.

Compound Steam Engine.

No. 238,241. Patented March 1, 1881.

Fig. 1

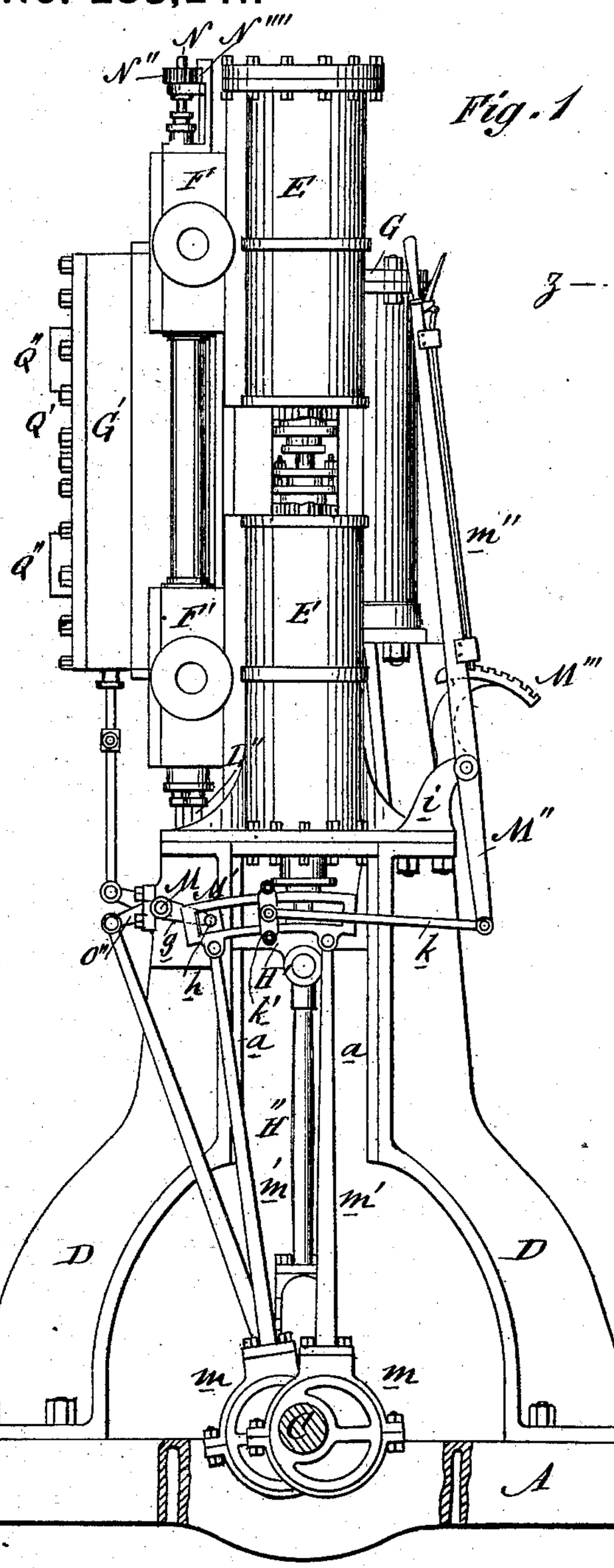
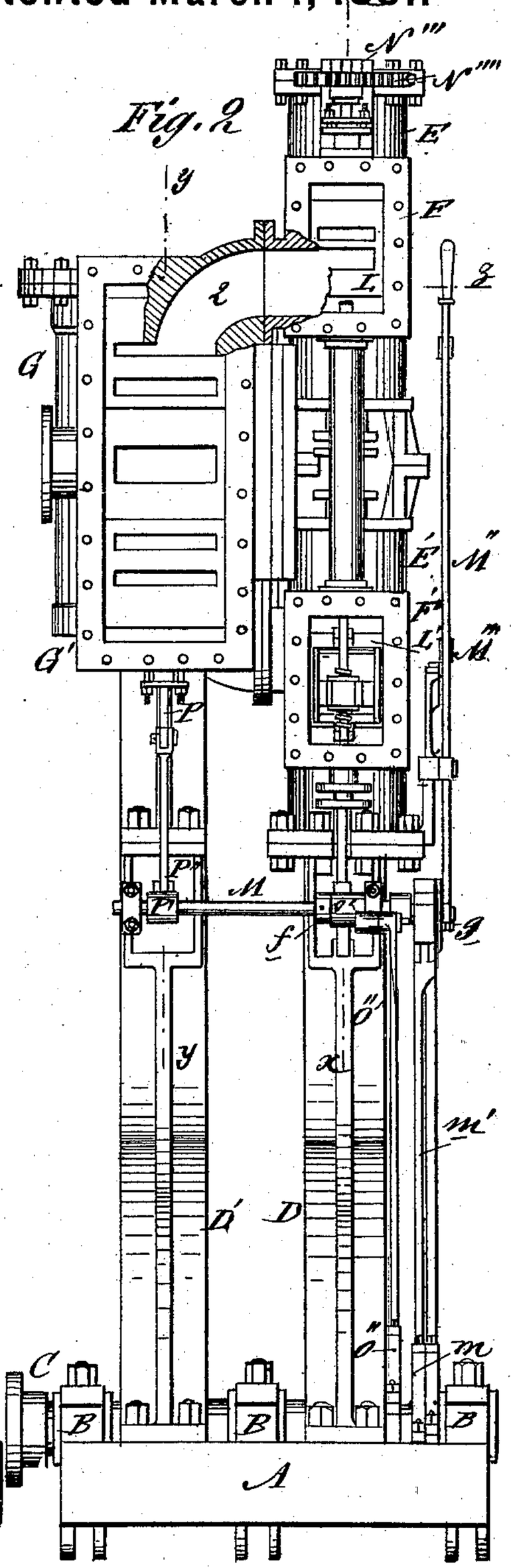


Fig. 2



WITNESSES:

C. Neveux

C. Sedgwick

INVENTOR:

M. MacMahon

BY Munn & Co.

ATTORNEYS.

(No Model.) 2 Sheets—Sheet 2.

M. MacMAHON.

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No. 238,241. Patented March 1, 1881.

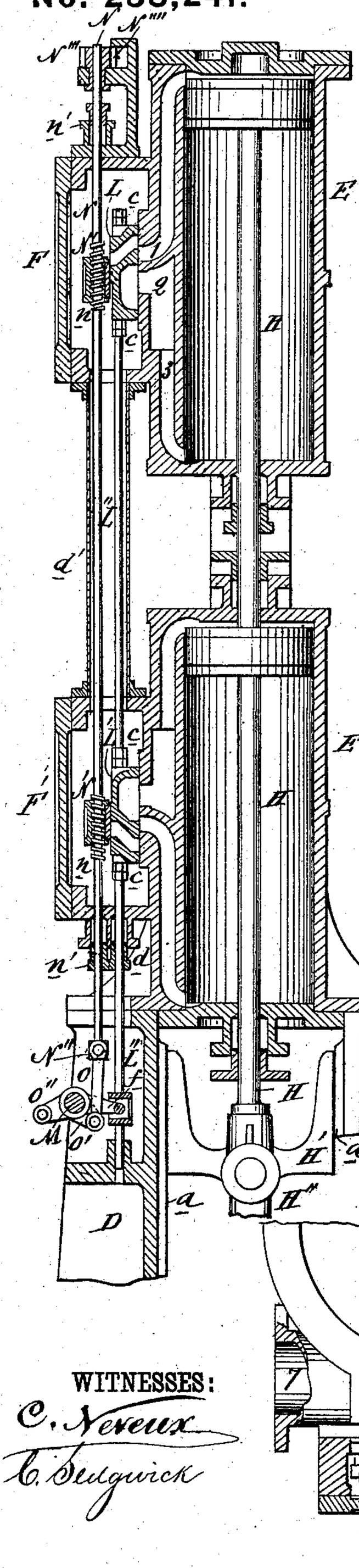

Fig. 3

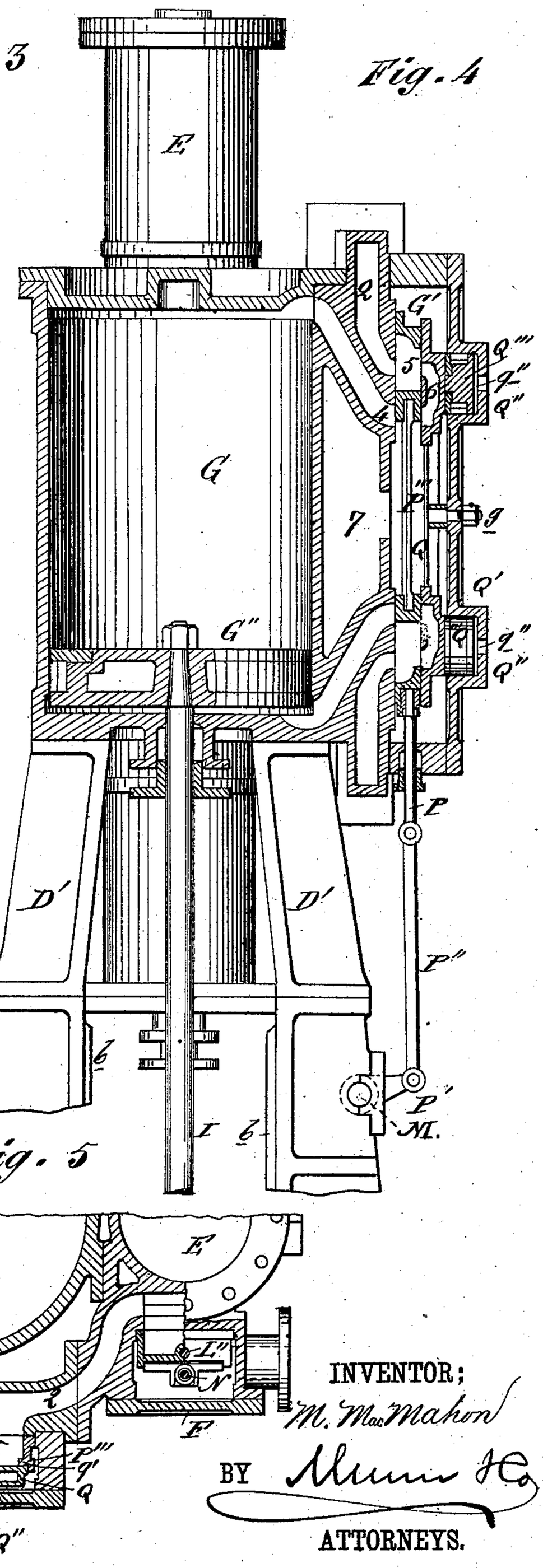

Fig. 4

Fig. 5

WITNESSES:

C. Neveux

C. Sedgwick

INVENTOR;

M. MacMahon

BY Munn & Co

ATTORNEYS.

UNITED STATES PATENT OFFICE.

MICHEAL MACMAHON, OF BROOKLYN, NEW YORK, ASSIGNOR OF ONE-FOURTH TO SAMUEL VANNESS, OF SAME PLACE.

COMPOUND STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 238,241, dated March 1, 1881.

Application filed June 16, 1880. (No model.)

To all whom it may concern:

Be it known that I, MICHEAL MACMAHON, of Brooklyn, in the county of Kings and State of New York, have invented a new and Improved Equilibrium-Piston Compound Steam-Engine, of which the following is a specification.

This invention relates to that class of steam-engines in which, by the arrangement and operation of suitable valves and ports, the exhaust-steam is conducted from the one to the other side of the piston, and into a communicating low-pressure or vacuum cylinder, for the purpose of equalizing the pressure upon the said piston.

The invention consists of a three-cylindered engine, two of which are called the "high-pressure" cylinders, and the third and larger one the "low-pressure" or "vacuum" cylinder. The high-pressure cylinders receive steam direct from the boiler, but only in one end of each. The pistons of both these high-pressure cylinders are on one rod, which rod is connected to a crank directly opposite the crank of the low-pressure cylinder, and by the admission of steam to the opposite or extreme end of each alternately a similar action to that of a single cylinder admitting steam alternately above and below the piston is obtained; but the similarity ceases there, as in all other respects the action of the steam in these cylinders differs from the action of the steam in the high-pressure cylinder of the present form of compound engine.

Steam being admitted to either high-pressure cylinder, it is cut off and allowed to expand in the usual manner; but, instead of exhausting directly into the low-pressure cylinder, it exhausts first into the opposite end of said high-pressure cylinder, and enters the low-pressure cylinder at the proper instant of time for "lead," the valves of both cylinders being constructed and set especially with the view of securing the proper distribution of the steam. The steam then continues, during the whole period of exhaust, to entirely fill this first high-pressure cylinder above and below the piston, said piston undergoing all the variations of pressure due to the expansion of the steam through its admission to the low-pressure cylinder, and these variations take place equally on both sides of the first high-pressure piston at the same instant of time, and consequently said piston is *in equilibrio* during all the time of exhaust to the low-pressure cylinder, and being on the same rod with the second high-pressure piston next receiving steam from the boiler, and whose lower side is in communication with a condenser, the said first high-pressure piston meets with no resistance to its motion. At the proper time for lead in relation to the stroke of the engine, this second high-pressure cylinder receives steam to produce the return-stroke to complete the revolution; but having yet to deal with the first admission of steam from the boiler, it is necessary to remember that the second admission of steam (the first admission into the second high-pressure cylinder) is really actuating the piston which received the first steam, as well as the piston on which it is now acting directly, and that this first piston is now *in equilibrio*, permitting both itself and the second piston to be impelled with all the force due to the full effective pressure of the steam admitted into the second cylinder, less whatever back-pressure is due to the uncondensed steam remaining in the condenser above a perfect vacuum, the under side of the second piston being, as stated, in communication with a condenser. Following this first admission of steam in its action until it enters the condenser will serve to show the action of steam in the second cylinder, and thereafter in both. The first supply of steam, having gone through its usual course of admission, cut-off, and expansion in one end of the first cylinder, is allowed, having completed a half-stroke of the engine, to exhaust into the opposite end of said cylinder and into the lower end of the low-pressure cylinder, where it undergoes a further expansion, that is communicated or distributed to both ends of the first high-pressure cylinder. This completes one revolution of the engine, and the communication between the lower ends of the first high-pressure cylinder and the low-pressure cylinder is then closed by the valve, and said first high-pressure cylinder is again ready to receive steam from the boiler. In the meantime the communication between the low-pressure cylinder and that

end of the first high-pressure cylinder which is not in connection with the boiler remains open, and the time the exhaust to the condenser commences both low-pressure and first high-pressure pistons are being simultaneously and equally affected by the partial vacuum produced in the condenser; and thus what is usually called the "high-pressure" cylinder, in contradistinction to the condensing-cylinder, becomes, in effect, a condensing-cylinder, effectually eliminating back-pressure and substituting an approximate vacuum instead, and so enabling the area of its piston to be added to the area of the low-pressure piston during condensation, for effective work, in addition to the advantage obtained by the absence of back-pressure, and securing, also, a further gain of mean absolute pressure of steam on the low-pressure piston, a pressure due to the terminal pressure of steam in the high-pressure cylinder becoming the initial pressure in the low-pressure cylinder.

The manner in which the steam from the high-pressure cylinders enters the low-pressure cylinder secures the advantage derived from perfect continued expansion, thereby giving to both high-pressure cylinders of this compound engine all the important features possessed by a single-cylinder engine, while still retaining the superior features of the compound engine.

The distribution of the steam in the high-pressure cylinders is effected and controlled by valves of the usual construction provided with cut-off plates sliding on the backs thereof; but the distribution of the steam to the low-pressure cylinder is effected by means of an improved balance-valve sliding between the face of the cylinder and the face of a valve suspended upon a bolt in the valve-chest cover, as shown in the drawings.

Figure 1 is a front elevation of the engine, partly in section. Fig. 2 is a side elevation of the same, partly in section. Fig. 3 is a vertical sectional elevation of a portion of the engine on line *x x*, Fig. 2. Fig. 4 is a vertical sectional elevation of a portion of the engine on line *y y*, Fig. 2. Fig. 5 represents a transverse section on line *z z*, Fig. 2.

Similar letters of reference indicate corresponding parts.

In the drawings, A represents the bed-plate; B, the journal-boxes for the double crank-shaft C, and D D′ represent the standards. The standards D support the high-pressure cylinders E E′, that are set one above the other and their respective valve-chests F F′, while the standards D′ support the low-pressure cylinder G and its valve-chest G′.

H is the piston-rod common to the two high-pressure cylinders E E′, and having secured on it the respective high-pressure pistons. H′ is the cross-head, moving in the ordinary manner between guides *a* of the standard D; and H″ is the pitman connecting said piston-rod H with a crank of the driving crank-shaft C, as shown.

I is the piston-rod of the low-pressure cylinder G, and having fixed on it the low-pressure piston G″. The piston-rod I is provided with a cross-head moving in the ordinary manner between guides *b* of the standards D′, and with a pitman connecting said piston-rod I with a crank of the driving-shaft C, opposite the crank to which the piston-rod H is connected.

The valves L L′ of the high-pressure cylinders E E′, respectively, are fixed and adjusted in the usual manner by nuts *c c*, on the valve-rod L″, which valve-rod passes down through suitable stuffing-boxes *d* and tube *d′*, and has its lower end engaged with a lever, *f*, that is rigidly fixed on the horizontal rock-shaft M, whose end crank, *g*, is connected with a sliding block, *h*, that moves in the slot of the link M′ as the latter is adjusted by the lever M″, that is pivoted on the lug *i* through the medium of the rod *k* and pin *k′*. The said link M′, the eccentrics *m m*, that are keyed on the driving-shaft C, and the rods *m′ m′*, (one for the forward and the other for the backward movement of the engine,) that are connected to the respective ends of the link M′, constitute the link-motion for reversing the engine, and the controlling-lever M″ is retained in any position that may be given to it by the engagement of its sliding spring-rod *m″* in the notched segment-bar M‴.

N is the cut-off valve-rod, provided with right and left screws *n n*, for the adjustment of the sliding-valve plates N′ N′, that move on the backs of the slide-valves L L′. Said rod N is arranged parallel with the valve-rod L″, and passes through suitable stuffing-boxes *n′ n′*, tube *d′*, and valve-chest F F′, and is connected at its lower end to a cross-head, N″, within which it turns, said turning being effected by means of a pinion, N‴, within which said rod N has also a vertical sliding motion fixed on the upper end of said rod and operated by a movable rack, N⁗, as shown. The cross-head N″ obtains motion through the connecting-links O and lever O′, which latter is movable on the rock-shaft M, which are actuated by the eccentric, eccentric-rod, and lever O″, the eccentric of this combination being secured on the shaft C. The links O are severally suspended from or attached to the two opposite arms of the cross-head N. The rock-shaft M also operates, through the connecting-lever P′ and link P″, the valve-rod P of the low-pressure cylinder balanced valve P‴. This balanced valve P‴ is held against the face of the low-pressure cylinder G by means of the valve-plate Q, that is suspended by the bolt *g*, which passes centrally through the valve-chest cover Q′. This valve-plate Q is retained in its vertical position by means of the projections *q′* on the back of the slide-valve P‴, which latter is held in a vertical position in the usual manner. The valve-chest cover Q′ is provided with two cylindrical projections, Q″, within which are fitted steam-tight pistons Q‴ that are pressed against the back of the suspended valve-plate Q by steam admitted from the boiler against the back of said

pistons Q''' through the openings q'' in the said projections Q'', thereby keeping the valve-plate Q pressed closely upon the back of the valve P''', and the latter steam-tight against its seat.

In lieu of the steam-actuated pistons Q''', springs may be used for the purpose of holding the valve-plate and valve steam-tight against their respective seats.

The parts being in position shown in Figs. 3 and 4, and steam being admitted to the valve-chests F F' of the high-pressure cylinders, the steam enters through the valve L and port of the cylinder E, and having driven the piston E to the end of the stroke, the piston G'' of the low-pressure cylinder G at the same time being moved in the opposite direction, the position of the valve L is changed, and the steam is permitted to exhaust through the port 1 into the ports 2 3, and from port 2 through the sliding valve P''' to port 4, and thence into low-pressure cylinder G, above the piston G'', where said exhaust-steam then forces the piston G'' to the end of the stroke. Then the reversal of the movement of the valve P''' opens a communication between the upper end of the cylinder G and the lower end of the cylinder E, and simultaneously into the condenser that is designed to be connected with the engine, and the steam from the cylinder G then escapes through port 4, and at the same time from the cylinder E through ports 2 5 6 into the valve-chest G', whence it passes to the condenser through port 7. On the return-stroke of the engine a similar movement and action of the steam occurs in connection with the cylinders G and E', and their respective parts.

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

1. The combination, with the high-pressure steam-cylinders E E', provided with suitable pistons, ports, and valves, and a common piston-rod, of the low-pressure cylinder G, connected therewith by steam-passages and provided with slide-valve plate and valve P''', suspended valve-plate Q, and valve-pistons Q''', substantially as herein shown and described.

2. In a steam-engine, the combination, with the sliding valve P''', provided with back projections q', of the suspended valve-plate Q and pistons Q''', substantially as herein shown and described, whereby said valve-plate and valve are held steam-tight in their respective seats, as set forth.

3. In a compound steam-engine, the combination, with the low-pressure cylinder G and valve-chest G', provided with valve-chest cover Q', having cylindrical perforated projections Q'', of the piston Q''' and suspended valve-plate Q, substantially as herein shown and described.

MICHEAL MACMAHON.

Witnesses:
J. H. SCARBOROUGH,
C. SEDGWICK.