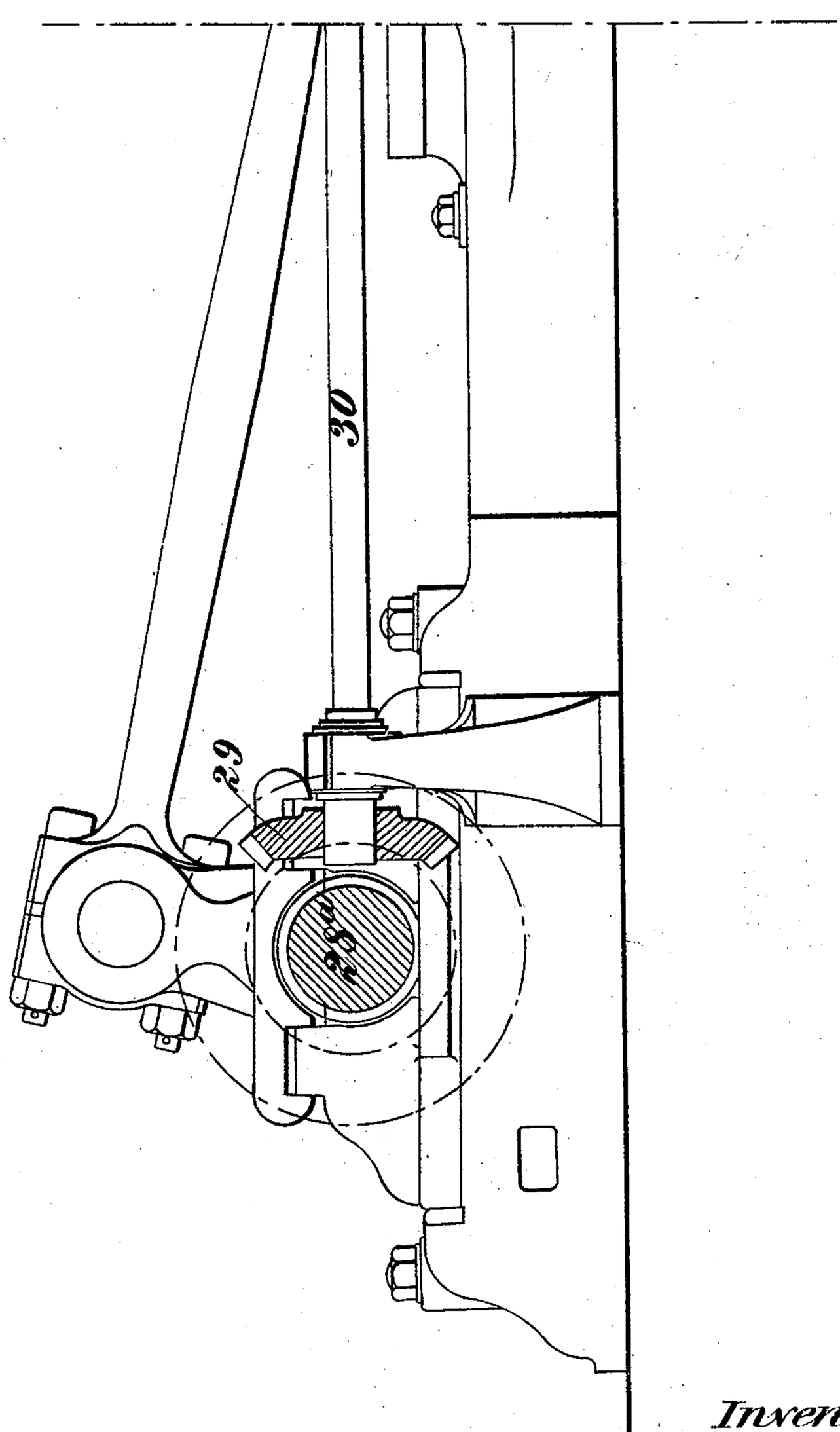
(No Model.) 9 Sheets—Sheet 1.

# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486. Patented Oct. 10, 1893.




Witnesses
E. E. Duffy
Hubert E. Peck

Inventor
Edward Field
per E. E. Duffy
Attorney

(No Model.) 9 Sheets—Sheet 2.

# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486. Patented Oct. 10, 1893.

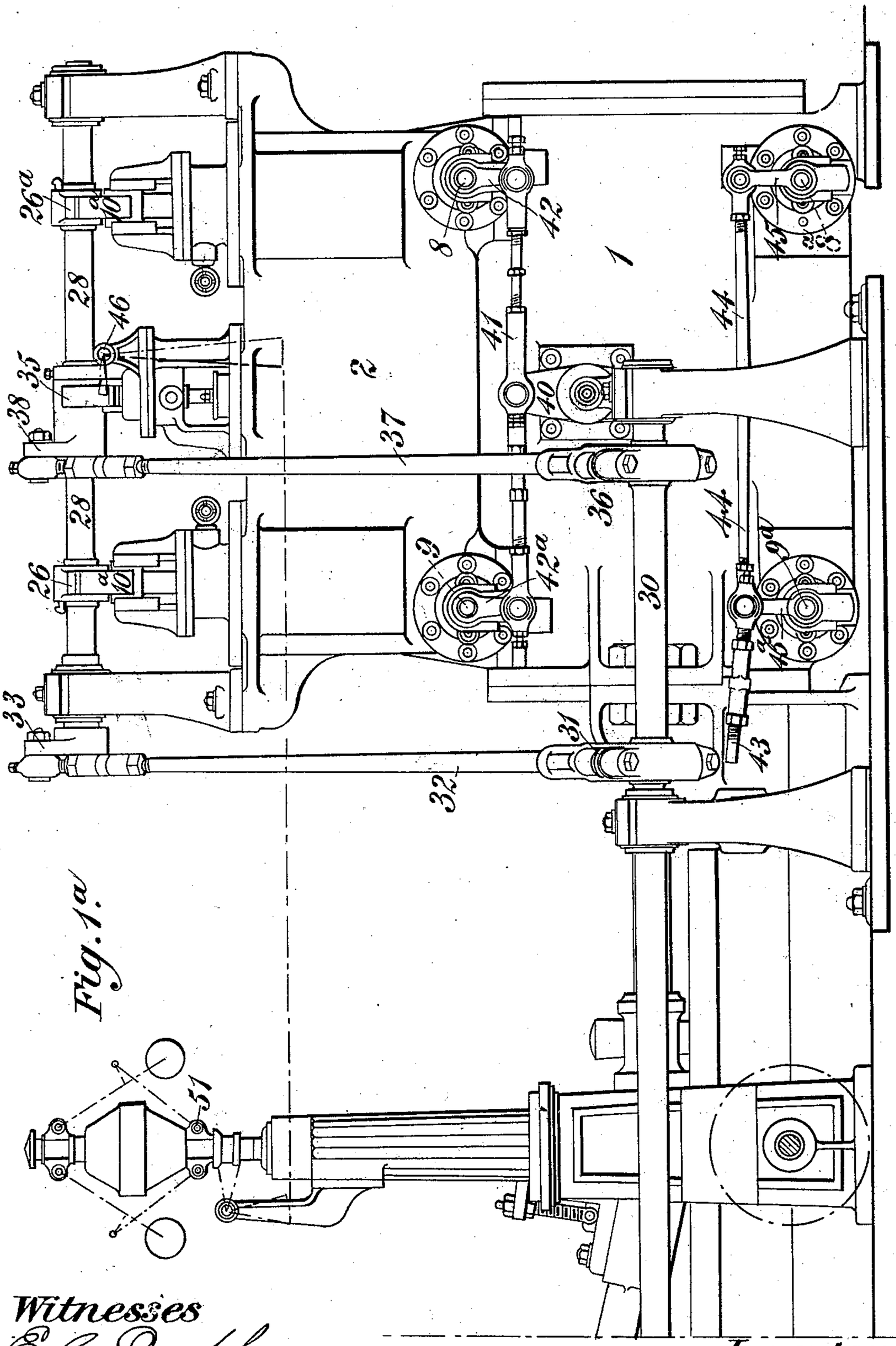



Fig. 1a.

Witnesses
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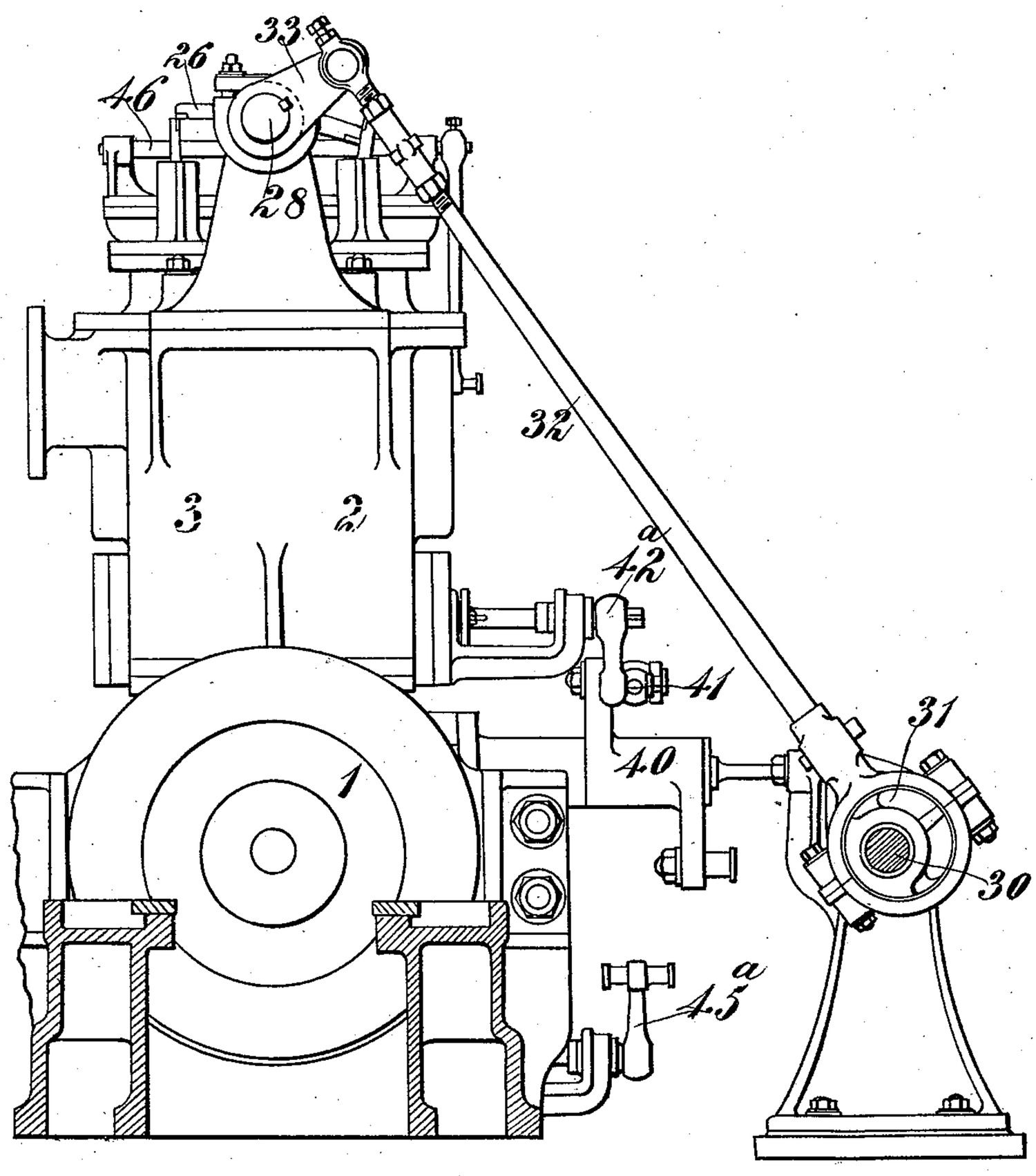
# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486. Patented Oct. 10, 1893.

*Fig. 2.*




Witnesses
E. C. Duffy
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Attorney

(No Model.)

9 Sheets—Sheet 4.

# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486. Patented Oct. 10, 1893.

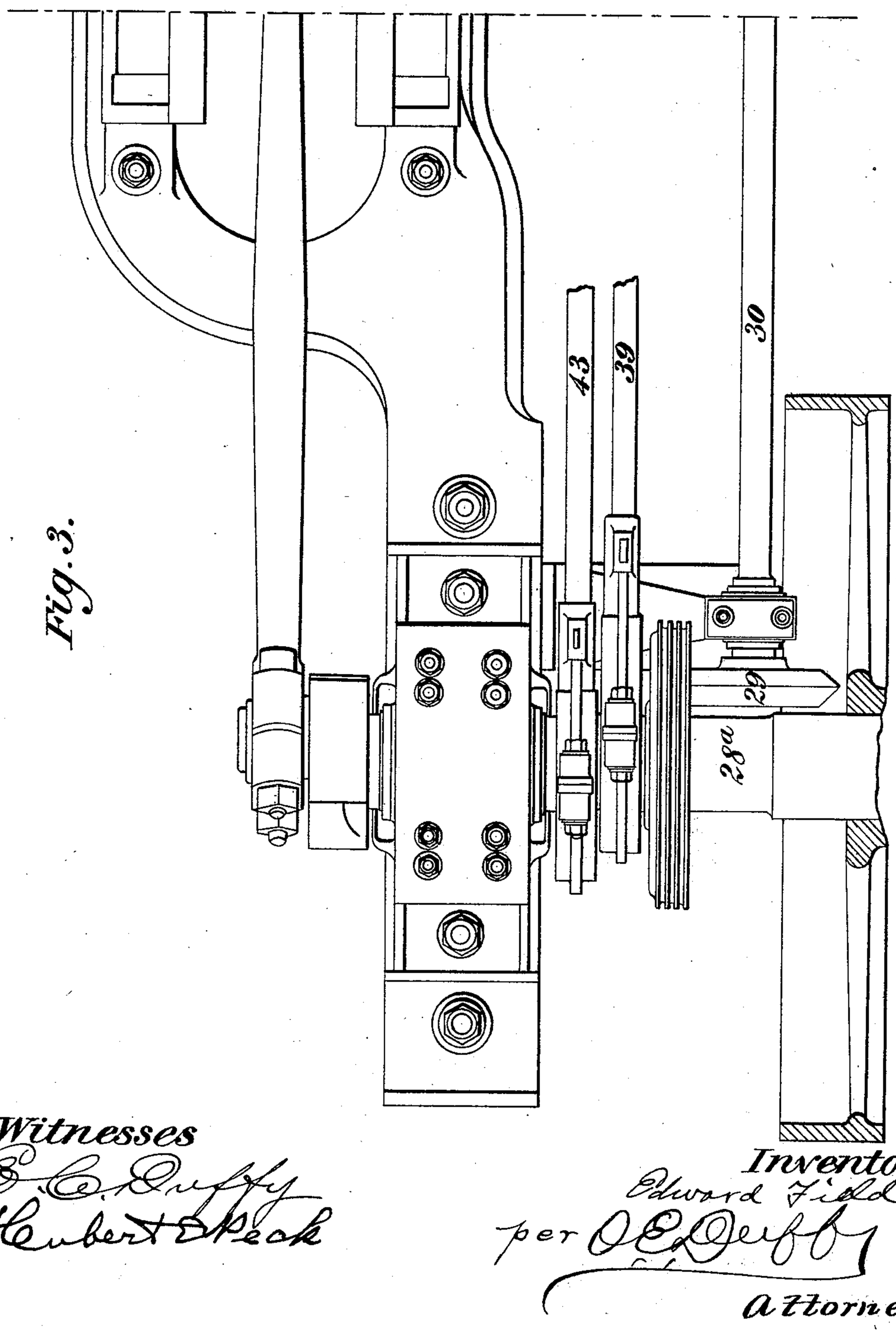


Fig. 3.

Witnesses
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Attorney

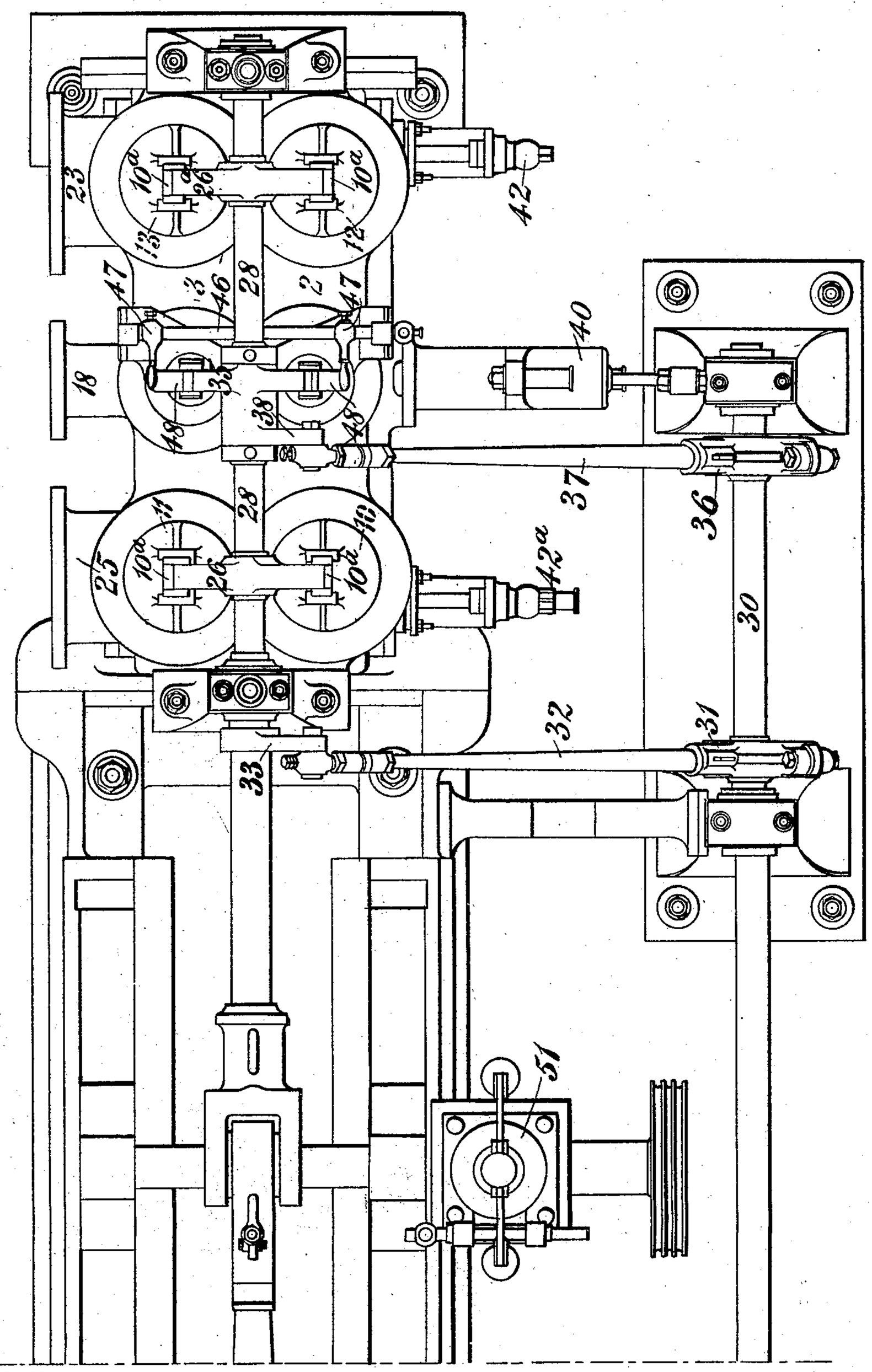
(No Model.) 9 Sheets—Sheet 5.

# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486 Patented Oct. 10, 1893.

Fig. 3a.




Witnesses
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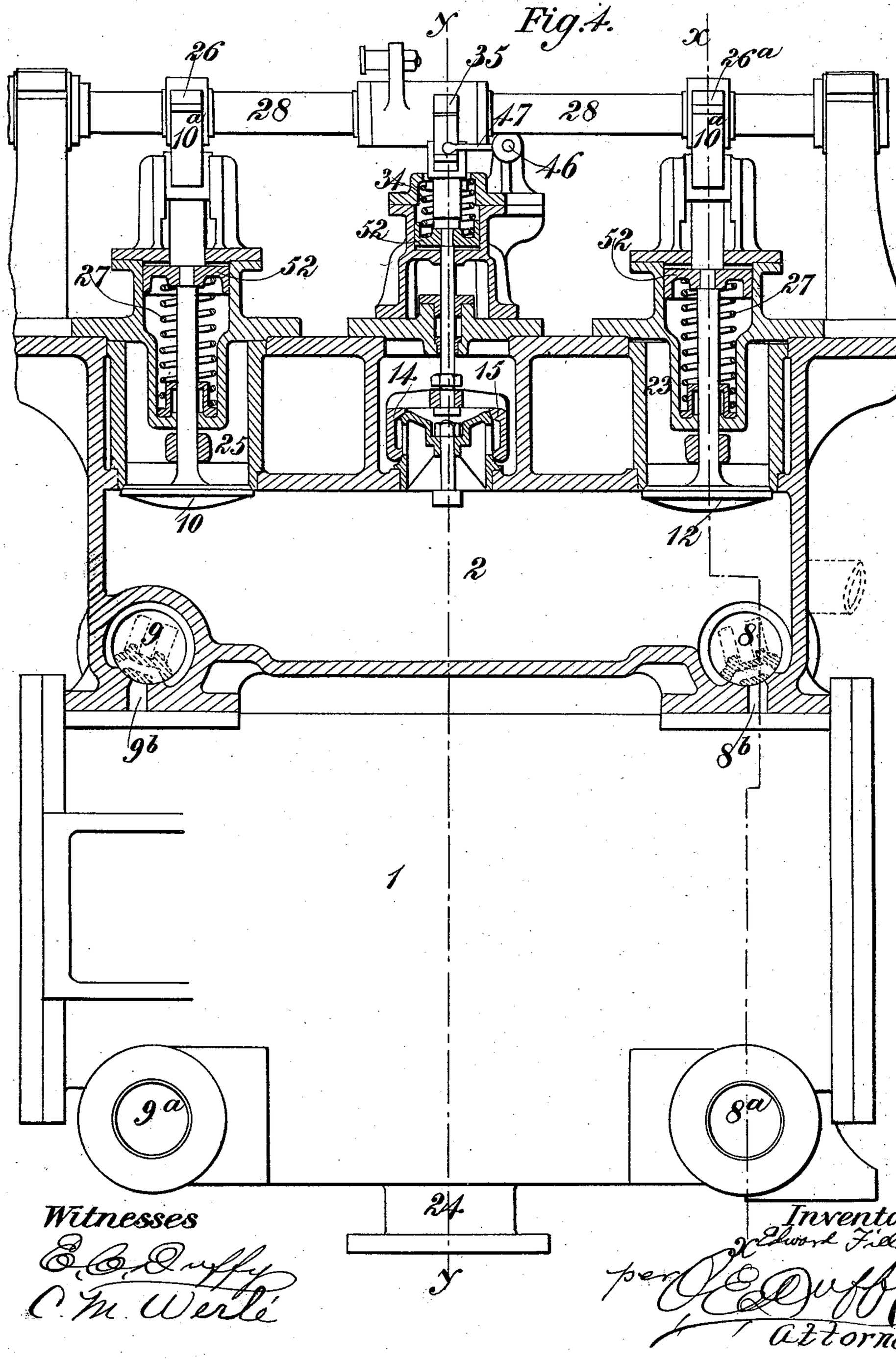
(No Model.) 9 Sheets—Sheet 6.

# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486. Patented Oct. 10, 1893.

*Fig. 4.*




Witnesses
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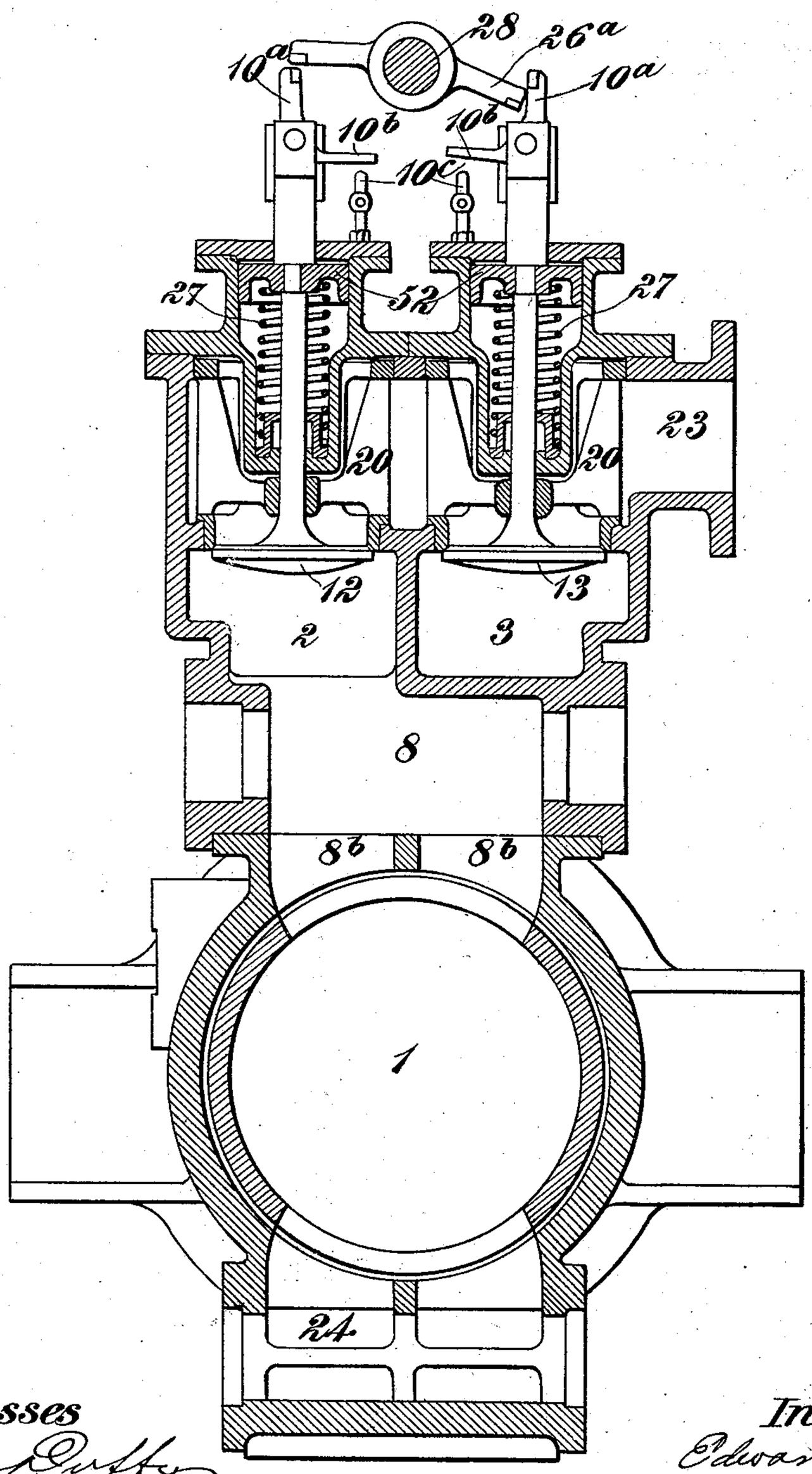
(No Model.) 9 Sheets—Sheet 7.

# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486. Patented Oct. 10, 1893.

*Fig. 5.*




Witnesses
E. C. Duffy
C. M. Werlé

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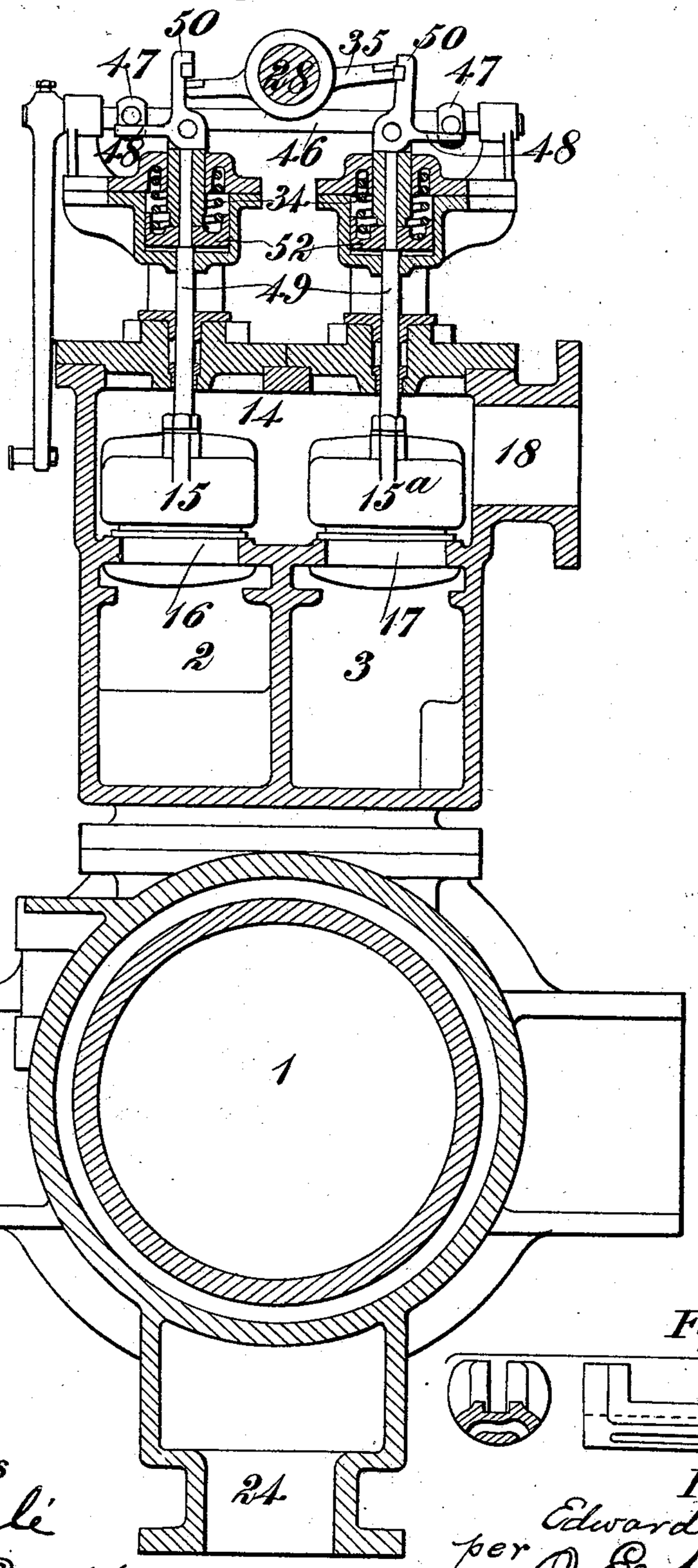
(No Model.) 9 Sheets—Sheet 8.

# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486. Patented Oct. 10, 1893.

*Fig. 6.*




*Figs 8.*



Witnesses
C. M. Werle
E. C. Duffy

Inventor
Edward Field
per O. E. Duffy
Attorney

(No Model.) 9 Sheets—Sheet 9.

# E. FIELD.

## GAS AND AIR ENGINE.

No. 506,486. Patented Oct. 10, 1893.

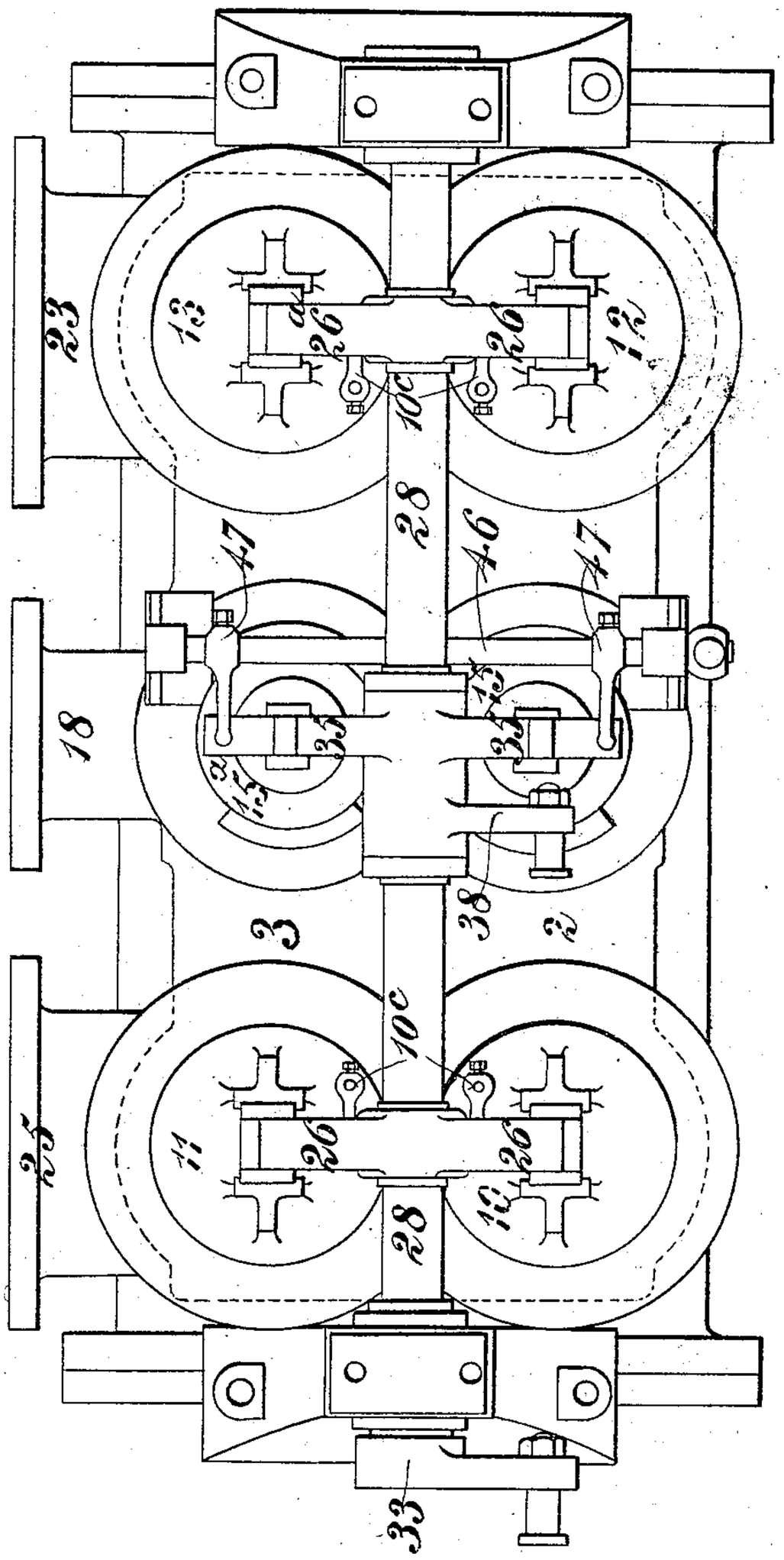



Fig. 7.

Witnesses
C. M. Werlé
E. C. Duffy

Inventor
Edward Field
per O. E. Duffy
Attorney

# UNITED STATES PATENT OFFICE.

EDWARD FIELD, OF LONDON, ENGLAND.

## GAS AND AIR ENGINE.

SPECIFICATION forming part of Letters Patent No. 506,486, dated October 10, 1893.

Application filed July 22, 1892. Serial No. 440,955. (No model.) Patented in France January 6, 1890, No. 202,990; in Germany January 7, 1890, No. 53,324; in Belgium January 8, 1890, No. 89,106; in Luxemburg January 22, 1890, No. 1,241; in Brazil March 20, 1890, No. 843; in Spain March 28, 1890, No. 10,437; in Italy March 31, 1890, LIII, 93; in England, October 27, 1891, No. 18,503; in Switzerland May 25, 1892, No. 5,467; in Norway May 27, 1892, No. 2,774; in Canada July 15, 1892, No. 39,363, and in India December 6, 1892, No. 144.

*To all whom it may concern:*

Be it known that I, EDWARD FIELD, a subject of the Queen of Great Britain and Ireland, residing at Chandos Chambers, 22 Buckingham Street, Adelphi, London, England, have invented Improvements in Engines to be Worked by Hot Gases—such as Air or Products of Combustion—with Steam, (for which I have obtained Letters Patent in Great Britain, No. 18,503, dated October 27, 1891; in Switzerland, No. 5,467, dated May 25, 1892; in Norway, No. 2,774, dated May 27, 1892; in Brazil, certificate of addition, dated July 16, 1892, to Brazil Patent No. 843, dated March 20, 1890; in Luxemburg, certificate of addition No. 1,629, dated May 28, 1892, to Patent No. 1,241, dated January 22, 1890; in India, No. 144, dated December 6, 1892; in Canada, No. 39,363, dated July 15, 1892; in France, certificate of addition, dated March 8, 1892, to Patent No. 202,990, dated January 6, 1890; in Italy, patent of importation No. 455, Vol. LXI, to Patent No. 93, Vol. LIII, dated March 31, 1890; in Belgium, patent of importation No. 98,705, dated March 8, 1892, to Patent No. 89,106, dated January 8, 1890; in Spain, certificate of addition No. 13,078, dated May 4, 1892, to Patent No. 10,437, dated March 28, 1890, and in Germany, patent of addition No. 64,456, dated March 10, 1892, to Patent No. 53,324, dated January 7, 1890,) of which the following is a specification.

This invention of "improvements in engines to be worked by hot gases such as air or products of combustion with steam" has reference to engines of the kind described in the specification of my former patent, No. 442,027, dated December 2, 1890.

The annexed illustrative drawings show an engine constructed with the present improvements:—

Figures 1 and $1^a$ are part elevations of the engine taken from its fly wheel side; this figure gives an external view of one mixing chamber and also shows the cylinder, Corliss valves and valve motion. Fig. 2 is an end elevation, partly in section, showing the cylinder, and the means for giving motion to the valves. Figs. 3 and $3^a$ are part plans of the complete engine, but without the air and steam pipes. Fig. 4 is an elevation of the cylinder, taken from the fly wheel side; this view also shows in section the jacket which forms the mixing chambers, the section being taken through the nearer mixing chamber, and the view also shows one set of air and steam valves, and the two distributing valves that admit mixture alternately to each end of the cylinder. Fig. 5 is a vertical cross section on the line $x\ x$ Fig. 4 looking from the back end of the cylinder. Fig. 6 is a similar vertical section through the line $y\ y$ Fig. 4. Fig. 7 is a plan of the cylinder and the jacket in which are the two mixing chambers; this view shows the reciprocating shaft and trip-levers for depressing alternately the two pairs of air valves which respectively open alternately the through passage of each mixing chamber. The figure also shows the independent sleeve shaft and levers which alternately lift each of the steam valves for the supply of steam to each mixing chamber when such chamber is otherwise hermetically closed. Fig. 8 shows in side elevation and transverse section, one of the "Corliss" distributing valves.

According to the present improvements the exhaust from the ends of the motor cylinder 1 is controlled by exhaust valves separate from those (herein called distributing valves) that control the passage of hot gases from the mixing chambers 2 and 3 to the respective ends of the cylinder 1. By this means, the supply and exhaust of the working mixture can be controlled in a more advantageous and efficient manner than can be done when one valve is used both for the supply and the exhaust of the working mixture. Each of the distributing valves in addition to controlling the passage of hot gases from its mixing chamber to the corresponding end of the motor cylinder may also control the exhaust of such mixing chamber.

In the arrangement illustrated 8 and 9 are the distributing valves and $8^a$ and $9^a$ are the exhaust valves, these valves being shown as arranged somewhat after the manner of Corliss valves. In this arrangement the exhaust of each of the mixing chambers 2 and 3 is ar-

ranged to take place, at the proper time, through the distributing valve 8 or 9 of such chamber, and through the corresponding end of the cylinder 1 and exhaust valve $8^a$ or $9^a$ as the case may be, but the construction might obviously be so modified that the exhaust of each mixing chamber would take place through a separate outlet pipe or passage. As indicated in dotted lines at the right hand end of Fig. 4 this pipe may be provided with an exhaust valve that may be arranged and operated like either of the valves 10, 11, 12 and 13 hereinafter described. Or such outlet pipes and valves may be used in addition to the distributing valves 8 and 9 and exhaust valves $8^a$ and $9^a$ arranged as shown when it is desired to more rapidly reduce the residual pressure in the mixing chambers 2 and 3. The closing of each of the exhaust valves $8^a$ and $9^a$ may advantageously be so timed (and in the drawings is so timed) that the gases confined in the cushioning space at each end of the cylinder will be raised to a pressure corresponding approximately to that of the mixture of hot gases produced in the corresponding chamber.

10 and 11 are the valves that serve for the exit of mixture alternately from the mixing chambers 2 and 3 respectively.

12 and 13 are the corresponding valves serving alternately for the admission of hot gases to the mixing chambers 2 and 3 respectively.

26 is a trip-lever for depressing the valves 10 and 11 alternately against the action of springs 27; and $26^a$ is a similar trip lever for depressing the valves 12 and 13 alternately. The stem of each air valve has pivoted to it a lever, one arm $10^a$ of which is acted upon by the lever 26 or $26^a$, while its other arm $10^b$ is arranged to come into contact with a vertically adjustable fixed stop $10^c$ and disengage the arm $10^a$ from the said lever 26 or $26^a$ at the required time. The levers 26 and $26^a$ are fixed on a rock shaft 28 operated from the engine crank shaft $28^a$ through bevel gear 29, rotary shaft 30, eccentric 31, eccentric rod 32 and crank arm 33.

15 and $15^a$ are double beat equilibrium valves for admitting steam to the chambers 2 and 3 alternately. They are each lifted in turn against the action of a spring 34 by a trip-lever 35 forming part of a sleeve shaft that is mounted to turn freely on the rock shaft 28, and is operated through an eccentric 36 on the rotary shaft 30, an eccentric rod 37 and a crank arm 38. The distributing valves 8 and 9 are operated from the engine crank shaft by an eccentric and rod 39, a lever 40, a rod 41, and lever arms 42 and $42^a$ that are fixed to the spindles of the respective valves. The exhaust valves $8^a$ and $9^a$ are operated from the engine crank shaft by another eccentric and rod 43 through a rod 44 and levers 45 and $45^a$ connected to the spindles of the respective valves.

18 is the inlet for steam to the valve chamber 14.

23 is the inlet for hot gases to the chamber 20.

24 is the exhaust from the cylinder 1 and chambers 2 and 3.

25 is the outlet for mixture from the mixing chambers 2 and 3.

46 is a rock shaft provided with tappet arms 47. Each of these tappet arms serves, by coming into contact with one arm 48 of a lever pivoted to the stem 49 of the corresponding steam valve (Fig. 6) to disengage the other arm 50 of the said lever from the trip-lever 35 and permit the said valve to be quickly closed by its spring. The time during which each steam valve is held open depends upon the position of the tappet arms which are controlled by the engine governor 51 through suitable connections as well understood and as indicated for example in dotted lines. The stem of each of the air and steam valves is provided with a piston 52 arranged to work in a cylinder and act after the manner of a dash pot to prevent the valve striking its seat violently.

The operation of the improved engine illustrated is as follows:—Assuming that the mixing chamber 2 is fully charged with mixture at working pressure and that the piston has arrived at the back end of the cylinder; that the exhaust valve $8^a$ has been previously closed for a sufficient time to produce the required cushion pressure; and that the distributing valve 8 has been opened at or slightly before the completion of the backward stroke of the piston, thus opening the chamber 2 to the back end of the cylinder 1 through the port $8^b$, then the engine piston after completing its backward stroke will commence its forward stroke under the pressure of the mixture thus admitted. When it has completed six-sevenths or thereabout of this forward stroke, the exhaust valve $9^a$ will be closed, thus producing the "cushion pressure" at the front end of the cylinder. Simultaneously the exhaust valve $8^a$ will be opened, whereby the spent gases in the cylinder, and the residual gases in the mixing chamber 2, will pass to the exhaust 24, the distributing valve 8 and exhaust valve $8^a$, remaining open until the residual pressure in the cylinder, and also that in the mixing chamber 2 has been reduced approximately to that of the external atmosphere. The distributing valve 8 will then be closed, and the two air valves 10 and 12 will be simultaneously opened by the trip levers 26 and $26^a$, and hot air supplied to the chamber 20 will then be caused to rush through the mixing chamber 2 clearing it out, drying it, and leaving it full of hot-air at atmospheric pressure or thereabout. Assuming that the chamber 3 has been previously charged with a working mixture of hot air and steam, then the engine piston having arrived at, or near the end of its forward stroke, the distributing

valve 9 will be opened to the front end of the cylinder through the port $9^b$, and the said piston will make its backward stroke under the pressure of the mixture, during the greater part of which stroke the two air valves 10 and 12 will be held open. When the piston has completed about six-sevenths of its backward stroke or thereabout, the exhaust valve $8^a$ will be closed thus producing the residual pressure at the back end of the cylinder, the air valves 10 and 12 will be released from their operating levers 26 and $26^a$ and closed by their springs, and the steam valve 15 will immediately after be opened for a short time by the trip lever 35 to admit steam to the mixing chamber 2 to produce the working mixture of hot gases for the next forward stroke of the piston, and then released and closed, the time during which it will be held open being determined by the engine governor, as before explained. The exhaust valve $9^a$ will be opened simultaneously with the closing of the exhaust valve $8^a$ to permit of the escape of the spent gases from the front side of the piston, and also the residual gases from the chamber 3, the valves 9 and $9^a$ being held open until the pressure in the front end of the cylinder and the mixing chamber 3 has been reduced approximately to that of the external atmosphere. The distributing valve 9 will then be closed, and the two air valves 11 and 13 will be opened and hot air will then be caused to rush through the mixing chamber 3, clearing it out, drying it, and leaving it full of hot air at atmospheric pressure or thereabout. The mixing chamber 2 having been charged with a working mixture of hot air and steam as hereinbefore explained, and the piston having arrived at or near the end of its backward stroke, the distributing valve 8 will be again opened so as to admit the said mixture from chamber 2 to the back end of the cylinder through the port $8^b$. The piston will then again make its forward stroke, during the greater part of which, the two air valves 11 and 13 will be held open. When the piston has made about six-sevenths of its forward stroke, the exhaust valve $9^a$ will be again closed, and the exhaust valve $8^a$ will be simultaneously opened, after which the distributing valve 8 will be closed, and the air valves 10 and 12 opened in the manner and for the purposes hereinbefore explained. After the exhaust valve $9^a$ has been closed, the air valves 11 and 13 will be released from their operating levers 26 and $26^a$ and closed by their springs, and the steam valve $15^a$ will immediately after be opened by the trip-lever 34 to admit steam to the mixing chamber 3 to produce the working mixture of hot gases for the next backward stroke of the piston. On the arrival of the piston at or near the forward end of its stroke, the distributing valve 9 is again opened to admit working mixture from the mixing chamber 3 to again cause the backward stroke of the piston. The above described operations are then repeated as the engine continues to work.

As will be obvious, the form and the means for operating the several valves can be variously modified. Thus instead of using steam valves of the double beat equilibrium type as shown, slide valves can be used, as described in my said former specification, such valves being operated in any convenient manner. It may be by trip mechanism similar to that hereinbefore described for the double beat equilibrium valves 12, $12^a$.

What I claim is—

1. In an engine to be worked by hot gases such as air or products of combustion with steam, the combination with a cylinder, or with each cylinder, if more than one be used, of two mixing chambers each adapted to be placed in connection with one end only of said cylinder, distributing valves for controlling the passage of hot gases from said mixing chambers to the respective ends of said cylinder, and separate exhaust valves for controlling the exhaust from the respective ends of said cylinder.

2. In an engine to be worked by hot gases such as air or products of combustion with steam, the combination with a cylinder, or with each cylinder, if more than one be used, of two mixing chambers each adapted to be placed in connection with one end only of said cylinder, distributing valves each arranged between one end of one of said mixing chambers and the corresponding end of said cylinder, and exhaust valves arranged at or near the ends of said cylinder, and means for operating said distributing and exhaust valves in such a manner that during part of each stroke the distributing valve and exhaust valve at each end of said cylinder are simultaneously open to exhaust substantially as described for the purpose described.

3. In an engine to be worked with hot gases, such as air or products of combustion, with addition of steam, the combination with the working cylinder, of mixing chambers each arranged to be placed in communication with one end only of said cylinder, rotary distributing valves adapted to place said mixing chambers in communication alternately with the respective ends of said cylinder, and rotary exhaust valves for the ends of said cylinder, said exhaust valves being connected and operated independently of said distributing valves substantially as herein described for the purpose specified.

4. In an engine to be worked with hot gases, such as air or products of combustion with addition of steam, the combination with the working cylinder, of two mixing chambers 2 and 3, rotary distributing valves 8 and 9 each controlling a short passage between one end of each of said mixing chambers and one end of said cylinder and provided with an external lever arm, a rod 41 connecting said lever arms, a lever 40 for operating said rod, means

for operating said lever, rotary exhaust valves $8^a$, $9^a$ for controlling the exhaust from each end of said cylinder independently of said distributing valves and each provided with an external lever arm, a rod 44 connecting said last mentioned lever arms, and means for operating said rod 44 substantially as herein described.

5. In an engine to be worked with hot gases, such as air or products of combustion with addition of steam, the combination with the working cylinder, of two mixing chambers arranged to be placed in communication with one end only of said cylinder and provided with inlet and outlet openings for hot gases, valves for controlling said openings, springs for normally holding said valves closed, trip levers for opening said valves alternately against the action of said springs, bent levers pivoted each to the stem of one of said valves and against which the corresponding trip lever acts, stops for disengaging said bent levers from said trip levers, and means for operating said trip levers, a steam chamber with passages for placing the same in communication with each of said mixing chambers, steam valves for controlling said passages, springs for normally holding said valves closed, a trip lever for opening said steam valves alternately against the action of their springs, bent levers pivoted each to one of the steam valve rods and against which said trip lever acts, tappet arms for disengaging these bent levers from said trip lever, a governor for controlling the position of said tappet arms, and means for operating each of said trip levers substantially as herein described for the purpose specified.

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

EDWARD FIELD.

Witnesses:
CHAS. E. BROUGHAM,
RAMSAY FIELD,
*Both of* 46 *Lincoln's Inn Fields, London, W. C.*