No. 844,504. PATENTED FEB. 19, 1907.

H. L. DOHERTY.

APPARATUS FOR REGULATING COMBUSTION IN FURNACES.

APPLICATION FILED FEB. 1, 1904.

5 SHEETS—SHEET 1.

Fig. 3.

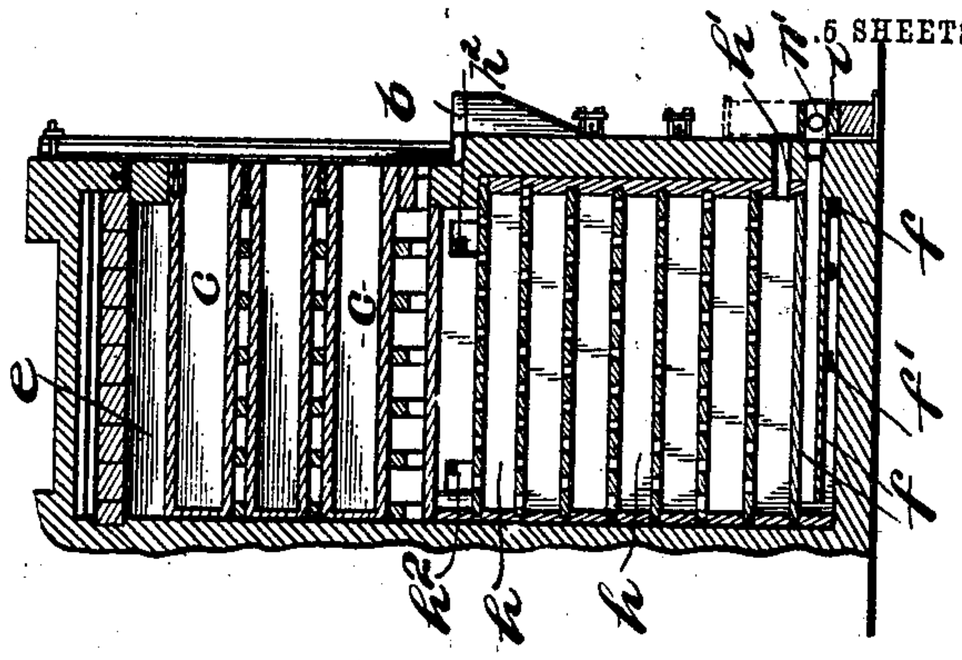


Fig. 2.

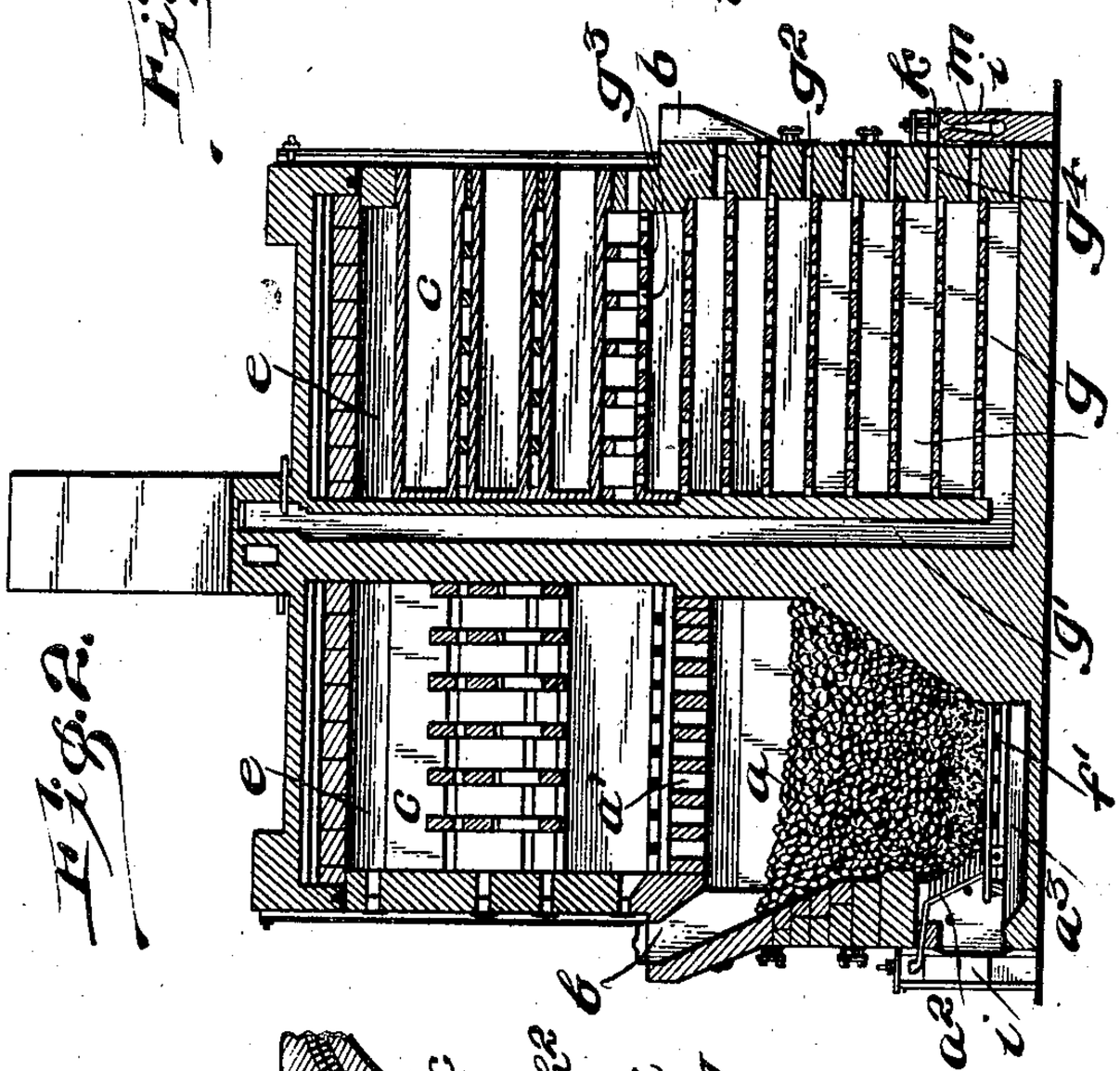
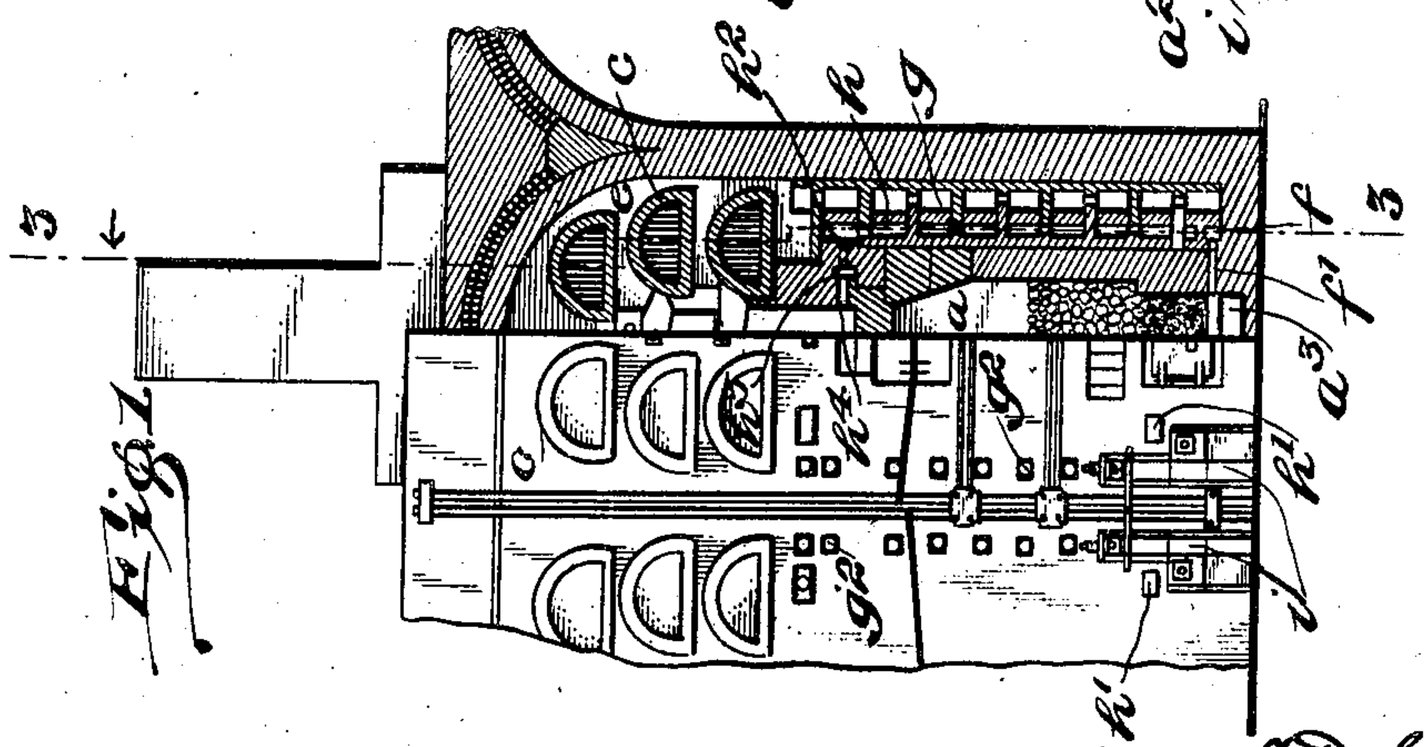


Fig. 1.



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5 SHEETS—SHEET 2.

Fig. 6.

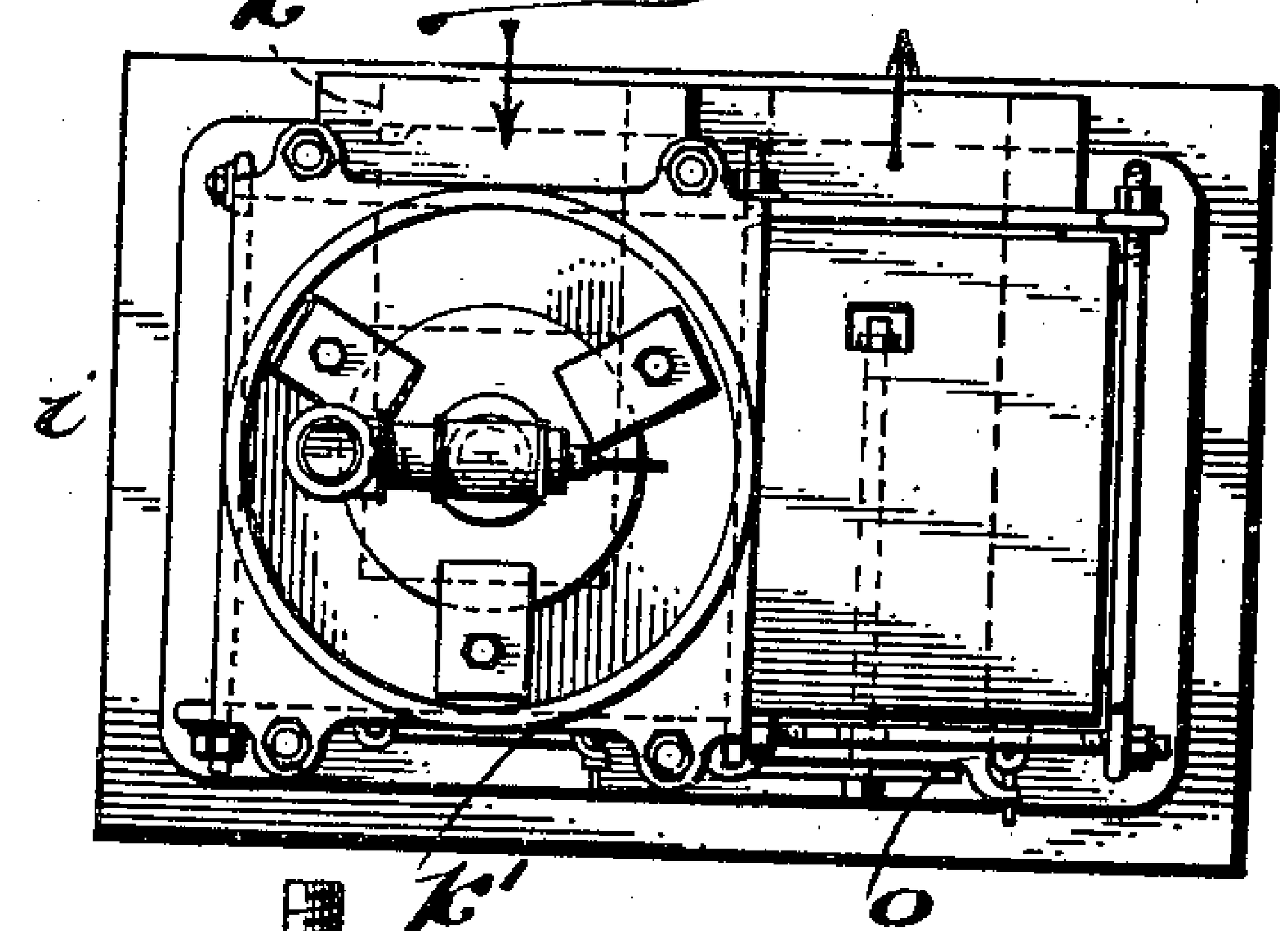


Fig. 4.

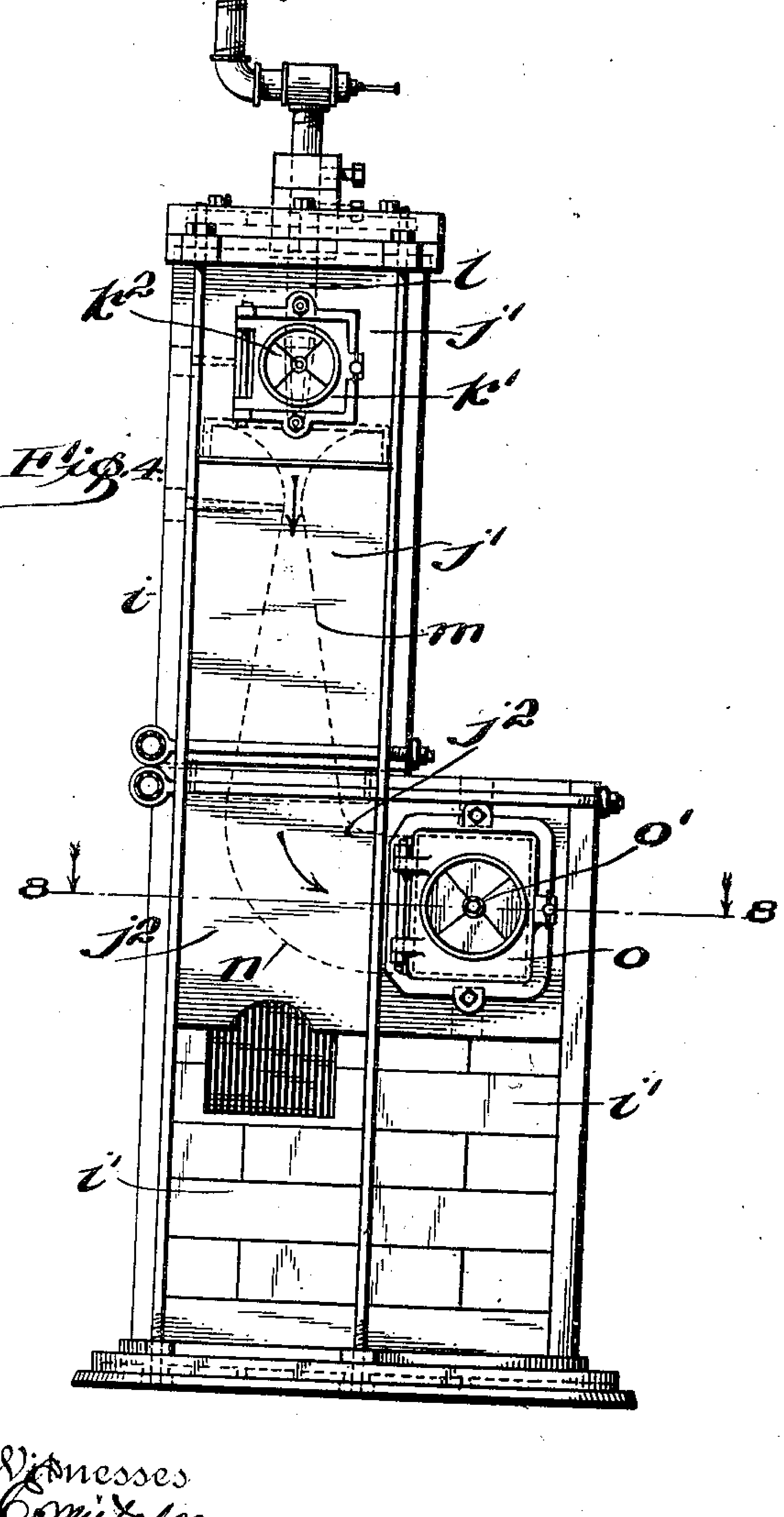
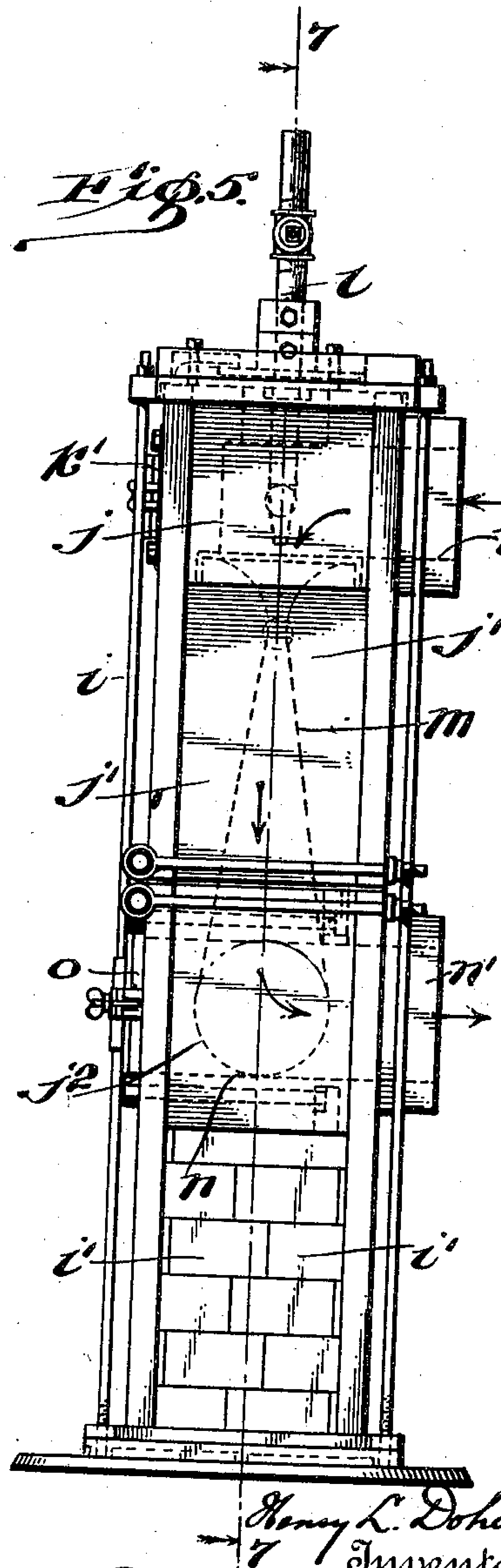


Fig. 5.



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5 SHEETS—SHEET 3.

Fig. 7.

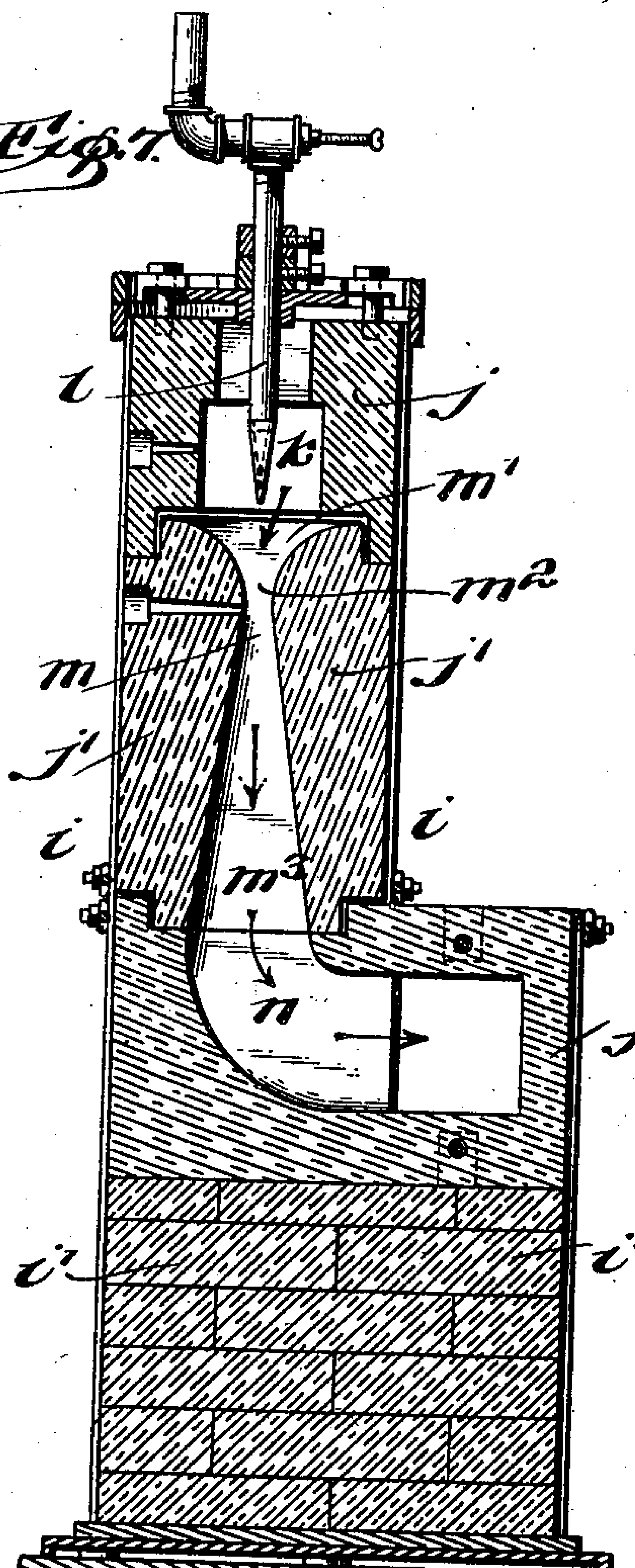


Fig. 9.

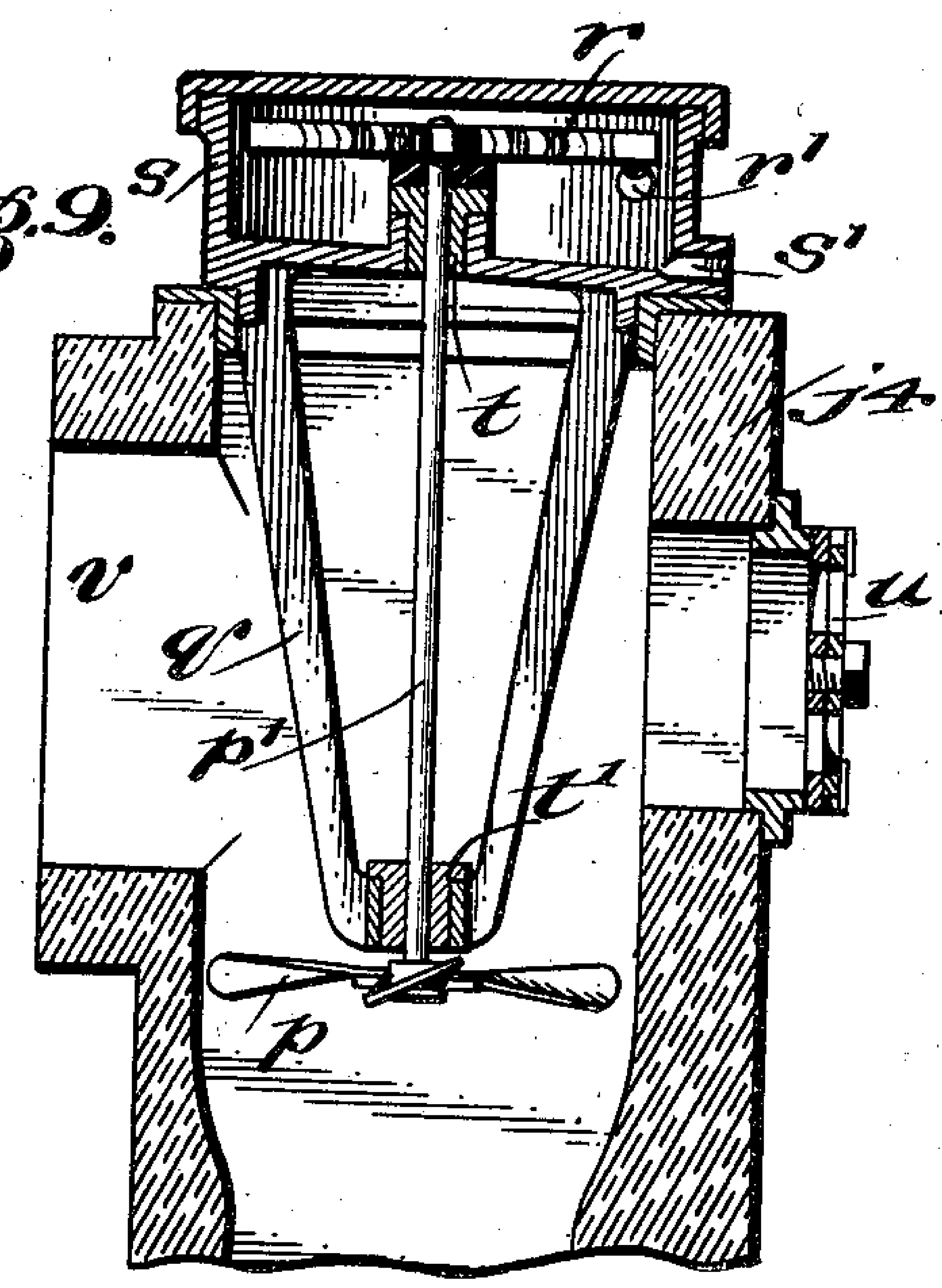


Fig. 10.

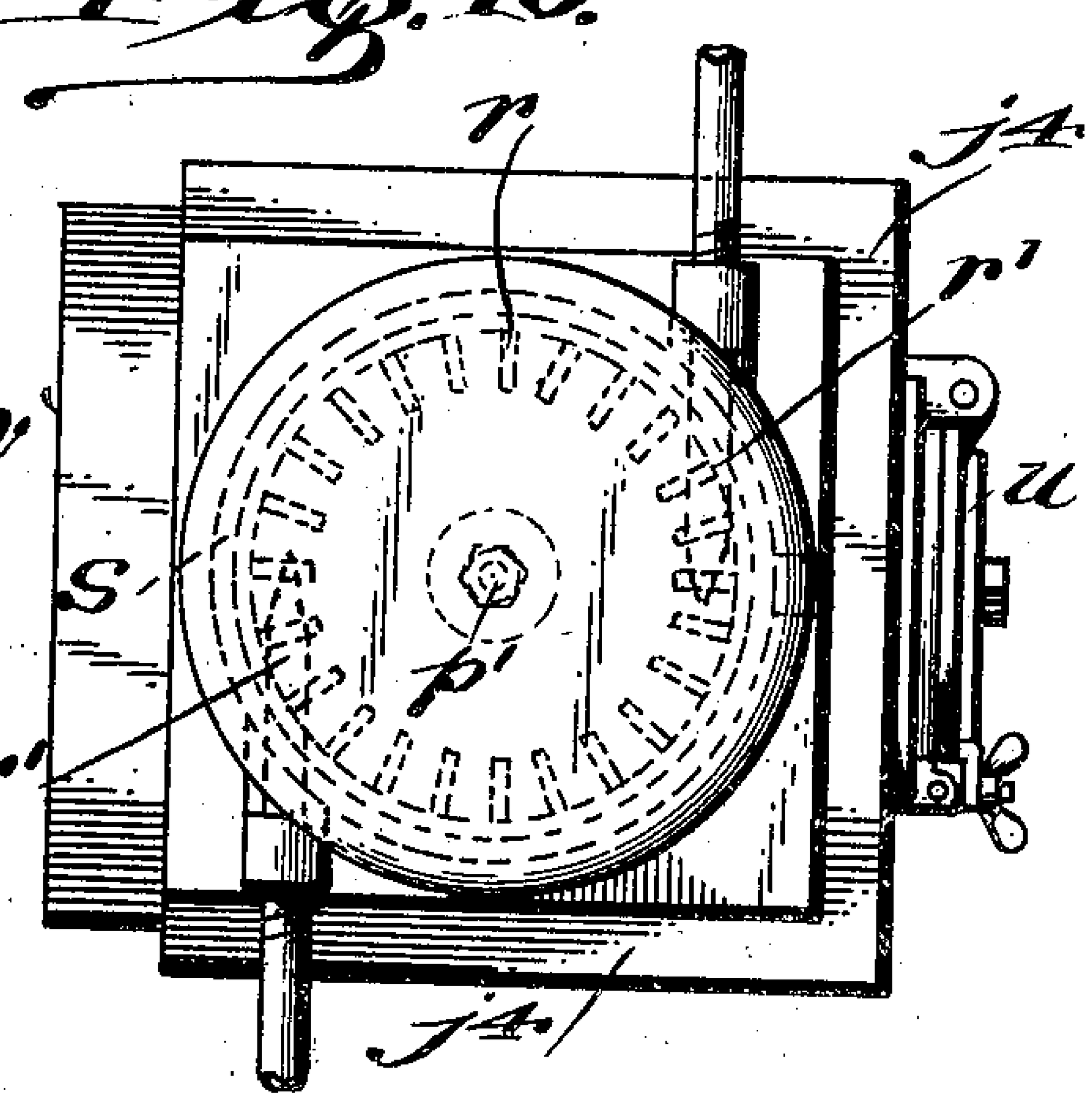
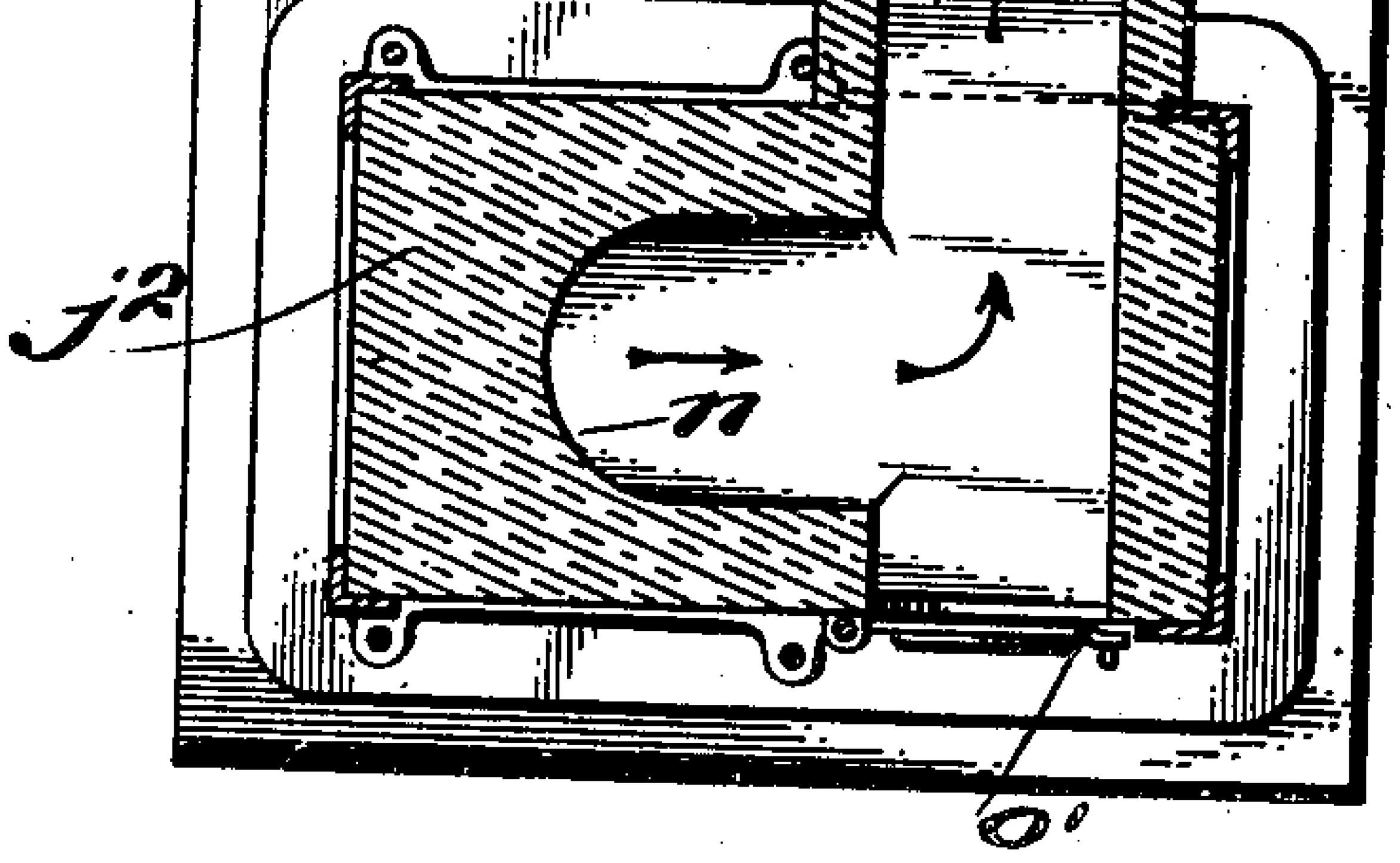


Fig. 8.



Witnesses

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5 SHEETS—SHEET 4.

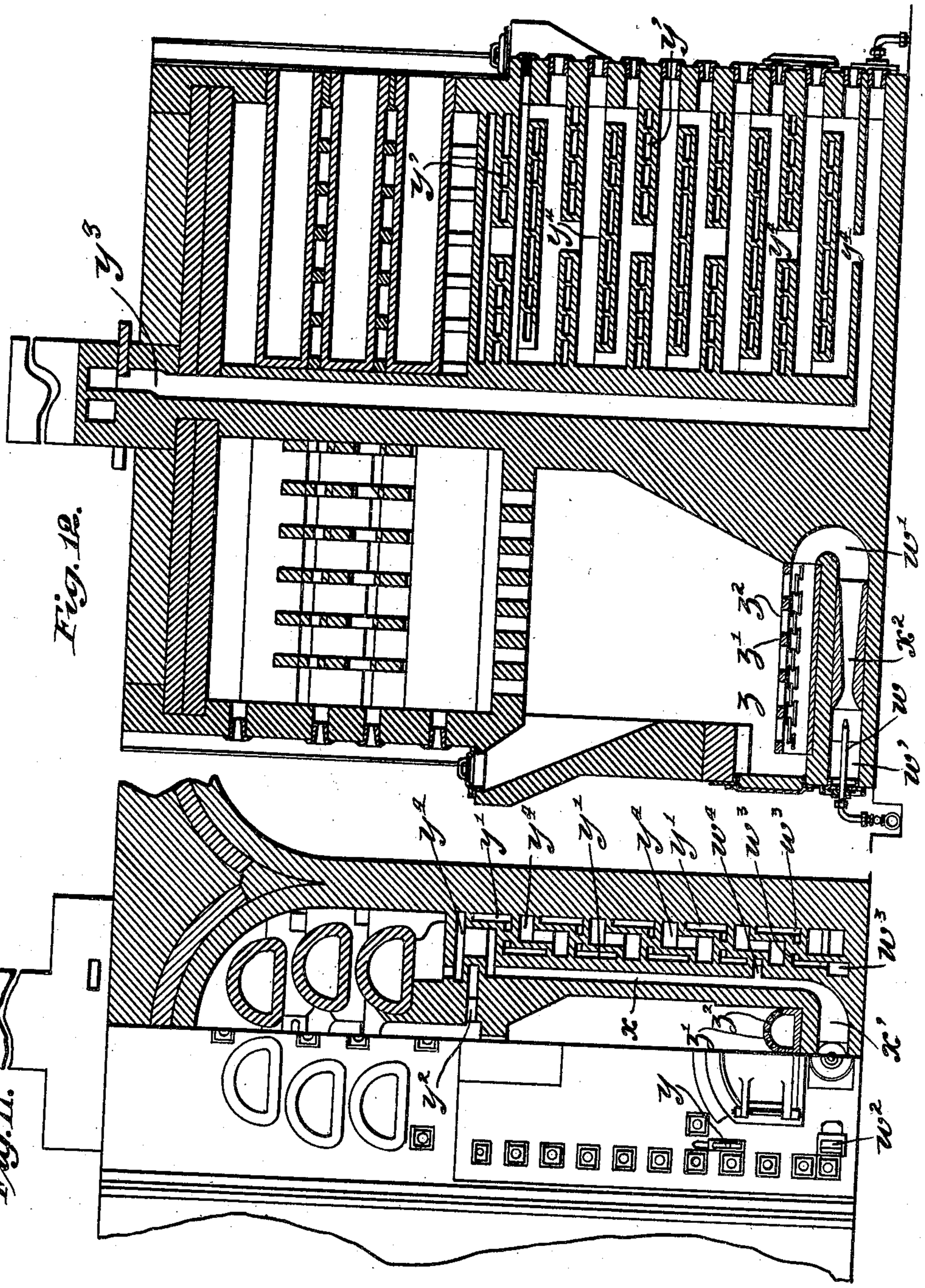

Fig. 12.

Fig. 11.

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No. 844,504. PATENTED FEB. 19, 1907.

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5 SHEETS—SHEET 5.

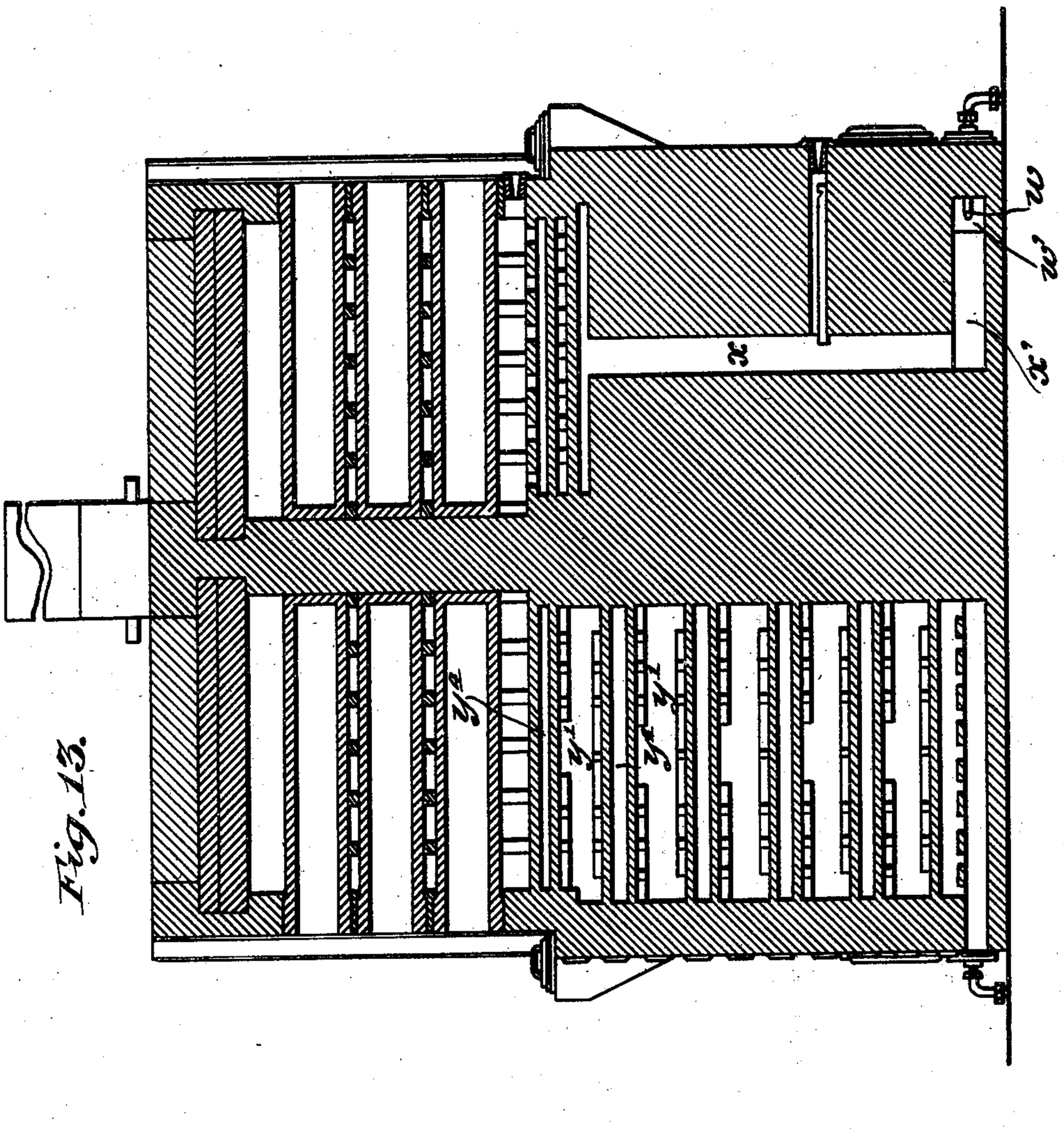

Fig. 13.

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UNITED STATES PATENT OFFICE.

HENRY L. DOHERTY, OF MADISON, WISCONSIN, ASSIGNOR, BY MESNE ASSIGNMENTS, TO COMBUSTION UTILITIES COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

APPARATUS FOR REGULATING COMBUSTION IN FURNACES.

No. 844,504. Specification of Letters Patent. Patented Feb. 19, 1907.

Application filed February 1, 1904. Serial No. 191,404.

To all whom it may concern:

Be it known that I, HENRY L. DOHERTY, of Madison, Wisconsin, (post-office address care of The Improved Equipment Company, 405 Seventeenth street, Denver, Colorado,) have invented certain new and useful Improvements in Apparatus for Regulating Combustion in Furnaces, of which the following is a specification.

This invention relates to apparatus for regulating combustion in furnaces, and is particularly desirable and useful in connection with gas-producers and other furnaces wherein the temperature tends to become excessively high if oxygen or air alone is introduced to the fuel.

As is well known in the art, the process of generating gas in a producer is usually carried out by passing air or air with steam through the body of fuel, which may be soft coal, hard coal, coke, or other suitable carbonaceous material. Water-boshes and drip plates are used for the purpose of facilitating the production of steam, which acts upon the carbon, parting with its oxygen, and thus producing a mixture of carbon monoxid and hydrogen. If the steam is not used, the bed of fuel will become gradually hotter and hotter, causing caking and clinkering and giving trouble in cleaning out. Also the steam or water-vapor serves to keep down the temperature.

In carrying out the objects of the invention carbon dioxid is introduced to the fuel, so as to be present with the oxygen that supports combustion, means being provided for introducing the carbon dioxid in quantities commensurate with the supply of air, and both being so limited that the carbon of the fuel is not burned completely to carbon dioxid by the air so admitted. The carbon dioxid, which is introduced and which may be pure or impure, is used in place of water or steam and may be obtained from any suitable source and is preferably preheated. Usually it can be obtained from the products of combustion already heated, and by returning it under the grate that much heat is saved as compared with the heating of coal-gas up to the ignition temperature. The carbon dioxid, if obtained from the previously-formed products of combustion and already preheated, will accomplish the reduction of temperature in the furnace with the greatest economy and without any such waste of energy as would occur if water were employed in place of the carbon dioxid and first raised to boiling and then introduced as steam. There is also a further economy effectuated through the introduction of the hot flue-gases and products of combustion under the grate, because they invariably contain a considerable amount of unburned oxygen and some unburned combustible gas, which, being already heated, saves the amount of energy that would be required to heat the equivalent quantity of air with its four volumes of inert nitrogen for each volume of oxygen, all of which would have to be raised to the temperature of the furnace.

In carrying out the invention in connection with a gas-producer a suitable injector or fan is preferably used for introducing the air and the carbon dioxid. Preferably the form of injector or fan which is to be described herein is used.

In the accompanying drawings there is shown for the purpose of clearly indicating the principles of the invention a twin gas-producer, and in these drawings, Figure 1 is a sectional front elevation of a gas-producer. Fig. 2 is a vertical section thereof, the same showing to the left the producer which is shown in section in Fig. 1 and to the right showing the setting and regenerative parts of the producer which is relatively back of or to the rear of the producer shown in Fig. 2. Fig. 3 is a section on the line 3 3 of Fig. 1. Fig. 4 is a front elevation of the flue-gas injector shown in the aforesaid figures. Fig. 5 is a side elevation of said injector. Fig. 6 is a plan. Fig. 7 is a vertical section through the injector on the line 7 7, Fig. 5. Fig. 8 is a transverse section on the line 8 8, Fig. 4. Fig. 9 is a vertical sectional view showing a flue-gas propeller or fan, which may be used in place of the injector. Fig. 10 is a plan view thereof; and Figs. 11, 12, and 13 are views of similar character to 1, 2, and 3, showing another form of the invention.

Referring now to these drawings, and more particularly to Figs. 1, 2, and 3, which will be briefly described, the gas-producer *a* is provided with a charging-chute *b*, through

which the coke from the retorts *c* is discharged into the producer after distillation. The retorts are mounted in the setting of the furnace in the usual way, within the combustion-chamber *e*, which is connected with the gas-producer *a* by the gas-nostrils *a'*. The drip-plates a^2 and the water-boshes a^3 are shown simply to indicate that the invention is applicable to any ordinary type of furnace in which these parts are provided. Primary air, admitted, preferably, as hereinafter described, passes through the horizontal ducts *f* and through openings *f'* under the grate. The regenerative part of the furnace may be of any suitable construction, as that shown, in which horizontal flues *g* are arranged, one set at each side of the producer, the lower flue leading to the chimney *g'* and the outer ends of the flues being closed, as by slide-doors g^2. The upper flue *g* is connected by openings g^3 with the combustion-chamber *e*, so that the products of combustion may pass off as usual. Counter-flues *h* are provided alongside of the flues *g*, these flues being arranged in two sets, one at each side of the producer, each set being controlled at its lower end by a slide-damper *h'* for admitting secondary air, which passes through the flues and side openings h^2, a passage h^3, and air-nostrils h^4. The action of the furnace in producing gas is well known to those skilled in the art.

The improvements forming the subject of the present invention may be applied either to the form of furnace shown or to any other gas-producing furnace, or they may be employed in connection with furnaces for steam-boilers. In carrying out the invention in connection with the gas-producer shown some of the flue-gases are drawn off, and may be forced under the grate in connection with a supply of air by means of an injector, such as more clearly shown in Figs. 4 to 8, inclusive. The injecting apparatus shown consists of a casing *i*, composed, preferably, of parts bolted together and supported upon a masonry foundation *i'*. Preferably the casing is composed of three sections, as *j j' j²*, which are of tile or fire-brick, so that they are non-combustible or non-fusible, because of the high degree of heat which they have to stand. The top section *j* of the injecting apparatus is provided with a horizontal passage *k*, one end of which is open to the atmosphere and the other end of which is connected with the passage g^4 of one of the lower waste gas-flues *g*, the wall around said passage being hermetically closed against the wall of the furnace. The front end of the passage is preferably closed by means of a swing-door *k'*, which is provided with openings suitably controlled by the blades of a damper k^2. An injector-nozzle *l*, supplied with injector air or steam, if desired, from a suitable source projects down through the top of the section *j*, and its jet-orifice is located within the passage *k*, before referred to. The injector-nozzle *l* is provided with adjusting-collars *l'* and set-screws l^2, and is arranged coincident with the axis of a downwardly-extending channel *m*, the upper end of which, adjacent the jet-orifice, has a wide flare *m'*, while from the throat m^2, a short distance below the passage *k*, the said channel *m* gradually increases in size, as indicated by m^3, so that the velocity given to the gases by the injector-air overcomes the suction in the waste-flues, which suction is greater than that under the grate. The downwardly-flaring channel *m* is connected at its lower end with an elbow-shaped channel *n* in the lower section j^2 of the injector apparatus, which channels *m* and *n* form practically one channel, the portion *n* of which extends at an angle relatively to the portion *m*. For this reason the lower section j^2 of the injector apparatus is about twice as wide as the upper sections. The sections *j j' j²* preferably form an **L**, the extension of the lower leg of the **L** forming a box which is closed at the front, as by a swing-door *o*, provided with air-inlet openings, suitably regulated by means of a rotary damper *o'*. The connection of the upper end of the injector apparatus with the waste-flues is shown at the right of Fig. 2, while the connection of the lower end with the ducts *f* for primary air is shown in Fig. 3. The upper primary air-passage *f* is connected at its outer end with a transverse passage *n'* in the lower section j^2, and this in turn with the outlet end of the channel *n*.

In the example shown and described, which is evidently but one form of which the invention is capable, carbon-dioxid gas is forced under the grate by the action of the injector, and with the carbon-dioxid gas air is also forced in under the grate. The carbon-dioxid gas in meeting the incandescent coals at a temperature above a minimum critical point, which seems to be about 1,500° Fahrenheit, reacts upon the carbon of the coals, giving up one atom of oxygen, thus forming two volumes of carbon monoxid for each volume of carbon dioxid introduced. In the reduction of the carbon dioxid to the monoxid heat is absorbed, and thereby the temperature of the bed of coals in the furnace is kept down to a temperature much nearer the critical point than would otherwise be the case. The oxygen to support combustion and to maintain the temperature at a sufficiently high point is drawn through the openings controlled by the damper k^2, and these openings being connected with atmospheric air about four parts of nitrogen to one of oxygen are drawn in by the action of the injector-nozzle *l*. The gases drawn in by the injector are heated by the waste flue-gases containing carbon dioxid, and these mingled gases are

forced through the channels *m n* into the ducts *f* and through the ports *f'* under the grate and to the fuel. Where atmospheric air is drawn in, of course the nitrogen gas is heated up by contact with the hot flue-gases, and thus does not produce any undesirable cooling effect, it being as hot as desired by the time it reaches the fuel, where the oxygen serves its purpose, as before stated. It is evident that pure oxygen may be drawn in or that carbon dioxid from any suitable source other than the producer itself may be supplied.

It is immaterial to the principle of the invention what form of injector, fan, or other apparatus is used for introducing the air and the carbon dioxid, though it is of course advantageous that the quantity of carbon dioxid introduced be controlled and made commensurate with the quantity of oxygen or air admitted. The greater the quanitty of carbon dioxid introduced the lower will be the temperature. The introduction of too great an amount would wholly retard combustion, while the introduction of an insufficient amount would maintain the temperature at too high a point. Consequently in the practice of the invention a greater or less amount is admitted, according to the temperature desired, it being preferable to admit a little more rather than less than the amount required to properly control the temperature. As this is known to vary under different conditions and different qualities of fuel, no exact rule can be given. In practice it is found that one volume of carbon dioxid for about twelve volumes of air will work advantageously. By properly controlling the dampers k^2 and *o'* the regulation may be accomplished to a nicety. When there is a certain pressure of the injector-air, and the flue-gases in the flues *g* carry a certain proportion of oxygen and carbon dioxid, the mixture of flue-gases and air delivered under the grate-bars can be varied by opening or closing the damper k^2. This could also be accomplished by opening or closing the damper *o'*, provided the pressure under the grate was less than atmospheric pressure, which would allow the outside air to pass through the openings controlled by said damper. Higher efficiency could also be maintained by using some of the heat of the waste flue-gases to heat the injector-air. Where the combustion is to be completed, instead of utilizing the gas elsewhere, a further supply of oxygen or air is admitted after the gases leave the fuel-supply, and the gases are burned substantially completely to carbon dioxid and hydrogen oxid.

In Figs. 9 and 10 a modification of the invention is shown in which, instead of an air-injector, a power-driven fan is used. This fan *p* is mounted on a vertical shaft *p'*, which turns in suitable bearings of a hanger-frame *q*, that is supported from the upper part of the tile-section j^4. The upper end of the shaft *p'* may be provided with a steam turbine-wheel *r*, which may be driven by steam from a nozzle *r'* in well-known manner, supplied from a boiler, which may be heated by the furnace. The fan turns in a fan-casing *s*, which is provided with a steam-outlet *s'*. The fan-shaft *p'* turns, preferably, in metaline bushings, such as *t t'*, which do not require lubrication, and which also can withstand the intense heat to which they are subjected. A damper *u* regulates the amount of air which is drawn in by the fan *p*, which fan also draws in the waste flue-gases through the opening *v*.

In Figs. 11, 12, and 13 another form of gas-bench is illustrated, in which the improved process can be carried out. This bench is quite similar in general design to that of the one shown in Figs. 1 to 3, inclusive, the difference being, however, that in the bench shown in Figs. 11 to 13 the waste gases, after heating the retorts, may be brought down to the fuel-bed in the furnace with the least possible loss of heat. In a furnace of this character or construction the waste gases, leaving the retorts at 2,300° to 2,500° and brought down without much loss of temperature, would probably melt the grate-bars generally in use. This calls for a change in the construction of the grate-bars and likewise a change in the location and construction of the injecting apparatus. The general parts of the apparatus having been described will be understood without specific reference in connection with the additional figures; but the changed parts will be given additional reference-letters. Additional or primary air other than that furnished by the injector-nozzle *w*, inserted into a flue *w'*, to be hereinafter referred to, is admitted through an opening controlled by a damper w^2, this additional air flowing through suitable passages w^3, which by means of a duct w^4 connect with the special vertical injector-flue *x*. The type of recuperator flues which are shown are believed to be more efficient than the ordinary type of flues now used. The damper-controlled opening *y* (shown to the left of Fig. 11) for the secondary air connects, by means of peculiarly-arranged zigzag passages *y'*, with the combustion-chamber in which the retorts are arranged, the ducts leading from said passages for the secondary air to said chamber being indicated by y^2. These passages and ducts *y' y²* are clearly shown to the right of Fig. 11, the transverse portions of the passages *y'* being shown to the right of Fig. 12. The flue-gases pass out of the chimney y^3 after first passing through a system of zigzag passages y^4, which are connected at their upper ends with the combustion-chamber. The upper portions of these passages y^4 for the flue-gases and products of

combustion are connected by means of said special injector-flue x with short branch flues x', which are located under the producer, or rather under the grates, and which communicate with flue w', which contains a bushing, tile, or fire-brick provided with a flaring passage x^2, similar to the corresponding passage in the injector apparatus shown in Figs. 1, 2, and 3. The said branch flue w' is formed in an elbow and extends or opens underneath the grate. Said injector-flute x serves for the purpose of bringing the waste or flue gas directly down with the least possible loss of heat. The injector w, being located as shown, serves alone for the purpose of taking care of the entire waste gases that are required. It will be understood that there is a special injector-flue x at each side of the producer, branching off from the horizontal flue w', into which the injector is inserted. As ordinary grate-bars would in all probability be melted by the intense heat of the waste gases, a special form of grate is desirable. The grate z shown is of fire-clay for the purpose of withstanding the additional heat. The grate is composed of two retort-shaped parts z', of fire-clay, which are open at both ends, the inner ends being connected with the branch flue w', while the upper walls of the said parts z' are provided with a number of longitudinally-extending holes or slots z^2. These holes allow the waste gases and air to pass directly up into the bed of fuel and the ashes to drop down. In this form of the apparatus the waste gases and the necessary air to support combustion are brought to the fuel-bed at the highest possible temperature in order to economize in the fuel which is necessary to operate the bench.

Having thus described my invention and without limiting myself to details, as obviously some features may be used without others or in modified form, what I claim as new and of my invention is—

1. In an apparatus for regulating combustion in furnaces, the combination with a gas-producing furnace comprising the producer, combustion-chamber, flues for primary air and for secondary air and flues for waste gases, of passages or channels connecting the waste-gas flues with the primary air-flues, said channels being provided with a damper-controlled opening for air and an adjustable injector projecting into said channels or passages.

2. In an apparatus of the character specified, the combination of a gas-producer, a gas-furnace having a regenerator, a discharge-passage therefrom for the waste gases, a conduit for products of combustion connecting said discharge-passage with the combustion zone of the producer, and adjustable draft-accelerating means in said conduit.

3. In apparatus of the character described, the combination of a gas-producer, a combustion-chamber, retorts therein, secondary air-flues leading to the combustion-chamber, return-flues for products of combustion leading from the combustion-chamber to the stack and arranged in proximity to the secondary air-flues, primary air-flues leading underneath the grate, an injector for conducting air and a portion of the products of combustion from the return-flues to the grate, and means in addition to the injector for regulating the mixture of air and products of combustion.

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

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Witnesses:
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