No. 799,001. PATENTED SEPT. 5, 1905.

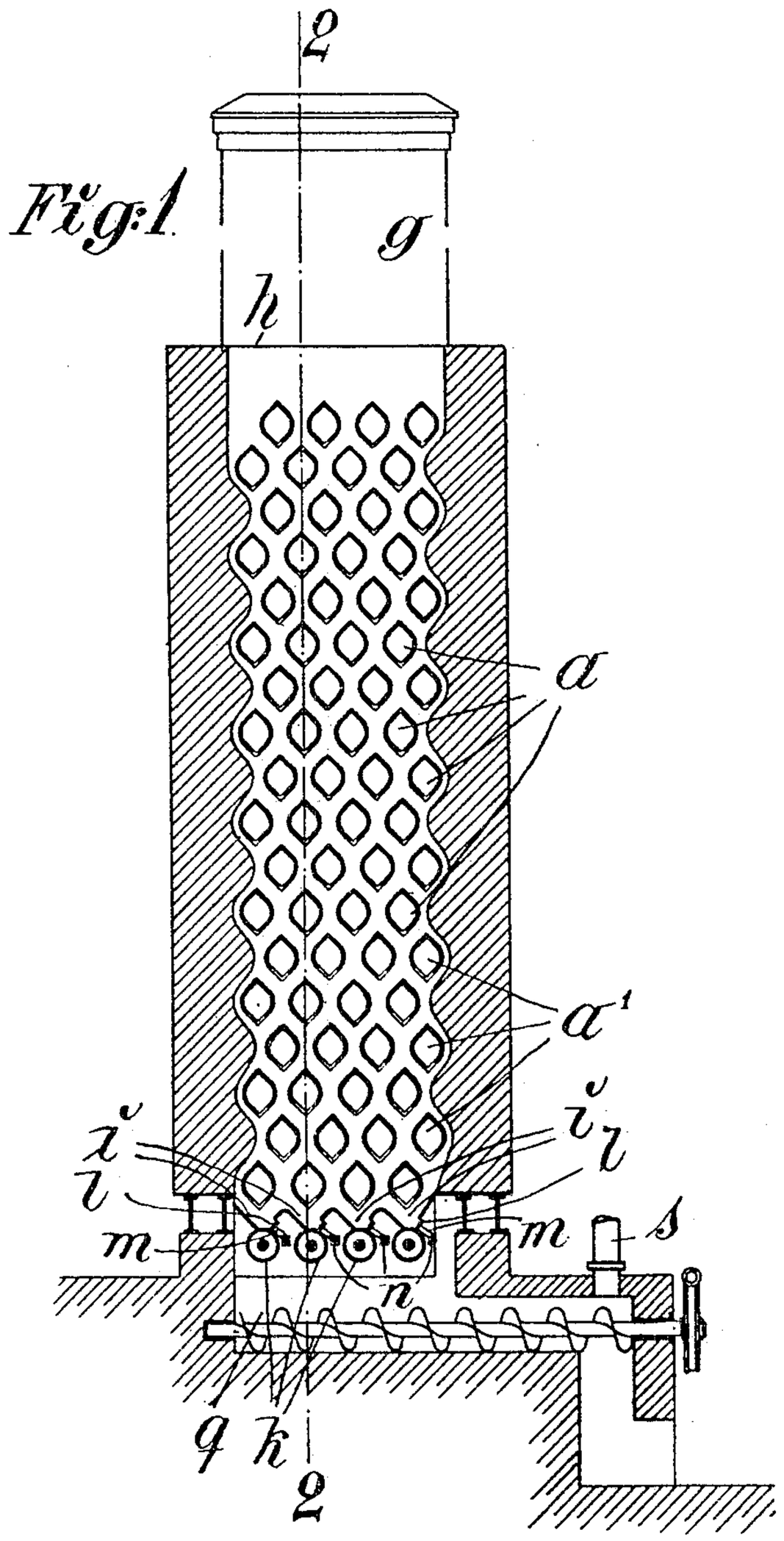
G. GRÖNDAL.

FURNACE FOR THE MANUFACTURE OF IRON SPONGE.

APPLICATION FILED MAR. 31, 1903.

7 SHEETS—SHEET 1.

Fig. 1.



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E. W. Collins

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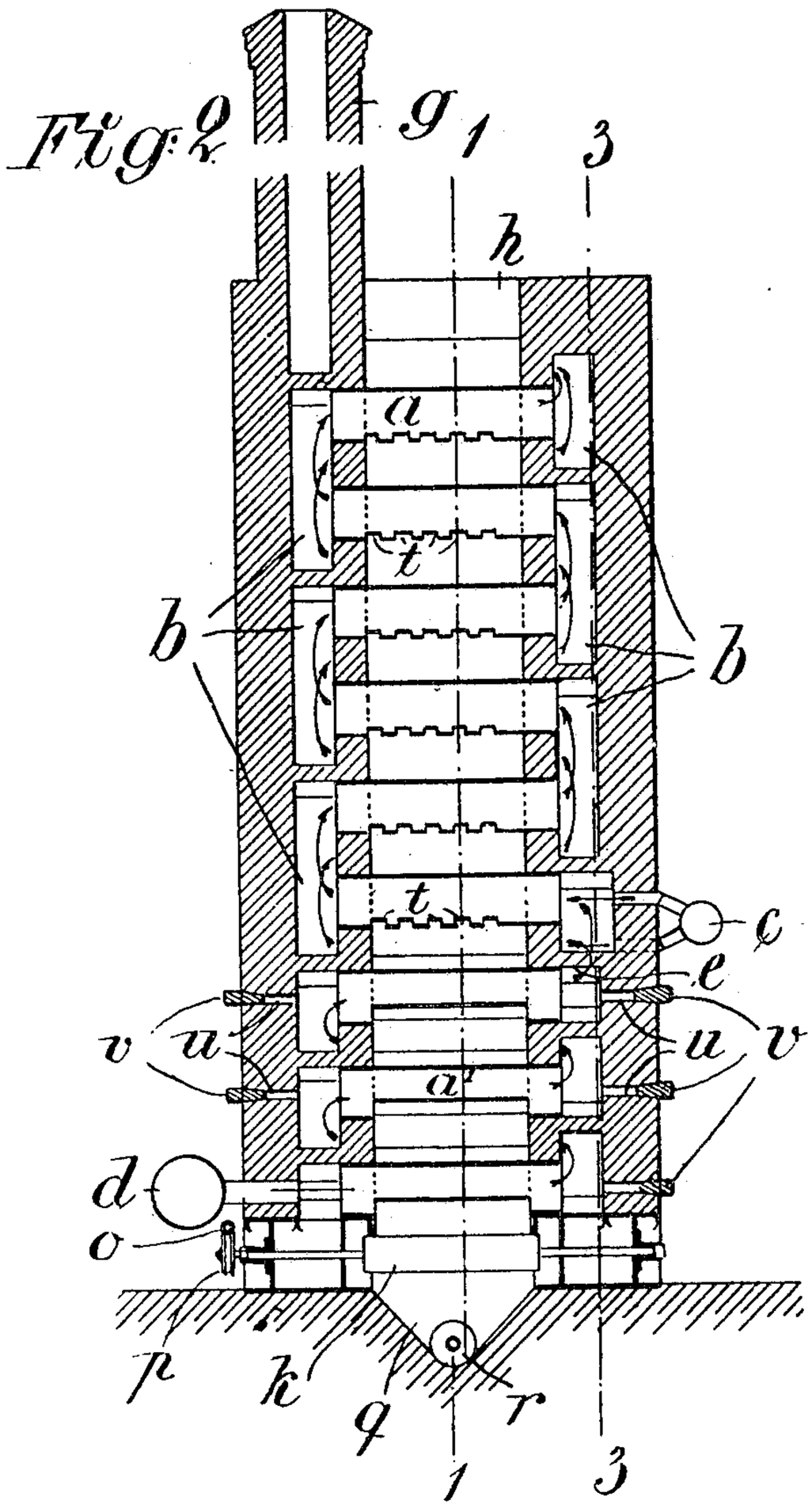
7 SHEETS—SHEET 2.

Fig. 2



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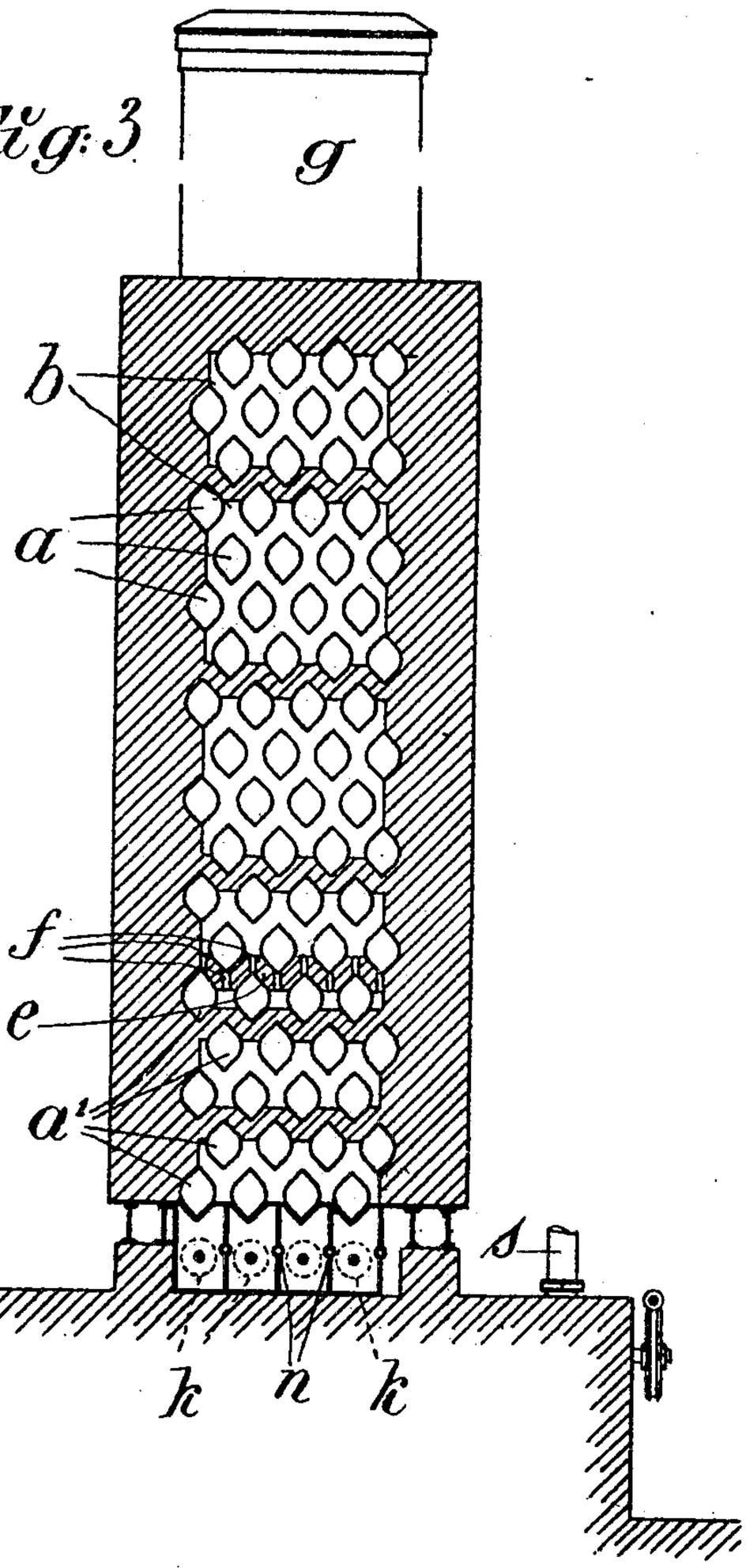
7 SHEETS—SHEET 3.

Fig: 3



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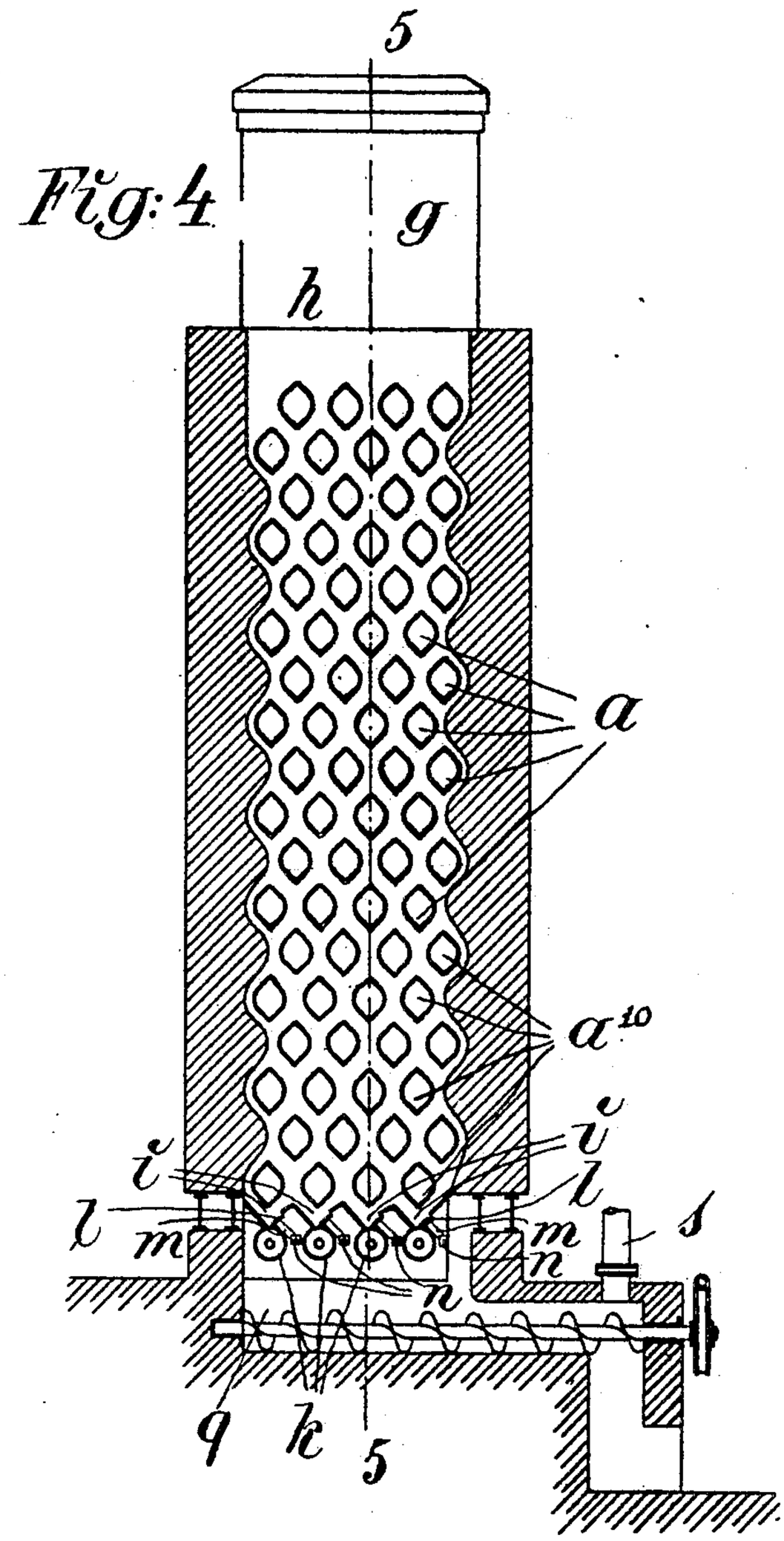
7 SHEETS—SHEET 4.

Fig: 4



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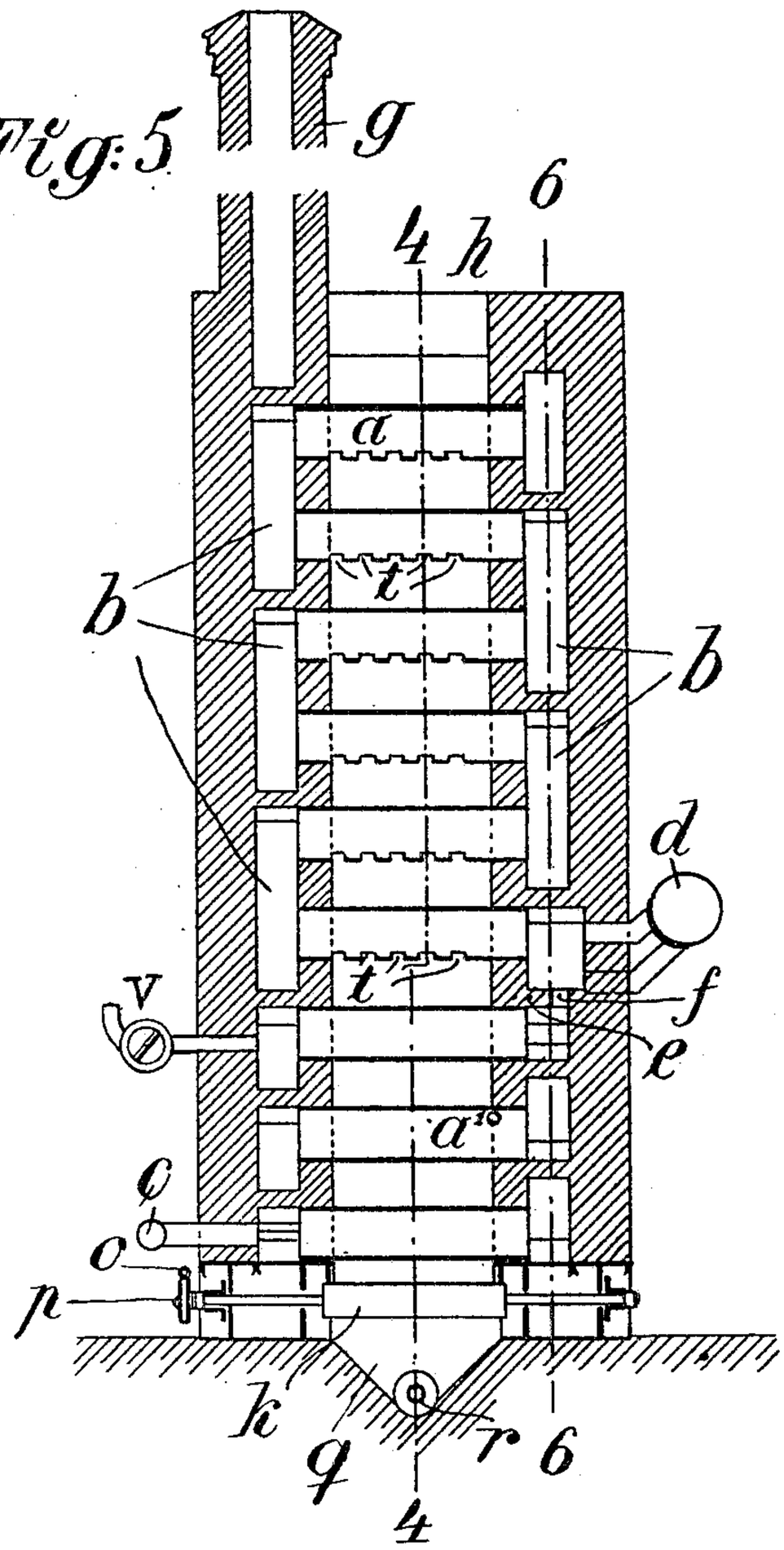
7 SHEETS—SHEET 5.

Fig: 5



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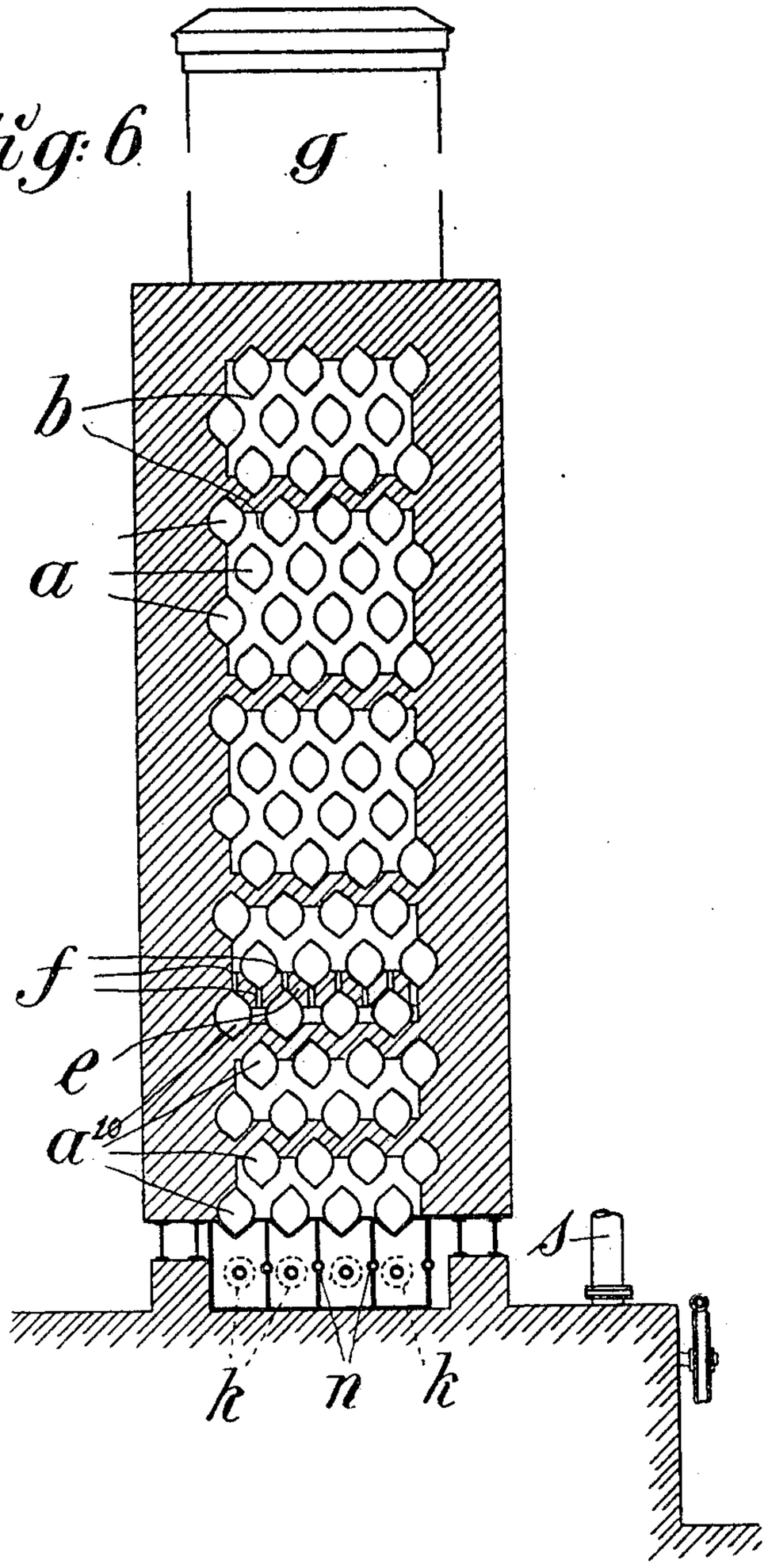
7 SHEETS—SHEET 6.

Fig: 6



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7 SHEETS—SHEET 7.

Fig. 7.

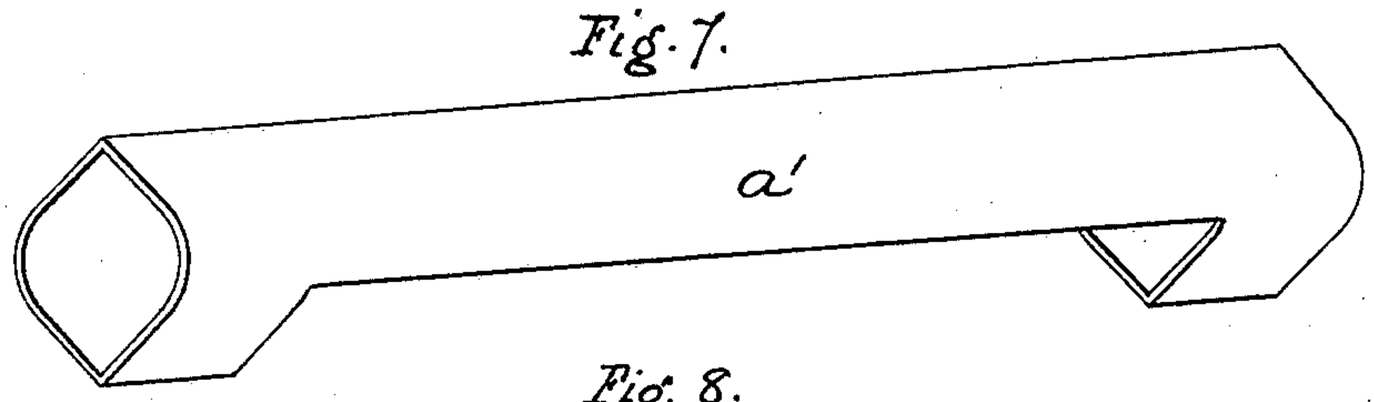


Fig. 8.

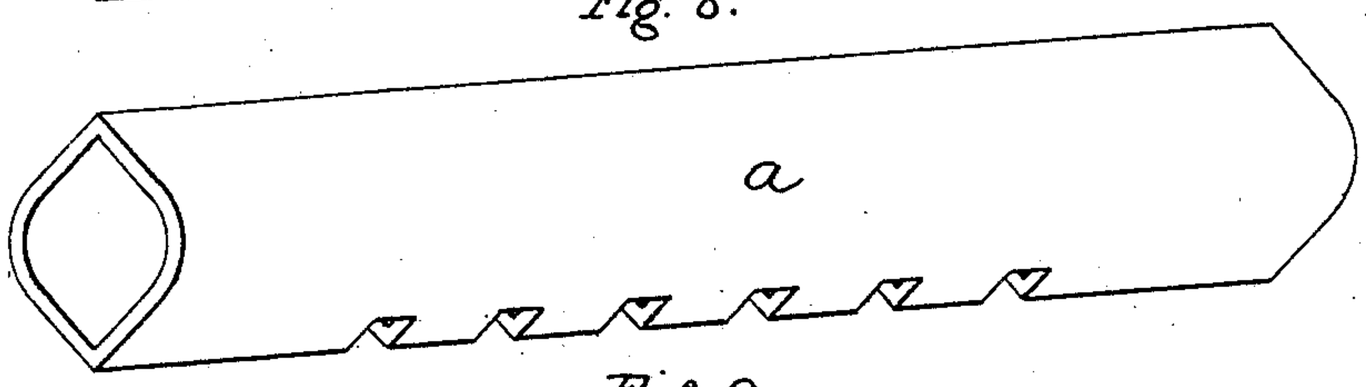


Fig. 9.

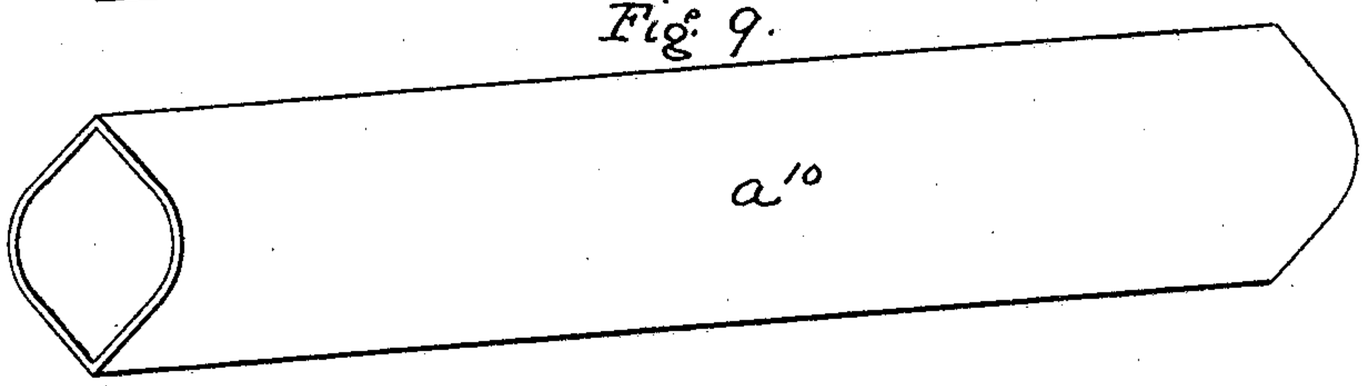


Fig. 10.

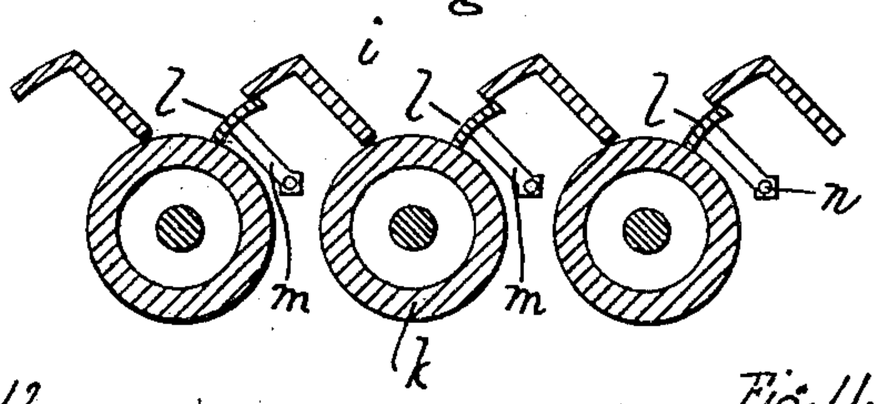


Fig. 12

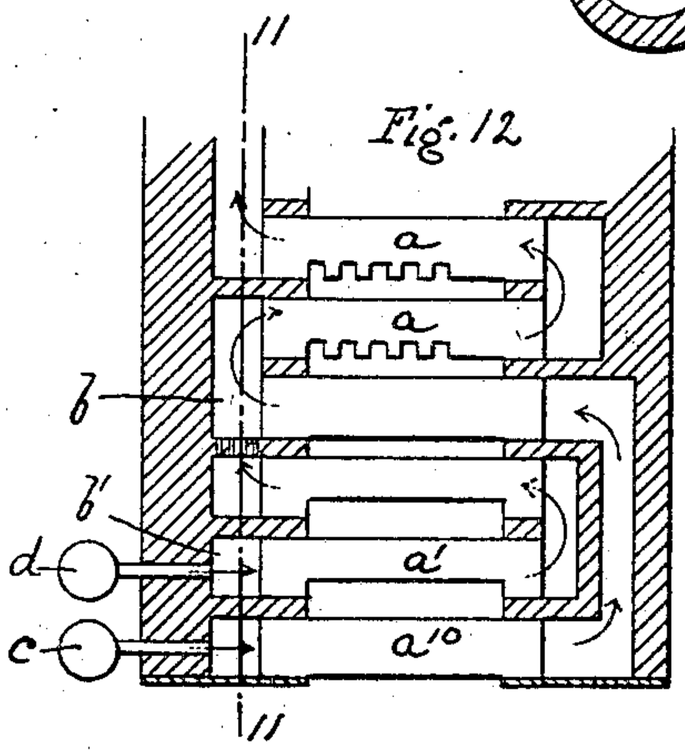
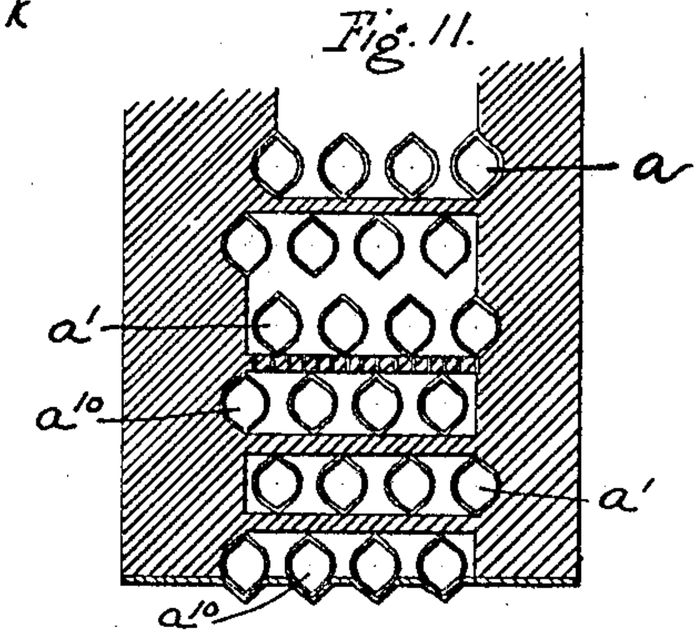


Fig. 11.



WITNESSES

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UNITED STATES PATENT OFFICE.

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FURNACE FOR THE MANUFACTURE OF IRON SPONGE.

No. 799,001. Specification of Letters Patent. Patented Sept. 5, 1905.

Application filed March 31, 1903. Serial No. 150,441.

To all whom it may concern:

Be it known that I, GUSTAF GRÖNDAL, a subject of the King of Sweden and Norway, and a resident of Djursholm, Sweden, have invented a certain new and useful Improved Furnace for the Manufacture of Iron Sponge, (for which I have applied for a patent in Sweden, dated February 7, 1903, No. 235, and in Norway, dated March 9, 1903, No. 16,148,) of which the following is a specification.

On heating a mixture of iron ore and charcoal, coal, cokes, &c., hereinafter called "carbon," without access of air the iron is reduced, as well known, into the form of so-called "iron sponge."

The object of the present invention is to carry out this method with pulverous or pulverized materials, which is advantageous for the reduction, and to render the process economical, uniform, and continuous. I employ for this purpose an upright furnace of any suitable cross-section, so arranged as to allow, on the one hand, the charged mixture of ore and carbon of its own weight to move through the furnace from the mouth to the discharge opening or openings, and, on the other hand, he combustible mixture used for producing the suitable temperature for the reduction to act in the necessary manner on the ore and carbon mixture in the reducing zone of the furnace.

In order to carry out the invention in the desired manner, I use as a cooling agent for the cooling of the iron sponge either the combustible gas or the atmospheric air, which is forced or led through passages to and fro until the iron sponge has been cooled in the necessary degree before being delivered through the discharge-openings, and I make the furnace so high that the combustion products of the gaseous combustible, which are also led through passages to and fro, have time enough to give off the main part of their heat to the charged mixture of ore and carbon and to preliminarily heat said mixture, and the gases generated during the reduction of the ore are drawn off from the spot where they are generated in the furnace. When combustible gas is used as cooling agent, it is advantageous to make the passages open at the under side toward the interior of the furnace in order to allow the iron sponge to come into contact with the combustible gas, which it imbibes eagerly, and thereby the iron sponge in issuing from the furnace becomes insensible to the otherwise injurious action of the air. During the cooling action of the combustible gas on the hot iron sponge the gas is heated, and in the lowest part of the reducing zone of the furnace atmospheric air is admitted into the passages, and the mixture of combustible gas and air is or becomes ignited and heats up the mixture of ore and carbon. The passages wherein the gaseous mixture is burned, as well as the passages for the combustion products, are perforated on the under side toward the interior of the furnace in order that the gases generated by the reduction of the ore may escape immediately through these perforations into the passages and pass off at the upper end of the furnace together with the combustion products. When the air is used for cooling the iron sponge, the passages belonging to the cooling zone must be without perforations, and the combustible gas is made to enter the passages at the lowest part of the reducing zone, and the gas-and-air mixture becomes ignited in the same manner as above described. The passages above the cooling zone even now must have perforations at the under side in order to draw off the gases generated by the reduction.

On the accompanying drawings there are shown, by way of examples, two forms of furnace suitable for the purpose, having a rectangular cross-section and being provided with passages both in the walls and in the interior.

Figures 1 to 3 show a furnace in which the combustible gas is used as a cooling agent, and Figs. 4 to 6 show a furnace in which the air is used as a cooling agent. Figs. 1 and 3 are vertical sections of the furnace along the lines 1 1 and 3 3 of Fig. 2, and Fig. 2 is a vertical section along the line 2 2 of Fig. 1. Figs. 4, 5, and 6 are like sections along the lines 4 4, 5 5, and 6 6 in Figs. 4 and 5. Fig. 7 is a perspective view of an open-bottom cooling-tube for gas. Fig. 8 is a similar view of a perforated combustion-tube. Fig. 9 is a similar view of a cooling-tube for air. Fig. 10 is an enlarged view of a part of the outlet to the furnace; and Fig. 11 is a partial sectional view, similar to Figs. 3 and 6, of a furnace in which both air and combustible gas are separately used for cooling and afterward united for combustion; and Fig. 12 is a section on the line 11 11, Fig. 11.

As shown, all forms of furnaces are provided with tubes a a' a^{10}, arranged in zigzag across the shaft and of such an exterior form

that will not prevent the uniform sinking of the mass of ore and carbon through the furnace.

b represents chambers in the furnace-walls connecting the tubes of one range with the tubes of the range or ranges lying next above.

c represents an inlet-pipe for the atmospheric air; *d*, an inlet-pipe for combustible gas.

The chamber *b*, in which the air, Fig. 3, or the gas, Fig. 6, enters, is separated from the chamber located below by means of a bottom *e*, provided with holes *f*, through which the heated gas or air from the tubes *a'* enters.

t represents the holes in the bottom of the tubes *a*.

g is the chimney for the escaping combustion products, and *h* is the mouth of the furnace.

The whole area of the bottom of the furnace consists of longitudinal depressions *i* with sloping sides lying alongside each other and open downward. Under each opening there is a roll *k*, covering part of the opening. The remaining part of the opening is covered by a shutter *l*, resting in the shut position with one edge against the roll *k*. Each shutter *l* is carried by arms *m*, projecting from a shaft *n*, which is capable of being turned from the outside. By turning all those shafts the shutters *l* can be adjusted, and thereby the width of the discharge-openings, and thus the delivery of the iron sponge from the furnace can be regulated. The rolls *k* are kept rotating continually and are operated by any mechanical means—as, for instance, worm-gear *o* and *p*. The iron sponge, issuing from the openings mixed with carbon and it may be with non-reduced ore, falls down into a room *q*, in which there is provided a screw conveyer *r*, which carries the iron sponge farther out of the furnace. When the iron sponge has just been discharged from the furnace proper, it is necessary that it should be protected against the action of the air, and for this purpose the room *q* is closed and connected by a pipe *s* with a supply of an indifferent or reducing gas, which is absorbed by the iron sponge in the case the air is the cooling agent, the iron sponge being thereby rendered indifferent to the oxidizing action of the air.

In Figs. 1 to 3 the tubes *a'*, through which the combustible gas passes from the inlet-pipe *d*, have no bottoms, as shown, and opposite the ends of these tubes the furnace-walls are provided with holes *u*, through which the run of the operation in the cooling zone of the furnace may be observed and through which a rod or the like may be introduced into the furnace for stirring the material, if required. *v* represents plugs for the holes *u*; but the holes may be closed in any other suitable way.

In Figs. 4 to 6 the tubes a^{10}, through which the air passes from the pipe *c*, are unperforated, so that no air can penetrate into the surrounding mass and oxidize the iron sponge. In the case that the amount of air required for the cooling of the iron sponge is larger than is suitable to admit into the combustible gas for obtaining a good self-burning mixture the furnace is provided with air-escape valves V at suitable places.

If desired, both the combustible gas and air may be used together as cooling agents for the iron sponge; but then they ought of course to be led through separate passages. I have shown such an arrangement in Figs. 11 and 12, in which a^{10} are the cooling-tubes for air and *a'* the cooling-tubes for gases, both being led from separate headers b^{10} *b'* in the walls of the furnace and uniting in a common header *b* to then flow through combustion-tubes *a*. The tubes a^{10} are of course the closed variety of Fig. 9 to prevent the direct contact of the air with the iron sponge. The tubes *a'* may be of the open style of Fig. 7 to allow the gas to come into intimate contact with the iron sponge, and thus help to prepare it for issuance into the air by fortifying it against oxidation as it comes hot from the furnace. The combustion-tubes *a* are of the perforated form shown in Fig. 8.

In the drawings all the tubes are shown to be of the same thickness, and they are all assumed to be made of iron; but, if desired, some of them, especially at the beginning of the reducing zone, where the heat is highest, may be made of refractory material.

The features of the operation of the furnace described are that the iron sponge produced is cooled down sufficiently in the furnace by means of one of the component parts of the gaseous combustible, which part is thereby heated before being mixed with the other component of the gaseous combustible at the reduction zone of the furnace, and the combustion products are kept passing to and fro through the upper part of the furnace until they have given off the greater part of their heat to the charged mass of ore and carbon, thereby heating the latter before it enters the reduction zone, and the gases evolved by the process of reduction are drawn off immediately from the spot where they are generated.

I claim as my invention—

1. A furnace for the continuous production of iron sponge, comprising means for allowing the material to be treated to pass continuously through the furnace, tubes across the direction of feed of said material in the interior of the furnace, and means for passing a combustible gaseous mixture through the said tubes, in combination with cooling-tubes for the material across the furnace and near the outlet, substantially as described.

2. A vertical furnace for the continuous production of iron sponge, comprising an outlet, cooling-tubes across said furnace near the outlet, a reducing zone thereabove, tubes through

the reducing zone, and means for supplying a combustible gas to said tubes in the reducing zone, substantially as described.

3. A vertical furnace for the continuous production of iron sponge, comprising an outlet, cooling-tubes across said furnace near the outlet and open to the interior of the furnace, means for supplying gas to said tubes, a reducing zone thereabove, tubes across said reducing zone, means for burning the gas in the tubes of the reducing zone, substantially as described.

4. A furnace for producing iron sponge, comprising tubes for repeatedly passing a gaseous body through the ore under treatment in the furnace, means for burning said gaseous body as it passes through the reducing zone of the furnace and means for preventing combustion in the tubes of the lower portion of the furnace, perforations in the tubes of the upper part of the furnace open directly to the ore under treatment and means for progressively feeding ore and carbon through the furnace, substantially as described.

5. A furnace for producing iron sponge, comprising a number of ranges of tubes, so connected one with the other, as to produce a continuous passage through the furnace, means for supplying the lower ranges of tubes with a gaseous mixture to cool the ore, means for burning said gaseous mixture in higher ranges of tubes and means for progressively feeding ore and carbon through the furnace, substantially as described.

6. A furnace for producing iron sponge, comprising a number of ranges of tubes, perforations on the under side of the tubes of the upper ranges, means for introducing a cooling gaseous body to the lower ranges of tubes and means for sustaining combustion in the perforated tubes, substantially as described.

7. A furnace for producing iron sponge, comprising a number of ranges of tubes, the tubes of adjacent ranges being so disposed as to form zigzag passages for the ore, perforations on the under side of the tubes of the upper ranges, means for introducing a cooling gaseous body to the lower ranges of tubes and means for sustaining combustion in the perforated tubes, substantially as described.

8. A furnace for producing iron sponge, comprising a number of ranges of tubes forming to-and-fro passages through the furnace, means for supplying a cooling gaseous body to the lower ranges of tubes, means for mixing said gaseous body adjacent to higher tubes with another gaseous body to produce a combustible gaseous body, and perforations in said tubes of the higher ranges, substantially as described.

9. A furnace for producing iron sponge, comprising a number of ranges of tubes forming to-and-fro passages through the furnace, the tubes of lower range having opened lower portions, and means for passing gas through said tubes, tubes of higher range having perforated lower portions, means for mixing air with the gas before the combined mixture passes through said higher ranges of tubes, and means for progressively passing ore and carbon through said furnace, substantially as described.

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

GUSTAF GRÖNDAL.

Witnesses:

GUSTAV JUNK,

OTTO VON FRIESEN.