4 Sheets—Sheet 1.

H. BESSEMER.

Evaporating Pan.

No. 9,607.

Patented Mar. 8, 1853.

Fig. 1.

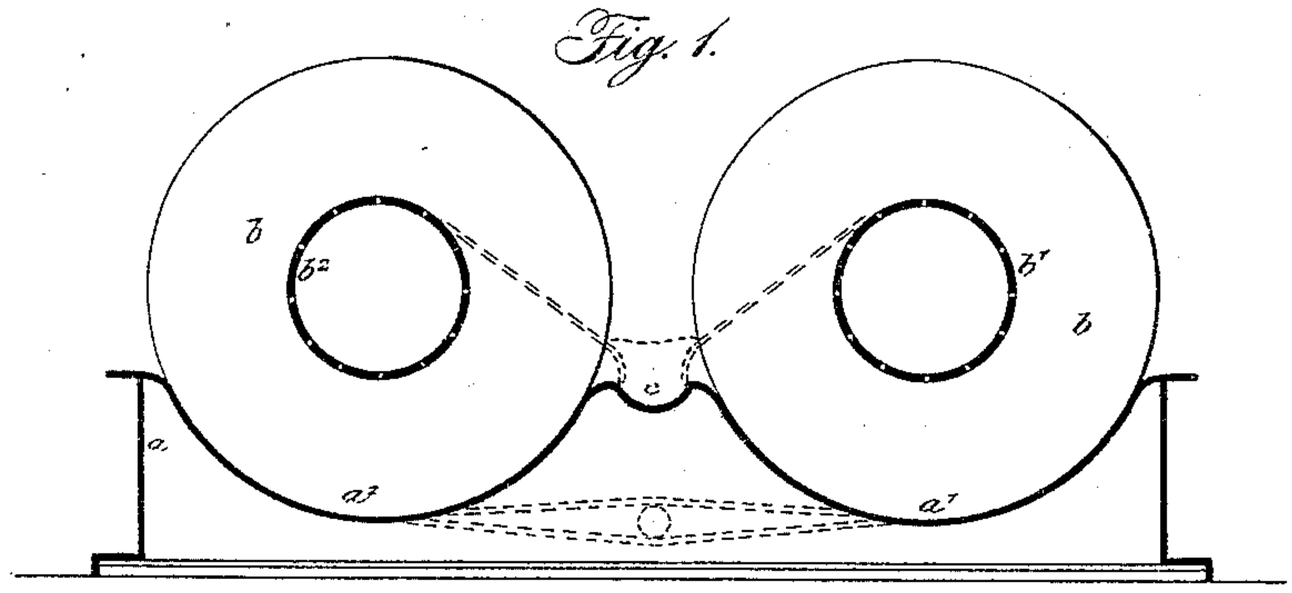


Fig. 2.

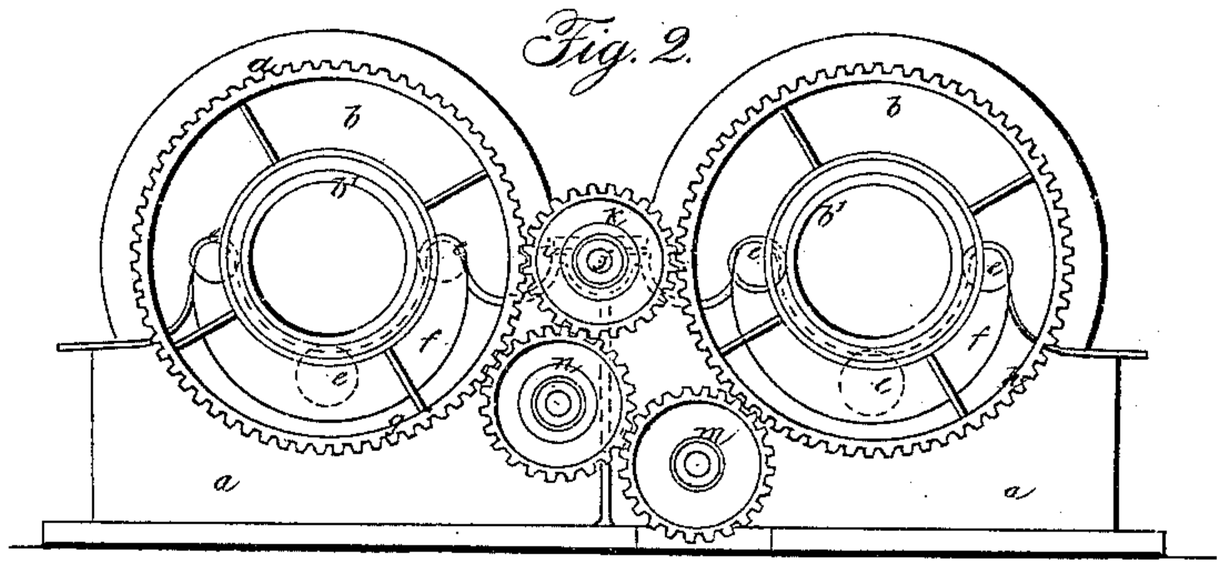
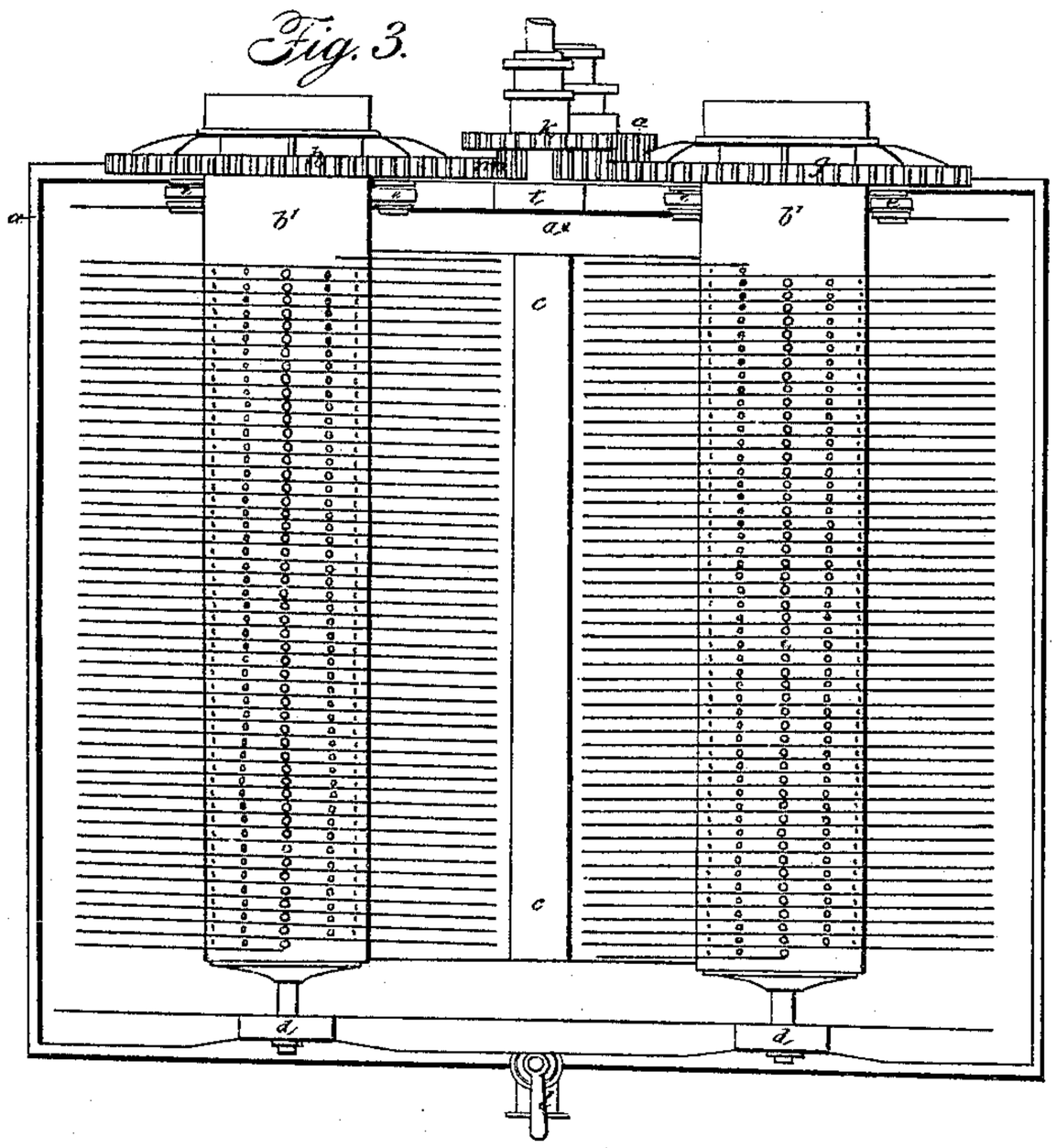


Fig. 3.



4 Sheets—Sheet 2.

H. BESSEMER.

Evaporating Pan.

No. 9,607.

Patented Mar. 8, 1853.

Fig. 3.

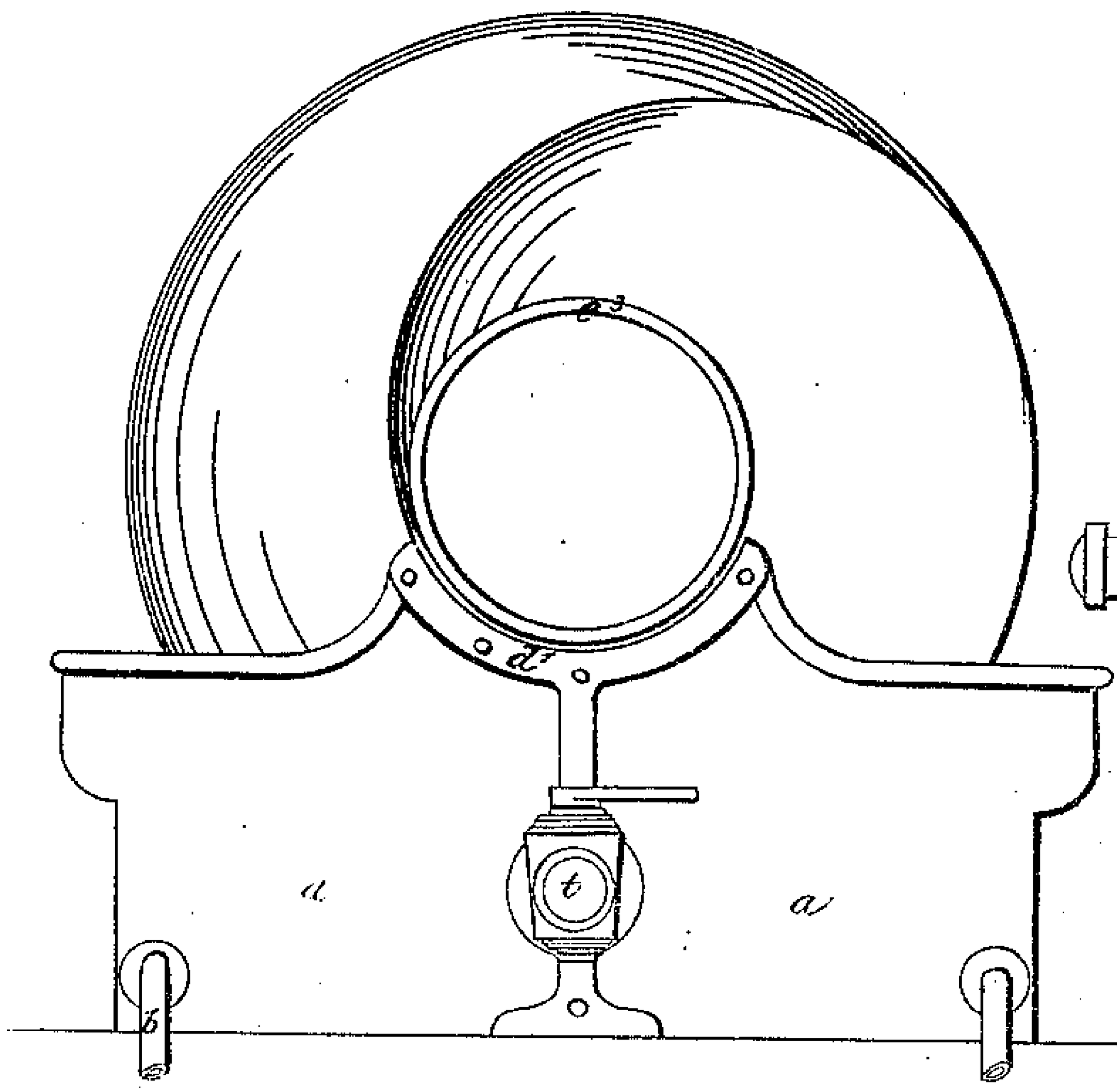


Fig. 5.

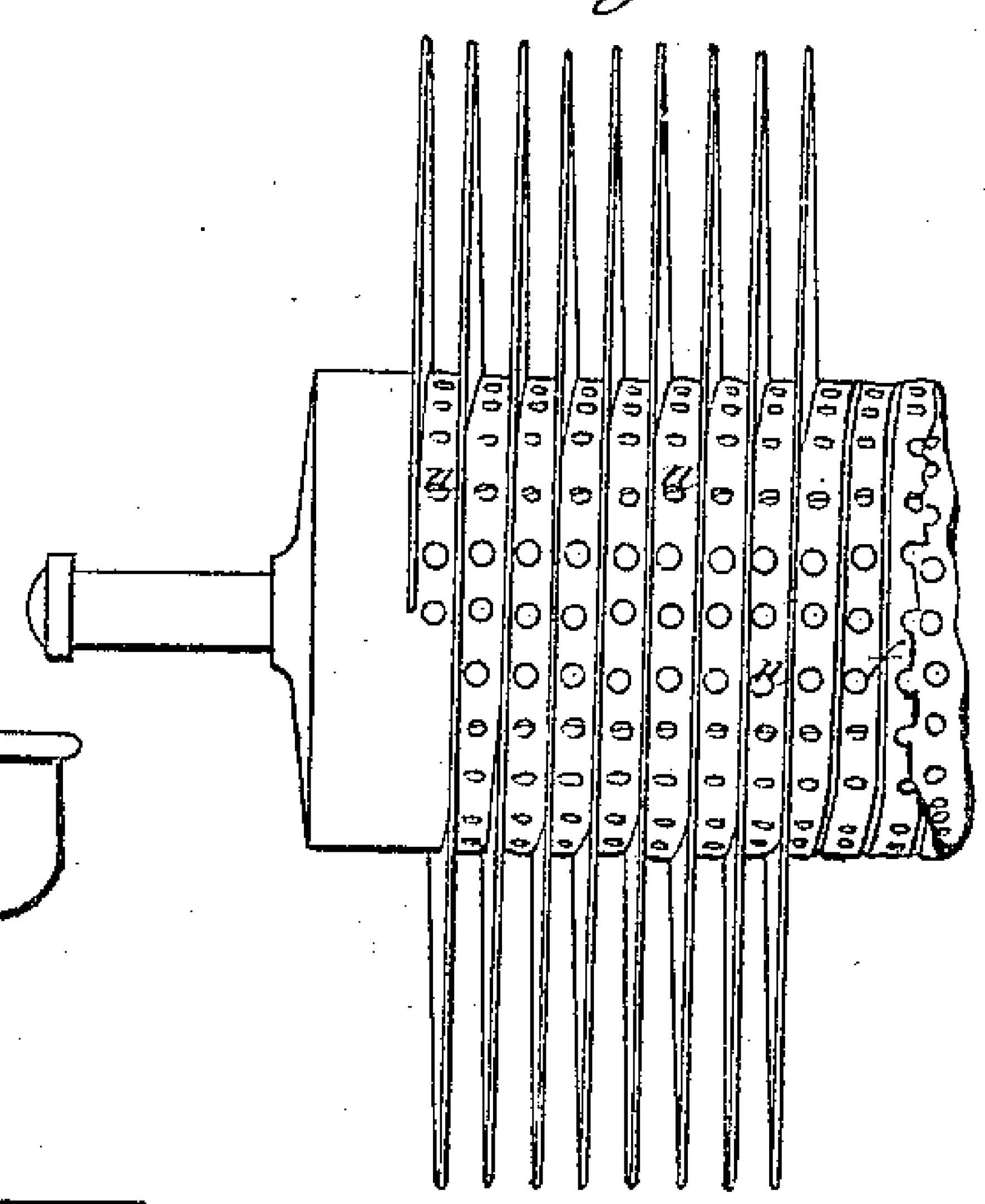


Fig. 6.

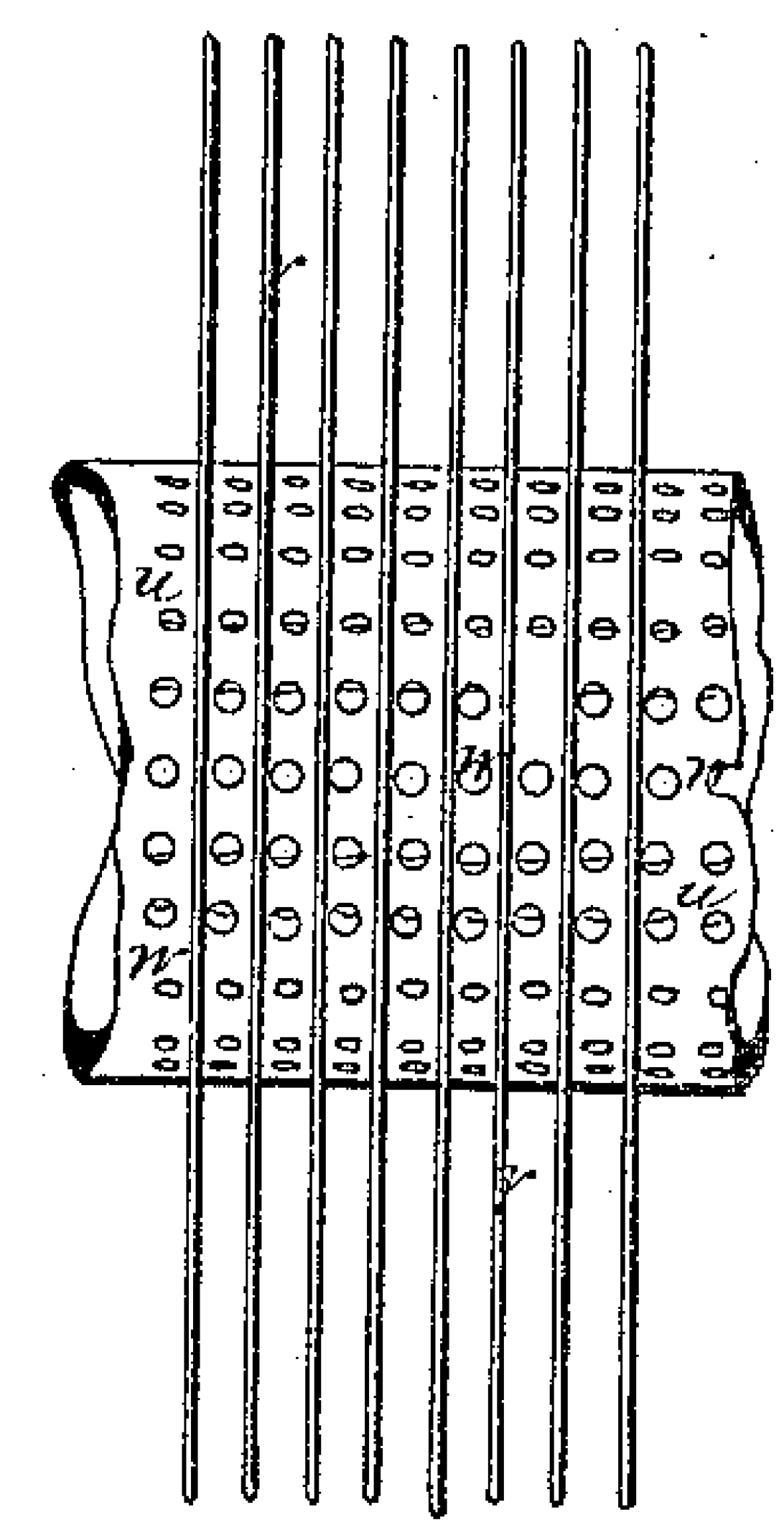


Fig. 4.

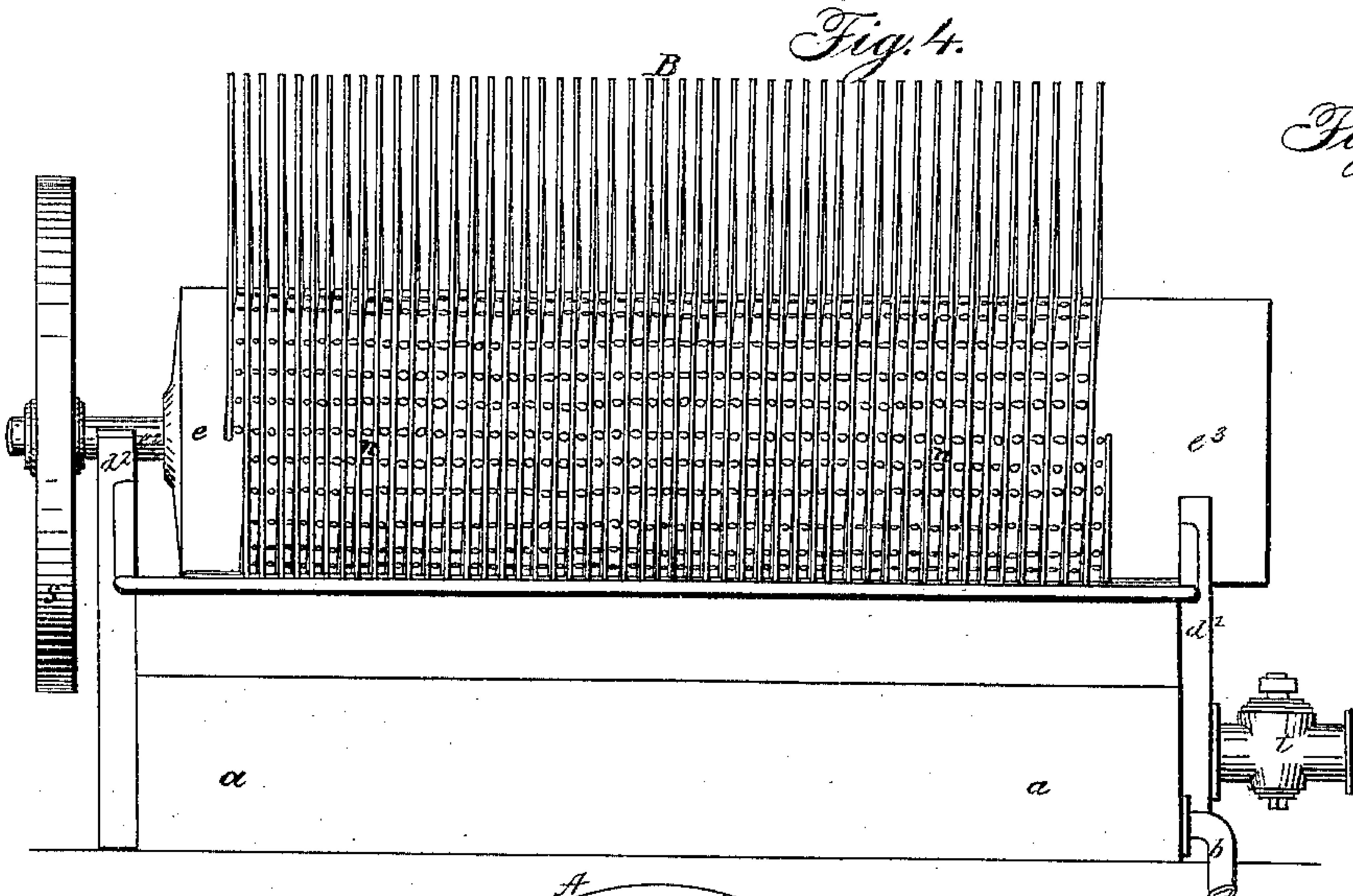


Fig. 8.

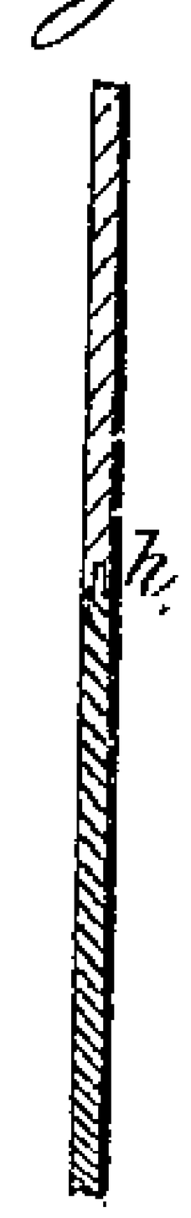


Fig. 9.

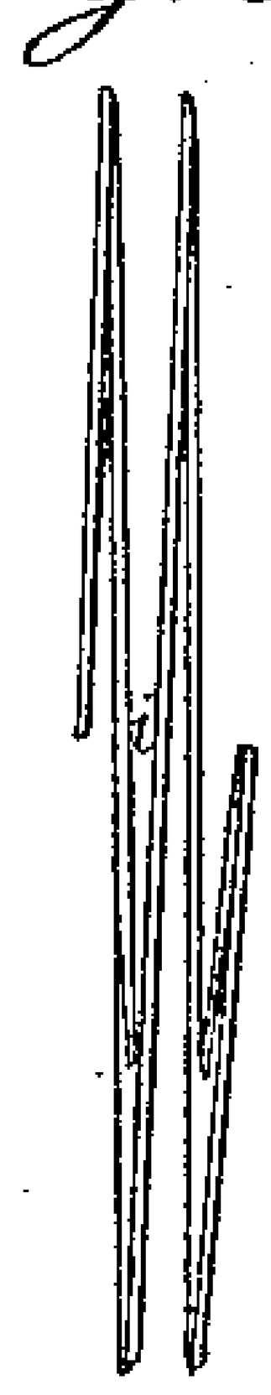


Fig. 10.

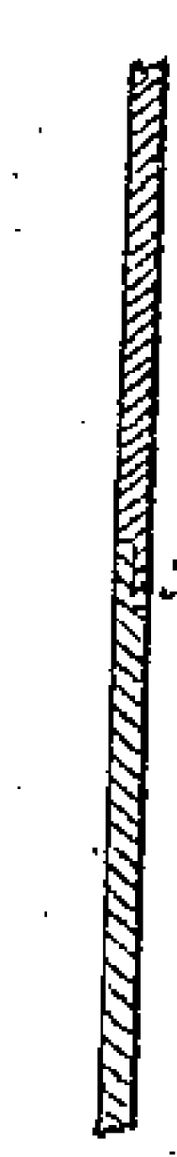


Fig. 7.

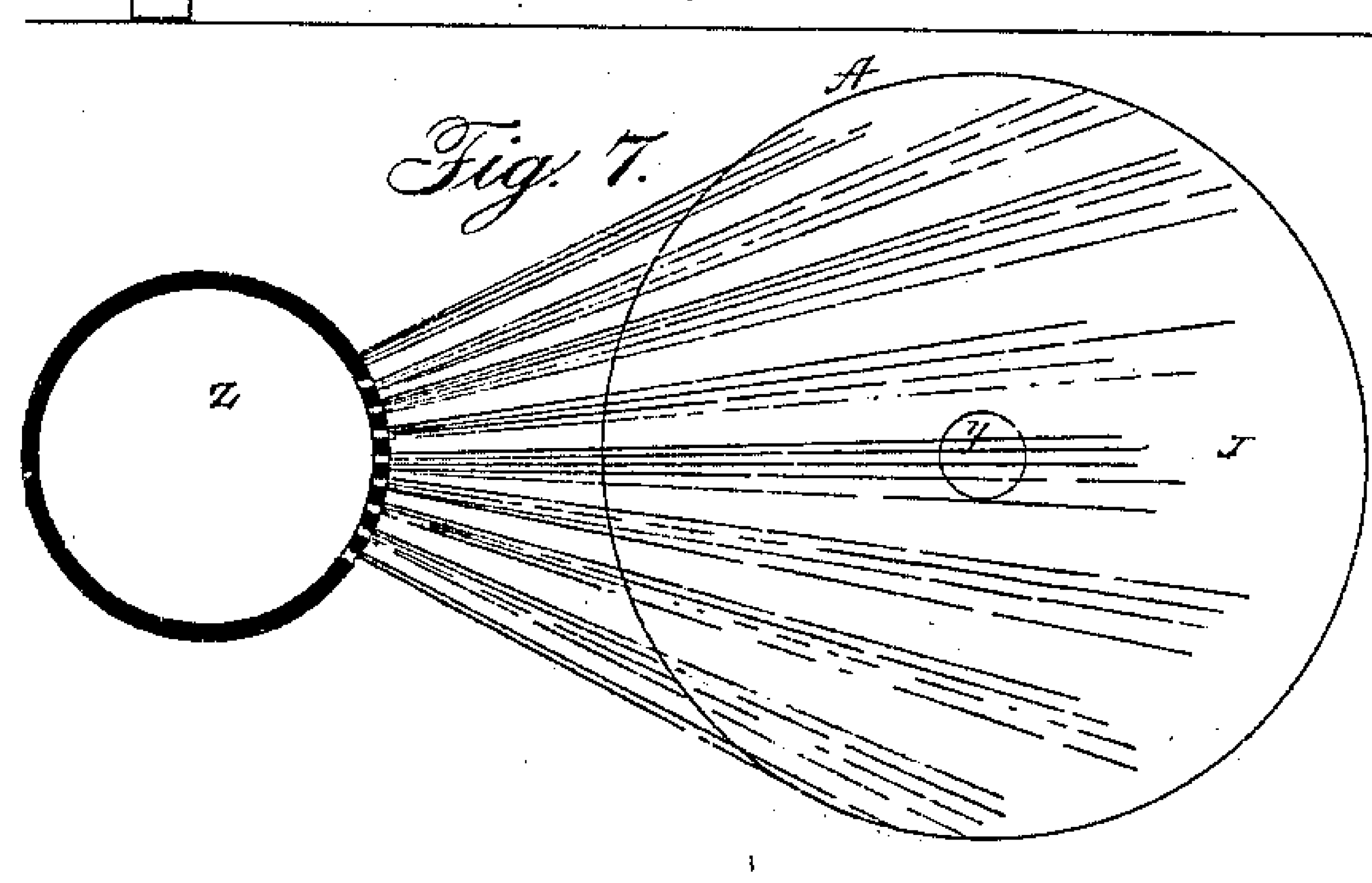
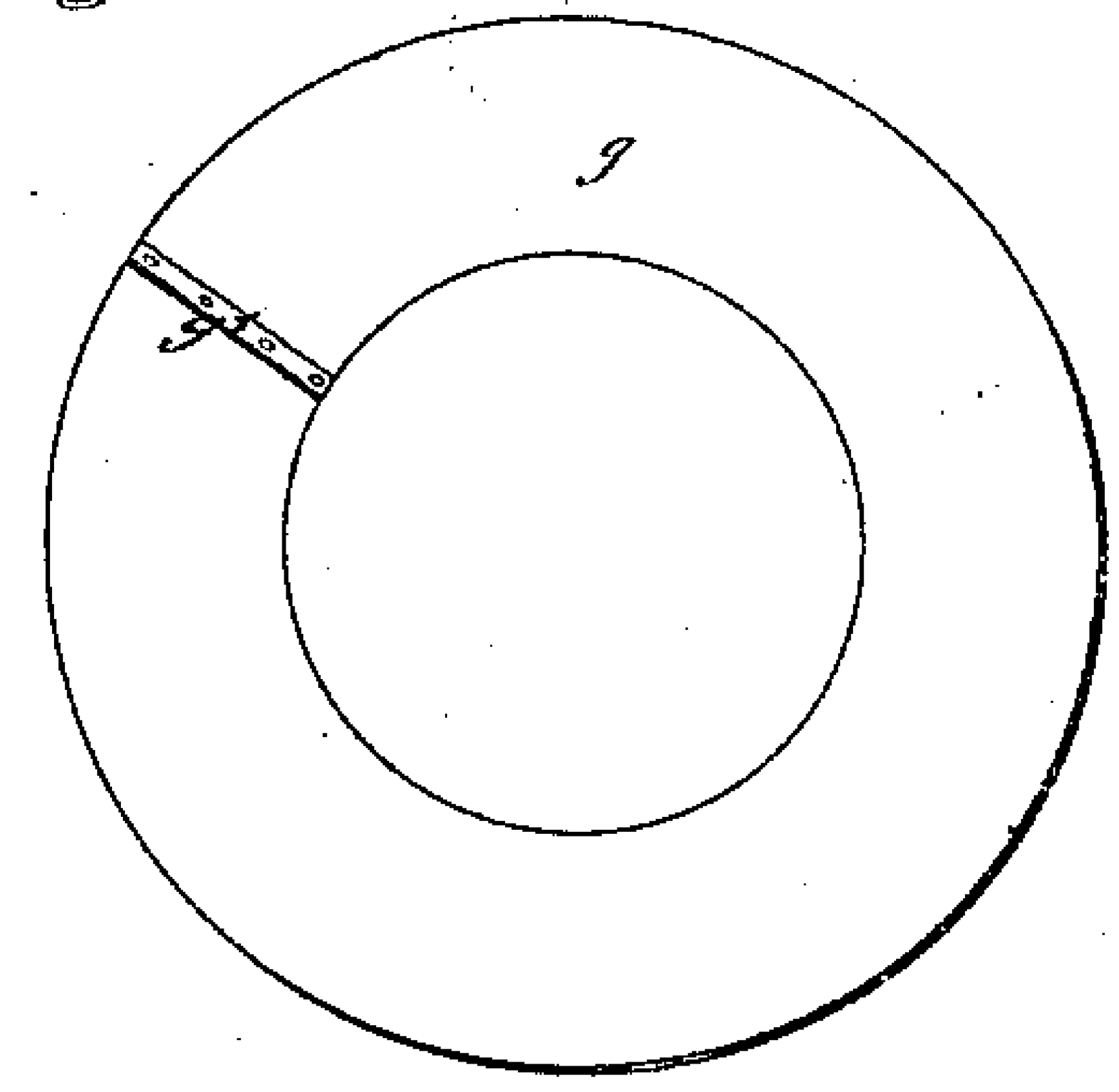


Fig. 11.



4 Sheets—Sheet 3.

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Fig. 4.

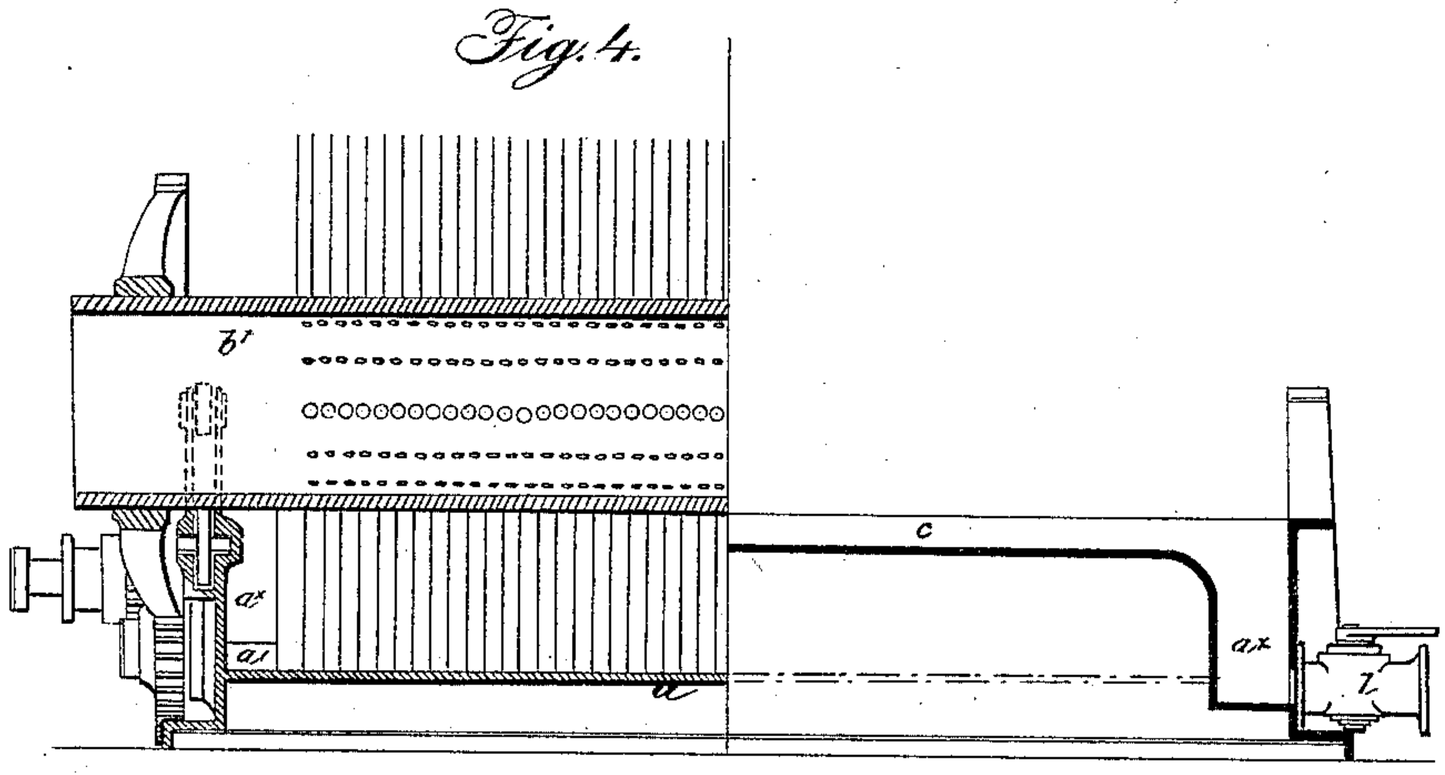


Fig. 5.

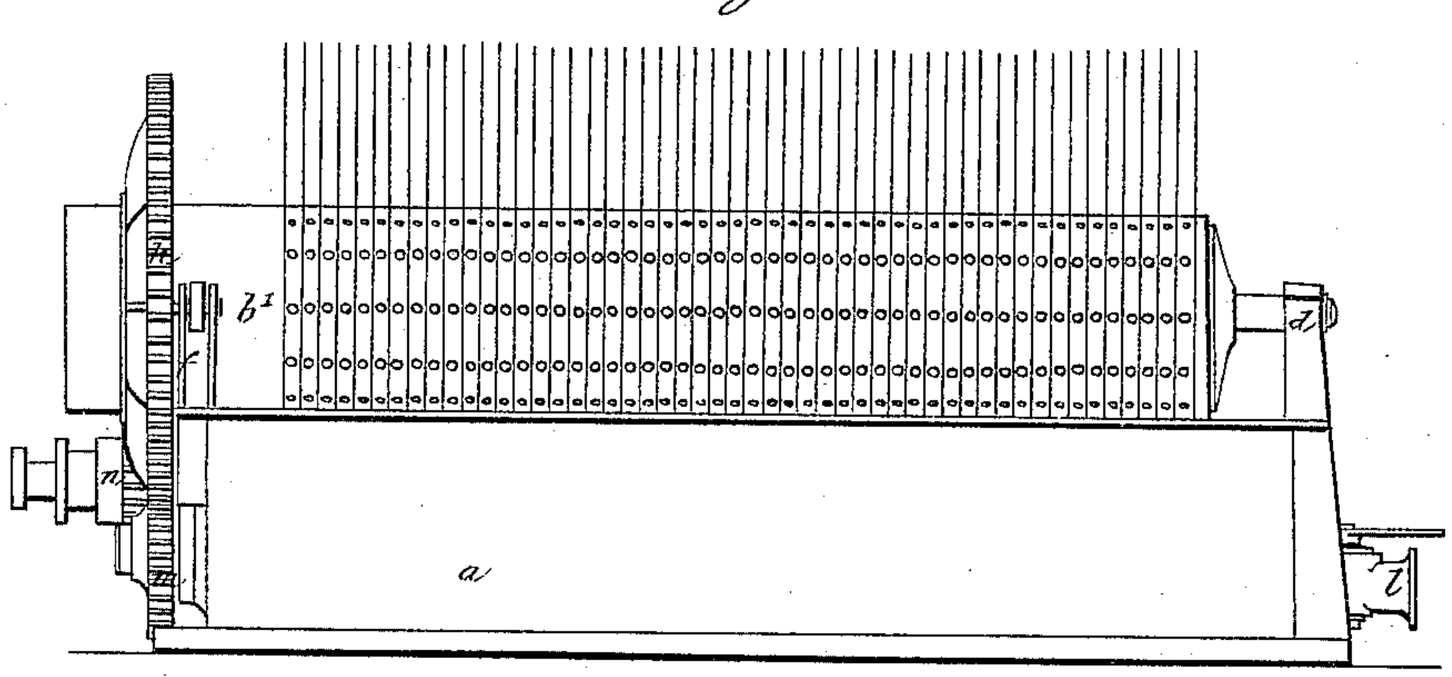


Fig. 6.

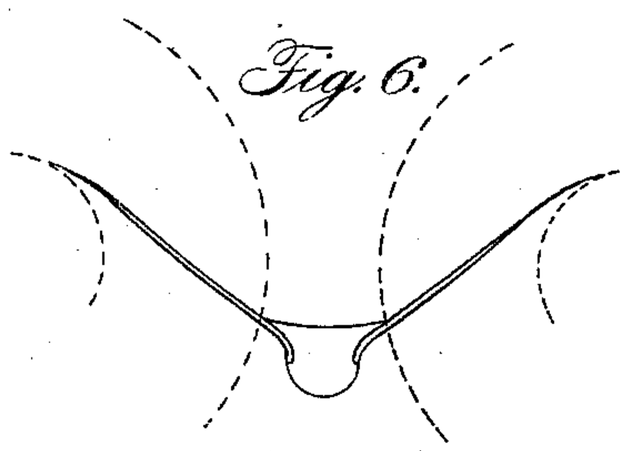
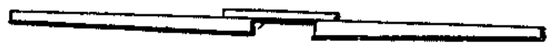


Fig. 7.



4 Sheets—Sheet 4.

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Patented Mar. 8, 1853.

Fig. 1.

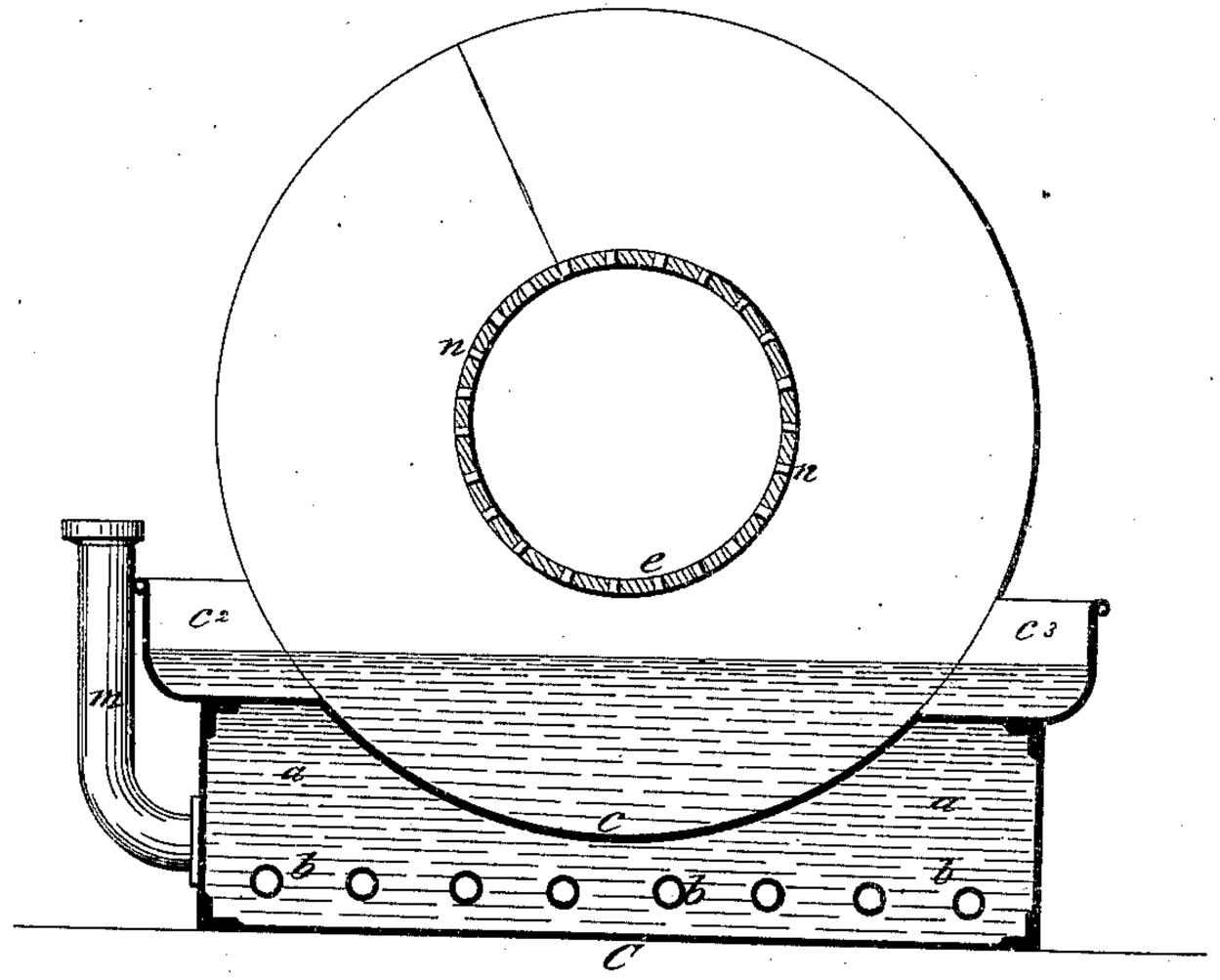
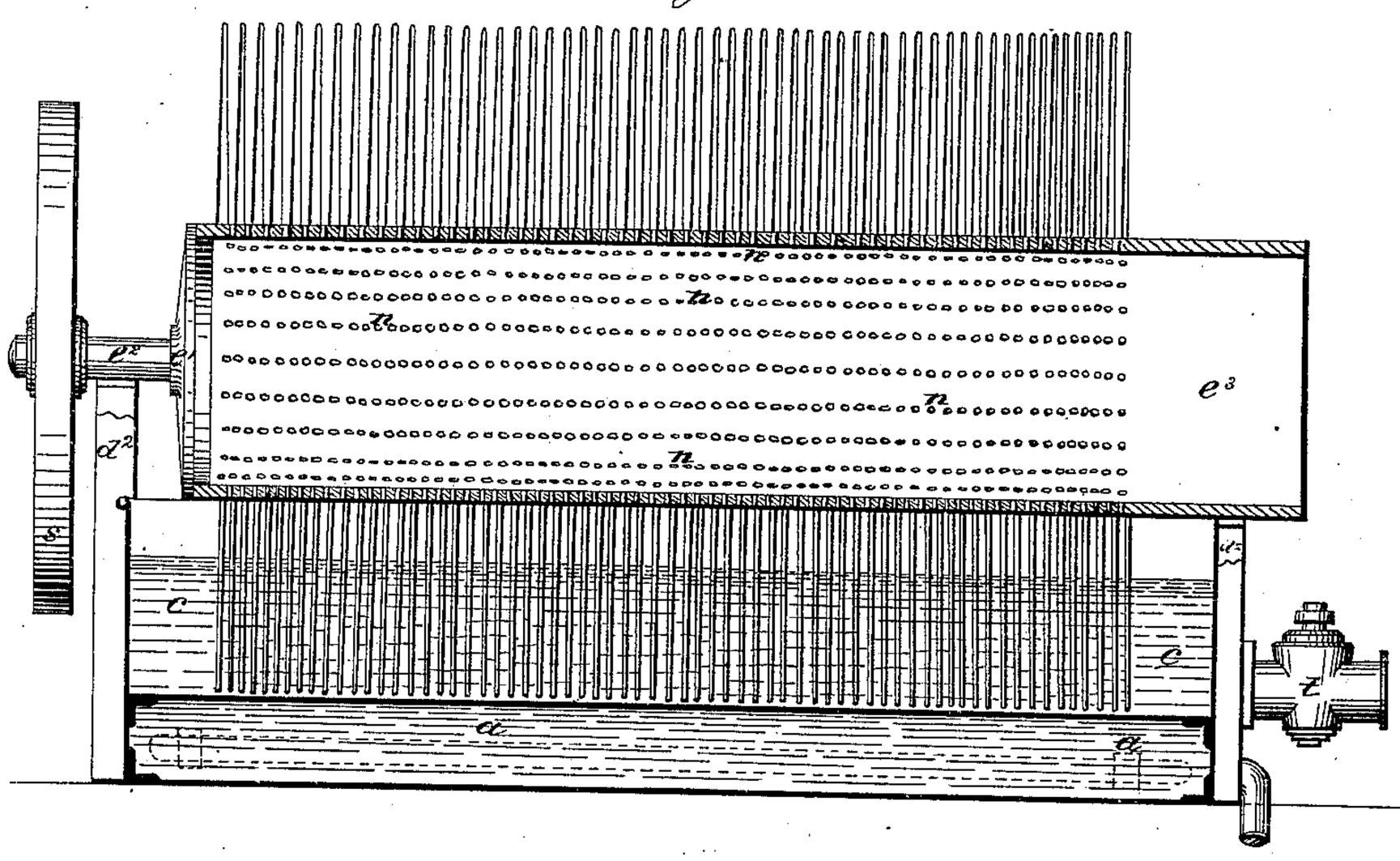


Fig. 2.



UNITED STATES PATENT OFFICE.

HENRY BESSEMER, OF BAXTER HOUSE, COUNTY OF MIDDLESEX, ENGLAND.

IMPROVEMENT IN CANE-JUICE EVAPORATORS.

Specification forming part of Letters Patent No. **9,607**, dated March 8, 1853.

To all whom it may concern:

Be it known that I, HENRY BESSEMER, of Baxter House, Old Saint Pancras Road, in the county of Middlesex, England, have invented or discovered certain new and useful improvements or mechanism for evaporating and concentrating saccharine fluids without boiling or bringing such fluids in contact with pipes or surfaces heated by direct contact with fire or steam; and I do hereby declare that the same are fully described and represented in the following specification, reference being had to the drawings accompanying and making part of the same.

With regard to my invention of a method or methods of evaporating and concentrating saccharine fluids without boiling or bringing such fluids in contact with pipes or surfaces heated by fire or steam, in order that it may be fully understood, and in what respect the same differs from other methods of evaporating saccharine fluids already known or practised, I will first give a brief description of some of these methods, and then proceed to explain the manner in which I accomplish this object.

The evaporation of the saccharine juice of the sugar-cane has for a long period of time been effected by applying fire to the bottom of the vessel containing the fluid to be evaporated, and this method is still extensively used in the British Colonies and many other countries; but it has been found that saccharine solutions when exposed to a high temperature soon acquire a dark color, part of the sugar being converted into glucose and rendered uncrystallizable, in which form it is more generally known as "molasses." To lessen this evil various modifications of apparatus have from time to time been used in which heat is transmitted to the saccharine fluids by steam circulating in pipes which pass through and among the fluid, and thus impart the heat necessary to boil it, and throw off the aqueous portion in the form of steam, it further being found that boiling by steam also produces an injurious effect on saccharine fluids, and to remedy which numerous attempts have from time to been made. The apparatus invented by Howard for this purpose, and well known under the name of the "vacuum-pan," is intended to lessen such injurious effects by causing the fluid to boil and throw off vapor in a close vessel or pan, in which a partial vacuumn is maintained by a suitable condenser and air-pumps, the boiling-point of such fluid being lower in a vacuum-chamber than when under the influence of the atmosphere. The heat, however, required to produce ebullition in the vacuum-pan is transmitted thereto by steam-pipes which pass in and among the fluid to be evaporated, the lower side of the pan being double or jacketed, for the purpose also of containing steam.

Since the period of Howard's invention other means have been devised and patented for evaporating saccharine fluids in such manner that the bulk of the fluid should be maintained below the temperature at which such fluids boil in the open air. To effect this object Mr. Cleland invented an apparatus in which a convoluted worm or tube is mounted on a horizontal axis extending across the evaporating pan or vessel in such manner that a portion thereof is immersed in the fluid to be evaporated, to assist which steam is made to pass through the convoluted tube, and as it revolves upon its axis a thin coating of the fluid is taken up upon it and exposed to the action of tthe surrounding atmosphere. In order to heat the fluid to be evaporated, the pan or vessel is constructed with a chamber below it containing steam, which steam, by contact with the bottom of the evaporating-pan, transmits heat to the fluid in which the revolving tube is partially immersed. After the publication of this invention a patent was obtained in England by Mr. Augustus Gadesden, whose invention consists of a revolving cylinder or drum composed of bars or tubes. This drum is mounted on an axis, which extends across the pan and at such a height above it that the bars of the drum as it revolves may dip into the fluid to be evaporated, a thin coating of which is taken up upon them and exposed to the atmosphere, whereby it becomes cooled and assists in lowering the temperature of the fluid in the pan. The pan or vessel is usually inclosed in a furnace, and fire is applied directly to the under side of it for the purpose of heating the fluid therein. In like manner plain circular disks or plates of metal have been mounted on an axis and made to dip into the fluid to be evaporated, and take up upon their surfaces a thin coating of it, which

is thus exposed to the cooling influence of the atmosphere, and at the same time assists evaporation.

On the 15th of April, 1851, a patent was obtained for England by Mr. Herman Schroder, for "improvements in manufacturing and refining sugar," the invention consisting of a combination of steam-pipes with revolving disks. Other plans have also been proposed in which air has been forced below the surface of the fluid and allowed to bubble through it, and thus keep down the mean temperature of the bulk of the fluid below the point at which the same would boil in the open air.

Before entering into the details of my apparatus for evaporating saccharine fluids, I wish it to be understood that I have discovered that in all cases, and in all forms of apparatus in which solutions of sugar are brought in contact with metal tubes or surfaces heated by steam, the heat thus transmitted produces an injurious effect in such saccharine matter, and also that to prevent such injurious effects of heat it is not sufficient that the mean temperature of the fluid should be kept below the boiling-point of such fluid in the open air by exposing it in thin films or coatings to the cooling action of the atmosphere, while at the same time other portions of the fluid are in contact with metal heated by fire or steam, whereby the low mean temperature of the saccharine fluid in the pan is the joint effect of exposing such fluid to an injuriously-high temperature on one set of surfaces and to an unnecessary cool one on others, and is not the result of the application of heating media at a low temperature, as in my invention, which is hereinafter described. In all cases where I apply heat to the bulk of the saccharine fluid in the pan, I prefer that the surfaces used to transmit such heat shall not exceed a temperature of 140° or 150° Fahrenheit, and so ebullition cannot take place at this low temperature. I force large quantities of heated air, also, at about 140° or 150° Fahrenheit, in contact with the fluid, which has the effect of keeping it at a uniform temperature and of absorbing the aqueous portions of such fluid, which pass off, in combination with the air, in an invisible vapor.

The apparatus for carrying into effect my invention is represented in sheet D of the accompanying drawings, whereof—

Figure 1 is a cross-section of it taken on the line A B of Fig. 4. Fig. 2 is a longitudinal vertical section of it taken on the line C D of Fig. 1. Fig. 3 is an end elevation of it. Fig. 4 is a side elevation of it, and Figs. 5, 8, 9, 10, and 11 details of the same.

a is a tank or vessel (constructed of plate-iron or other suitable material) for the purpose of containing water, which is kept at any desired temperature by the pipes *b*, which pass through it, and are heated by steam. The upper part of the tank has a close cover riveted thereto, which is hollowed out so as to form the sugar-pan *c*, the central part of which is accurately curved, forming a segment of a cylinder, the rivets being countersunk and the plates put together with butt-points, so as to leave no projections on the inside of the pan *c*. At each end of the tank there are formed bearings *d* and d^2, for the purpose of supporting a large tubular axle, *e*, which is closed at one end by a suitable cover, e'. This cover is elongated, and forms an axis, e^2, on which that end of the tube is supported. The opposite end of the tube e^3 is open, and rests on the bearing d'. The tubular axle *e* has a screw-thread on it, as shown at *f f*, Fig. 5. This thread is to be about a quarter of an inch in depth, and of such breadth as to fit a plate of sheet metal, which is to be inserted therein. The distance between the convolutions I prefer to be from half an inch to one inch; but it is by no means limited to these dimensions.

Fig. 11 represents a plate of metal, *g*, having a circular hole in its center of about half an inch less in diameter than the axle *e*. The plate *g* has a slit cut in it at g', and each edge of the metal next to this slit is reduced to half its thickness, in order that a similar edge of another plate may be riveted thereto without increasing the thickness at that part. This joint is shown on a large scale at g^2, Fig. 10. Two plates thus united are represented at Fig. 9, where *i* shows the riveted junction; or, instead of this mode of uniting the plates, the edges may be "plowed and tongued," as represented at *h* in Fig. 8. A number of circular plates thus prepared are sprung sufficiently to cause their under edges to be inserted in the spiral groove or thread of the axle *e*, on which they are fitted and riveted together, the plates assuming the form represented in Fig. 9. The above-described modes of joining the plates together constitute no part of my invention. When as many plates are thus put on as will occupy the spiral groove from end to end, a large screw will be formed by them, as represented by Figs. 2 and 4.

On that part of the axle *e* which intervenes between the spiral blades or threads of the screw a great number of holes are drilled into the interior. (Shown at *n*.) These holes extend entirely around the axle at a distance of a few inches apart, and are for the purpose of admitting jets of air in between the convolutions of the screw.

The action of the apparatus is as follows: The tank *a* is first filled with water by the opening *m*, and steam is admitted to the pipe *b*, which consists of several lengths united by bends at each end, so as to form a continuous passage for the steam to rush through; or, instead of these pipes, fire may be applied to the under side of the tank *a*, the object in either case being to heat the water, which forms a bath for the sugar-pan, against the under side of which the water is in contact. A thermometer may be inserted in the opening *m*, for the purpose of ascertaining the temperature of the bath, which I prefer to use at 150° Fahrenheit. The opening *m* is left open to the atmosphere, in order to prevent (even with care-

lessness) the water from being raised above 212° Fahrenheit, and consequently so as to prevent latent heat of steam from acting upon the metal against which the saccharine fluid is in contact; and although I have herein described water as being used as a heating medium, the heat may be transmitted to the fluid in the pan by heated air, or by any liquid or aeriform fluid whose temperature is below 212° Fahrenheit; or the process of evaporation may be carried on by the application of heated air to the fluid on the surfaces of the moving or revolving apparatus without any application of heat to the bulk of fluid in the pan otherwise than what it may obtain from the revolving apparatus, which becomes heated by the air so brought in contact therewith.

I also use a blowing-fan or other convenient air-forcing apparatus, which I connect with a pipe. One end of this pipe is inserted into the open end e^3 of the hollow axis of the screw. The air so forced I prefer to heat to about 150° Fahrenheit by the application of heat to the pipe which conveys it to the evaporating apparatus, or by any convenient mode of heating air already known and practiced. The saccharine fluid is let into the pan so as nearly to fill it. Rotary motion is then to be communicated from any first mover to the axle *e*, which should revolve at the rate of about eight or ten revolutions per minute. As the screw revolves, it will take up upon its surface a thin coating of the saccharine fluid, and as the heated air rushes out of the numerous holes in the hollow axle it will be brought in contact with the thin stratum of fluid thus presented to its action, the aqueous portions of the fluid will be absorbed by the air and carried off in combination therewith, while the saccharine fluid on the screw, which has thereby become more dense, will again descend into and mix with the fluid, while fresh portions are rising out of it, to be acted on in like manner. As the quantity of fluid in the pan diminishes by evaporation, fresh portions should be added until the requisite density is obtained.

To prevent the deposit of the sugar, or the formation of a concrete mass on the bottom of the pan, I cause the screw to be fitted so as to come almost in contact with the bottom of the pan, whereby the blades of the screw will form a scraper and remove any such deposit or concrete matter to one end of the pan. This tendency to bring the charge to one end of the pan renders it necessary to leave room on both sides of the screw at e^2 and e^3, for the fluid to return to the opposite end of the pan, and thus keep up a circulation of the fluid during the whole process. When the charge is sufficiently concentrated, a sluice properly placed at one end of the pan may be opened and the screw continued in motion, which will greatly facilitate the discharge of the sirup from the pan, which can then be refilled, and the process continued as before. After the concentrated sirup leaves the pan, it should be heated before being allowed to crystallize, as already practiced with sirups concentrated in the vacuum-pan. Although the apparatus herein last described may be used for effecting the final concentration of the cane-juice or other saccharine fluids, I prefer to use it only for the purpose of increasing the density of such fluids to 27° or 30° Baumé, in which case the screw may be made to move an inch or two clear of the bottom of the pan, because no deposit of crystals will take place at that density. The convolutions of the screw or the disks may in that case be made much closer together in consequence of the degree of fluidity possessed by sirups of that density.

When two different pans are to be used, I prefer to construct the one used for the final concentration of the sirup, as represented on Sheet E of the drawings annexed, where Figure 1 is a cross-section of the invention; Fig. 2, an end elevation of it; Fig. 3, a plan of it; Fig. 4, a longitudinal section of it, and Fig. 5 a longitudinal elevation of it. Figs. 6 and 7 show a scraped used to cleanse the screws.

a is a tank or jacket, of cast-iron or other suitable material, in the upper part of which there are two large cylindrical hollows, *a' a'*, forming the sugar-pan, and which are of such a radius as to fit nearly close to the large screws *b*.

Between the large hollows *a'* there is a smaller one, *c*, which is for the purpose of receiving the thick sirup, which is scraped off the spiral blade during the emptying of the pan. The axes *b'* of the screws *b* are hollow, and perforated with numerous holes for the distribution of air between the blades of the screws. Each axis *b'* is supported at one end by brass bearings in the plumber-box *d*, and the large open ends of the axes *b'* are each supported by three friction-rollers, *e*, which work in a case, *f*, bolted to the end of the tank. The outer ends of the axes *b'* have spur-wheels *g h* keyed upon them.

On the end of the tank *a*, and midway between the two screws, there is a plumber-block, *i*, which supports one end of the main driving-shaft *j*. This shaft has upon it a wheel, *k*, that gears into both the wheels *g* and *h*, so as to drive both the screws *b* in one direction. The screws are made one right and the other left handed, so that each of them move the sirup to opposite ends of the pan. At each end of the pan there is a space of a few inches in width at *a**, which communicates with both of the screws, so that the sirup moved by one screw flows freely along this space and supplies the other screw, while the space at the opposite end in like manner allows the sirup propelled back again by the last-named screw to pass again into the first one, and thus a circulation of the fluid is obtained, which equalizes its temperature and density. When the concentration of the sirup is effected, the pan is to be emptied by reversing the motion of one of the screws, and thereby causing the sirup to be brought to that end of the pan where the sluice *l* is provided for

drawing it off. To produce this change of motion there is a wheel, *m*, which moves freely on a fixed stud projecting from the end of the tank *a*, and is always in gear with the driving-wheel *h* of the screw. There is also another wheel, *n*, which gears with the wheels *g*, *k*, and *m*. The wheel *n* is supported on a fixed stud, which projects from the end of the tank *a*, and is made to slide backward or forward upon it. The wheel *k* is also arranged so as to slide endwise on its shaft, a forked lever, if desirable, being made to act on the wheels *k* and *n*, so as to slide them along in opposite directions, in a manner well understood, so that when the wheel *k* is in gear with the wheels *g* and *h* the wheel *n* will be out of gear with the wheels *k* and *g*, and thus the screws will move both the same way, as before described. By reversing the forked lever, the wheel *k* will be thrown out of gear with the wheels *g* and *h*, while the wheel *n* will be thrown in gear with the wheels *g* and *m*, and as the wheel *n* is of double the breadth of tooth to the others it will continue in gear with the wheel *k*, and thus the wheels *j* and *h*, with their respective screws, will be carried round in opposite directions.

After the greater portion of the sirup has been run off by the sluice, it will be found that a considerable quantity of it is still left adhering to the blades of the screws. In order to remove this portion also, a scraper, formed as represented in Figs. 6 and 7, is placed between the convolutions of the screws *b* at that end farthest from the discharging-sluice. This scraper is shown by dots in Fig. 1. The semi-fluid matter adhering to the screws will thus be removed and be made to flow into the gutter *c*, and from thence it will flow into the space *a**, and escape by the sluice *l*. As the screws revolve the scraper will be carried along a distance equal to the breadth of one convolution every time they turn around, and thus the entire surface of both screws will be cleansed by the action of one scraper.

The atmosphere of large towns (in which sugar-refineries are generally carried on) has floating in it soot, dust, and other matters, which, if blown with it on the wet surface of the screw, would render the sirup impure and injure its color. I therefore force the air through silk, cotton, or woolen fabrics, and thus separate the solid matters from the air before allowing it to enter the screws. This filtration of the air may be readily accomplished by causing the air from the blowing apparatus to enter at one side of a wind-chest, which has a central division formed of some suitable textile fabric tightly stretched over a frame. The air passing through this fabric will collect and be carried off by a pipe proceeding from the opposite side of the chest from that at which it entered, while the solid matters floating therein will be separated by the fabric, from the surface of which they may be brushed from time to time.

Although the spiral blade or screw herein described affords great facility in discharging the contents of the pan and in scraping the bottom of it, nevertheless plain circular plates or disks may be used instead, and as this difference will not affect the general arrangements of the apparatus, I have shown only a portion of a hollow axle with plain disks. In Fig. 6, Sheet D, *u* is the axle, *v* the disks, and *w* the holes through which heated air is forced between the disks, to cause the evaporation of the fluid taken up upon their surfaces; and although I prefer to force heated air from the center of such disks, it will nevertheless be obvious that a similar, though less perfect, result may be obtained by forcing such heated air between disks mounted on a solid axis, as represented in Fig. 7, Sheet D, where *x* represents the disks, *y* the solid axis, and *z* a pipe placed parallel thereto, and perforated on that side next to the disks, so that heated air may be forced between and in contact with the wet surface of the revolving disks.

Although I have herein described the mode which I prefer of evaporating saccharine fluids by taking up thin films or coatings thereof upon revolving surfaces, it will nevertheless be obvious that plates or surfaces made to reciprocate or otherwise move into and out of the fluid to be evaporated may also be made to take up the fluid upon them and expose it to the action of heated air, and may therefore be used as a means of carrying into effect this part of my invention; and, further, instead of using revolving or moving surfaces as a means of exposing thin films of saccharine fluid to the action of heated air, fixed plates or surfaces may be used in a vertical or inclined position without being heated otherwise than by the heated air, which is forced between them for the purpose of absorbing the aqueous portions of such fluids. These plates or surfaces may be placed in an upright tank or vessel open at the top for the escape of the heated air and vapor, and connected at bottom with a pipe or trunk, through which heated air is forced by a fan-blower or other suitable means, and thus a strong current of heated air will be made to sweep over the wet surfaces and produce a rapid evaporation.

The plates or surfaces may be placed within a quarter or half an inch of each other, and the fluid allowed to flow onto the top end of them from perforated pipes, in connection with a reservoir, which may be supplied by a common lift-pump from a tank or vessel, into which the fluid falls after passing over the plates; and thus a repetition of the process may be carried on until the fluid has arrived at the desired density.

I have not hereunto annexed any drawings of such apparatus because the form and arrangement thereof will be readily understood by any workman, and admits of great variation without affecting the principle on which it depends.

It sometimes happens that, owing to certain interruptions caused by the state of the

weather or by other circumstances, a portion of the crop of canes of an estate is in danger of being lost or spoiled unless they can be used with great expedition, and whenever, from this or other causes, it is requisite to increase the evaporative power of the apparatus herein described, I either increase the temperature of the air up to or about 212° Fahrenheit, or I turn on steam from any suitable boiler into the jacket or tank below the pan, the opening or openings *m* being closed for the purpose, and a pipe attached to the tank *a* in connection with a steam-boiler, to which mode of heating separately I make no claim. I thus increase the rate of evaporation, considering it preferable in such emergencies to produce an inferior sugar to allowing the same to be entirely wasted from want of the means of sufficiently rapid evaporation.

Having thus described the nature of my said invention and the manner of constructing the same, what I claim therein is as follows:

1. The combination of a hollow and perforated shaft connected with an air-blast apparatus, a series of plates or a screw-plate, (placed around and on the shaft,) and a reservoir, trough, or basin for holding the liquor to be evaporated, all substantially as exhibited in Sheet D of the above-mentioned drawings, and as above specified.

2. The combination of a hot-water vessel and its heating apparatus, the cistern for holding the saccharine liquor, the apparatus for effecting its evaporation by means of hot air blown on thin or extended surfaces, and a screw or plates, as specified.

In testimony whereof I have hereto set my signature this 31st day of December, A. D. 1852.

HENRY BESSEMER.

Witnesses:
JOSEPH MARQUETTE,
JOHN R. DARKER.