Specification of Henry Bessemer : fuel and furnaces.

A.D. 1849 . . . . . N° 12,780.

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OF

HENRY BESSEMER.

FUEL AND FURNACES.

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Fuel and Furnaces.

BESSEMER'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, HENRY BESSEMER, of Baxter House, Old Saint Pancras Road, in the County of Middlesex, Engineer, send greeting.

WHEREAS Her present most Excellent Majesty Queen Victoria, by Her Royal Letters Patent under the Great Seal of the United Kingdom of Great Britain and Ireland, bearing date at Westminster, the Twentieth day of September, One thousand eight hundred and forty-nine, in the thirteenth year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said Henry Bessemer, my exors, admors, and assigns, Her especial license, full power, sole privilege and authority, that I, the said Henry Bessemer, my exors, admors, and assigns, or such others as I, the said Henry Bessemer, my exors, admors, or assigns, should at any time agree with, and no others, from time to time and at all times during the term of years therein expressed, should and lawfully might make, use, exercise, and vend, within England, Wales, and the Town of Berwick-upon-Tweed, my Invention of "IMPROVEMENTS IN THE PREPARATION OF FUEL, AND IN APPARATUS FOR SUPPLYING THE SAME TO FURNACES;" in which said Letters Patent is contained a proviso, that I, the said Henry Bessemer, shall cause a particular description of the nature of my said Invention, and in what manner the same is to be performed, by an instrument in writing under my hand and seal, to be inrolled in Her said Majesty's High Court of Chancery within six calendar months next and immediately after the date of the said in part recited Letters Patent, as in and by the same, reference being thereunto had, will more fully and at large appear.

NOW KNOW YE, that in compliance with the said proviso, I, the said Henry Bessemer, do hereby declare that my said Invention consists,—

Firstly, of so heating small coal as to soften the same as to admit of its being compressed into blocks or forms without requiring other cementing matters. This part of my Invention also consists in certain combinations of machinery for pressing, solidifying, and forming fuel into blocks or masses, and in apparatus for preparing small coal or coal dust as fuel, in which apparatus the fragments of coal are fused or softened by heat applied thereto in various ways, and afterwards subjected to pressure by the said machinery while in a partially fused or softened state, whereby the said fragments of coal are made firmly to cohere and form a dense mass, without the necessity of the admixture of any foreign adhesive matters therewith.

Secondly, my Invention consists in preparing fuel of different qualities from coal or coal dust, by separating therefrom different quantities of their gaseous or volatile constituents, and in some cases also of further altering and modifying the quality of the fuel by the admixture of different kinds of coal or coal dust, so as to render such fuel peculiarly adapted to the various circumstances and conditions under which it is to be used.

And, lastly, my improvements consist in supplying fuel to furnaces by a combination of revolving circular fire bars or wheels, which conduct the fuel into the furnace and progressively move it therein, and finally eject the clinkers or slag at the opposite end of the fire chamber.

Before describing the details of the plans referred to under the three heads just mentioned, I will briefly point out some of the most prominent defects of the various compounds hitherto proposed or manufactured as fuel, in order that the distinctive character of the present Invention may be more fully understood. In the manufacture of fuel composed partly of small coal or coal dust, a great variety of matters, such as tar, pitch, resin, oil, clay, lime, asphalte, gutta percha, Roman cement, &c. &c., have hitherto been used in order to cement the coal dust together, and both heat and pressure have sometimes been used separately or together to facilitate the aglomeration of the heterogeneous mass. From this admixture of foreign matters with the coal numerous disadvantages arise. In some cases the fuel is rendered expensive by the use of materials much more costly than coal. Many of the materials used are wholly incombustible, and thereby add to the weight and bulk of the fuel, while they check its combustible properties, and add materially to the slagging or clinkering of the furnaces in which they are used. The use of gas tar or like materials very much increases the production of dense black smoke, and when used in large quantities cause the fuel to soften or liquify in the furnace to such an

extent as to prevent the free passage of atmospheric air through the mass, the absence of which produces an imperfect combustion, accompanied by a dense black smoke. Many of these mixtures have a very offensive odour, while nearly all of them are but feebly coherent, and are broken into small fragments by a fall or a light blow. The object of the first part of my Invention is to remedy these defects, by producing a prepared fuel from coal or coal dust, without the necessity of the admixture of any foreign matters therewith. It is found that when coal or coal dust is heated up to a temperature of about five hundred or six hundred degrees Fahrenheit, it becomes softened, the bituminous portions undergoing a degree of fusion sufficient to cause the small pieces to adhere together. It is this peculiar property of partial fusion in coal that I make use of as a means of forming by pressure consolidated blocks or masses of coal, possessing the characteristic properties of the coal from which they are formed, but which have the advantage of being in pieces of uniform size instead of in the usually irregular state of coal. I would observe, that instead of forming the soft coal into large unwieldy masses (as usually practiced in the manufacture of artificial fuel), and which require to be broken into pieces before use, whereby much small coal or dust is again produced, I prefer to make them at once into small cylindrical pieces, of a size best adapted to furnaces or domestic use, according as required, whereby the trouble and loss of breaking is prevented, and a most convenient fuel obtained. The machinery or apparatus wherewith this first part of my Invention may be carried into effect is represented on Sheet A of the Drawings hereunto annexed; where Figure 1 is a longitudinal elevation of a furnace, and an end elevation of pressing machinery; Figure 2 is a plan of the same; Figure 3 is a longitudinal section of the furnace on the line A, B, of Figure 2; Figure 4 is a cross section of the furnace and longitudinal section of the pressing machinery on the line C, D, of Figure 2; Figure 5 is a side elevation of the pressing machinery, and an end elevation of the furnace; and Figures 6 and 7 are details of the travelling chain bed, on a larger scale. In this apparatus, the furnace for heating and softening the coal, the machinery for pressing it, and the steam engine which produces the required motive power, are all combined, and constitute one apparatus; and as the products of combustion will pass off from the furnace at a high temperature, it is intended that this surplus heat shall be applied to the generation of the steam required by the engine, for which purpose a steam boiler provided with suitable flues should be set as near as convenient to the end a^* of the furnace a, where it will be perceived that an opening is left at b, for the purpose of allowing the heated matters from the furnace a to pass into the flues of the steam boiler,

the arrangement of which is so well understood as not to require any detailed description here. The furnace *a* is of the reverberatory kind, and has a fire-place at *c*, provided with fire bars *d* and doors *e*. *f* is an endless chain bed, of peculiar construction, passing over polygonal drums *g*, mounted on axes *h*; the horizontal position of the chain *f* is insured by small iron rollers *i*, which support it at short intervals. The rollers *i* are provided with axes, which work in iron sockets let into the side walls of the furnace, as does also the axis *h** of the polygonal drum *g**. The chain bed consists of a number of iron bars, of about thirty inches in length, notched on each side, and fitting into each other in a similar manner to a common hinge joint, and, like the hinge, it has a pin passing entirely through it, and thus forms a joint capable of folding over the polygonal drums *g*, and also of presenting a nearly flat surface on the upper side, see Figures 6 and 7, where a part of the chain bed is shewn on a larger scale. Near the end of the furnace farthest from the fire there is fixed a hopper *j*, into which the small coal is thrown; this hopper has a roller *k*, with leaves projecting from it, working in a cylindrical part formed in the hopper. The roller *k* is mounted on a shaft *l*, which turns in bearings formed in the bosses cast on the sides of the hopper *j*. The shaft *l* is further supported by a plummer block *n*, and carries on its outer end a drum *m*, which receives motion from the strap *o*, and causes a regulated quantity of the small coal to pass from the hopper through the opening *p*, and fall upon the endless chain bed in a thin layer; the motion of the chain bed in the direction of the fire-place *c* will bring the coal along with it, and discharge it into the hopper *r*. To prevent any portion of the coal that may stick to the chain from being carried back again, a scraper *s* is made to press its edge against the lower part of the chain; the scraper is mounted on an axis, and has a lever and ball *q*, the weight of which presses the edge of the scraper against the chain. It will be seen that the fire bridge *t* rises sufficiently high to protect the chain from the violent action of the fire, and it at the same time forms one side of the hopper or receptacle *r*. I have shewn a break in the Drawing, to denote that the furnace and chain bed are to be made longer than is there represented; from thirty to forty feet of bed will be found to answer well. When a fire is made in the fire-place *c*, the heat will be reverberated on to the thin stratum of coal upon the chain bed, which, as it first enters from the hopper, will be subjected to the lowest temperature of the furnace, and will be brought progressively into the hotter part near the fire bridge, while new portions of coal will be deposited upon the chain bed as it passes under the hopper *j*, which will in turn be carried towards the fire bridge; the increased temperature to which it is thus subjected will cause the coal to soften, and commence to give off some of its volatile

constituents, which will inflame and add to the action of the furnace. The extent to which the fusion of the coal is carried may be regulated by the speed at which the chain moves, and also by the state of the fire. The small coal being thus softened by heat, and delivered in a regular and continuous stream into the hopper *r*, is then to be pressed by an apparatus constructed in the following manner:—A is a strong bed plate or frame, forming a sort of rectangular box, having a flange A^1 extending around the upper side, and another flange at the lower side, connected to the upper one by ribs A^2, and dividing it into pannels externally. Upon the upper flange of the bed plate are bolted the plummer blocks B, which support the trunnions of an oscillating steam cylinder C, which, with its steam pipes, slide valve, and valve gear, may be constructed in the ordinary way. D is a one-throw crank of great strength, working in plummer blocks E, and carrying on one end the fly wheel F. The piston rod G of the steam cylinder is connected to the crank by a gib head G*. There is also connected to the same crank-throw a connecting rod H, having a double gib head, so as to take hold of the crank on each side of the piston rod G; the other end of the connecting rod H is jointed at H* to the cross head I, which moves in slots formed in the guides J, J, which are bolted to the upper flange of the bed plate A. One end of the bed plate A passes through the lower part of the furnace *a*, and has bolted to it at that part a massive piece of iron K, with two cylindrical holes bored entirely through it, parallel to each other, and which for distinction I term the pressing cylinders; the piece K is held firmly in its place by bolts, and is further prevented from moving by projecting pieces K*, which abut against the flanges of the frame A. The upper side of the piece K has an opening or hopper *r**, through which the softened coal falls into it. There are two plungers L, L, fitted to the cylinders, and keyed into the cross-head I, so that the revolution of the crank by means of the connecting rod H and guides J, J, will produce a reciprocrating motion of the plungers L, L. The crank D has keyed upon it at one end a bevilled pinion M, working into a bevilled wheel N, which is mounted on a shaft P, supported by plummer blocks Q, Q; and at the other end of the shaft P there is a spur wheel R, in gear with another wheel S, on the axis *h* of the polygonal drum *g*; this axis *h* also carries a drum T, over which the strap *o* passes, and communicates motion to the roller K, and thereby regulates the supply of coal upon the chain bed. The action of the apparatus will be as follows:—Steam having been got up in the boiler by a fire made temporarily under it for that purpose, and the fire lighted in the fire-place *c*, the working of the apparatus will commence whenever a communication between the boiler and steam cylinder is opened. The rotation of the crank shaft will put in motion

the bevil wheels M and N and the shaft P, and by means of the spur wheels R and S, the shaft *h* of the polygonal drum *g* will receive a rotatory motion much slower than the crank shaft, by reason of the difference in the diameter of the wheels made use of for that purpose, and thus a slow travelling motion will be given to the chain bed. The shaft H also carries a drum T, which by means of a strap gives motion to the drum *m* and feeding roller *k*, and thereby causes a regular supply of small coal to fall upon the chain bed; as it passes under the hopper, the reverberated heat from the crown of the furnace acting on the thin stratum of coal upon the bed, will cause a partial fusion or softening of its bituminous parts before arriving at the hopper *r*, into which it falls. While this action is regularly and continuously going on, the crank shaft of the apparatus will, by means of the connecting rod H and cross-head I, give a reciprocating motion to the plungers L, L, which work in the cylinders K, and pass along the lower part of the hopper *r**, and push before them the softened portions of coal into that part of the cylinders marked K^1; the extreme distance to which the end of the plungers move is indicated by the letter Z. When the crank commences its backward movement the plungers will also recede until they assume the position represented in the Drawing; while this retrogade movement of the plungers is taking place some portions more of softened coal will have fallen down from the endless chain bed, and have been deposited in the hopper and upon the plungers; but as the plungers recede, as before stated, into the position shewn in the Drawing, the coal which has fallen upon them will fall off again into the space occupied by them, and when the plungers again advance, a fresh portion will be forced into the cylinders K^1; but as the plungers move forward an equal distance each time, the portion of coal pushed forward will be forced against the portion of coal left there by the former stroke of the plungers, and not only will it be forced against it, but it will move it further along the cylinders K^1, until the last portion occupies the place of the former one, and thus, by the continued action of the plungers, fresh portions of coal will be forced into the cylinders K^1. It will be observed, that the cylinders K^1 are open at the end, and it is towards this open end of them that each successive portion of coal is forced by the plungers. The friction of the mass of coal in sliding along the cylinder is very great, and the resistance thus opposed to the motion of the plungers L, L, causes a powerful compression of the fuel to take place, which is finally projected from the end of the cylinders in a solid and compact state, as shewn at W. I have before stated that the surplus heat of the reverbatory furnace may be applied to the production of steam for supplying motive power for the working of the apparatus, and in some cases it may be deemed advisable to so

far heat the coal by this process as to fire it and cause a combustion of the more volatile portions thereof, by which more heat will be given off to the boiler, and a fuel will be produced possessing many of the peculiar and valuable properties of coal, but at the same time not possessing sufficient bituminous matter to cake together when used in a furnace or common fire-place, and from the same reason not producing a dense black smoke, and may be used in many cases where coke is now employed. Although I have here stated that a fuel differing from coal in several respects may be produced by this apparatus, I wish it to be understood that I prefer to employ the apparatus hereafter described under the second head of my Invention for that purpose, and to use the apparatus herein-before described chiefly for the production of a fuel composed wholly of coal, and acted upon only as much by heat as is necessary to cause a firm adhesion of the particles when a powerful pressure is brought upon it in the heated state.

Secondly, with regard to my improvements in preparing fuel of different qualities from coal or coal dust, by separating therefrom different quantities of their gaseous or volatile constituents, and in some cases also of further altering and modifying the quality of the fuel by the admixture of different kinds of coal or coal dust, so as to render such fuel peculiarly adapted to the various circumstances and conditions under which it is to be used:—From what has been said under the first head of my Invention, it will have been perceived that the main object there aimed at was the production of solidified cylindrical lumps of coal, little being abstracted from it during the process of manufacture, and therefore producing a fuel possessing the general characteristics of the coal from which it was formed; but as there is no kind of coal which possesses in its natural state all the qualities desirable in fuel, I have endeavoured to supply this desideratum partly by the purification of coal, by driving off some of its volatile products, and partly by the admixture of coals of different qualities, by the blending of which several kinds of fuel may be produced having different properties, and peculiarly adapted to furnaces of various kinds. I have before shewn how the softening of the coal is effected by heat, and it will be readily understood how, by continuing the heat for a greater length of time, or using a higher temperature, that a portion of the fuel will be volatilized and pass off in the gaseous form. If a small quantity only of these volatile products are driven off two very important results will follow:—Firstly, the fuel when thrown on the fire will not give off those dense volumes of black smoke which raw coal does, because no more gaseous matter will be given off then the quantity of oxygen in the furnace will consume; and secondly, the coal being thus deprived of a part of the tar, &c. will be much

less fusible than raw coal; and therefore, instead of caking over the top of the fire, and preventing the passage of air through the fuel, as the raw coal does, the regular sized cylindrical lumps will to a great extent maintain their shape, and allow a free passage of air to play between them, by which means a vivid combustion will be kept up, and the formation of dense black smoke will be for the most part, if not wholly, avoided. In order to render fuel thus prepared suitable for locomotive engines, and other purposes requiring similar fuel, I carry on the process of volatilization to a much greater extent, varying from one-third to nearly all the gaseous matter contained in the coal. The limit to which this process is carried should always be such that the coal is not rendered so dry or hard as to prevent its cohesion in the pressing cylinder; but in order to obtain these volatile products from coal with as little heat as possible, and also to facilitate the formation of the fuel into a dense and compact mass, I sometimes use an air pump, and form a vacuum or partial vacuum in the retorts or vessels in which the coal is heated, so that the gaseous matters are more freely liberated; and being thus carried off from the pores, cells, or interstices of the fuel, the mass is more readily pressed in the cylinder, and its density and solidity greatly increased, and is therefore in the most favorable condition for burning in furnaces having a powerful blast; and from its great density and regularity of form, it is well adapted for stowage where space is of consequence. The volatile products resulting from the foregoing processes may be passed through water, by which a part will be condensed and may be applied for various useful purposes, and the remaining incondensible portions may be conducted through pipes and burnt beneath the retorts; or it may be conveyed to a gasometer, and supplied as fuel for generating steam, or other purposes, and also to be used for purposes of illumination. In certain localities (Staffordshire, for instance,) where coal is found which produces a white dusty ash, it is desirable to prevent or modify this defect by the admixture of another description of coal, such as that found at Newcastle-upon-Tyne, and known as caking coal; equal quantities of these coals mixed together, softened by heat and pressed in the manner herein-before first described, will be found to produce an excellent fuel, burning more freely than the Newcastle, and avoiding the dusty white ash of the Staffordshire coal; and also anthracite coal mixed with varying proportions of Newcastle caking coal will be found to produce a valuable fuel when treated and combined in the manner herein described; but as these different qualities of coal for mixing will be very much governed by local circumstances, I need not further particularize their use than by saying generally that in those cases where a particular property or quality is deficient in one description of coal, and is possessed to an undue

extent by any other kind, their union into one mass will be to the advantage of both. In order that the volatile products of coal given off while undergoing the softening process, as well as those portions which are purposely expelled for the purpose of modifying the quality of the fuel, and also in order that the lumps of fuel may be made of definite lengths, I construct an apparatus in which the retort furnace for heating the small coal, the pressing machine for solidifying the fuel, and the engine for producing the motive power, are combined so as to constitute one apparatus, and which is represented on Sheet B of the annexed Drawings; where Figure 1 is a longitudinal elevation, with the steam cylinder omitted; Figure 2 is a plan of the same; Figure 3 is a longitudinal section on the line A, B, of Figure 2, and shewing the position of the steam cylinder; Figure 4 is a longitudinal section on the lines C, D, Figure 2, and E, F, Figure 3; Figures 5, 6, 7, 8, and 9 shew sections of the pressing apparatus in different stages of the pressing process. In the furnace *a* is fixed the rectangular vessel or retort *b*, which is shewn broken through, to indicate that its length should be greater than represented in the Drawings; about thirty feet in length will be found to answer well. It should (for convenience of putting up) be made in three lengths, united by flanges, and the joints made tight with iron cement. One end of this retort projects from the furnace, and overhangs a part of the pressing apparatus. The retort has a partition b^1, extending nearly the whole length of it, and in a tangent line with the upper surface of the polygonal drums *c* and *d*, over which two endless chains *e* and *f* are made to pass (see Figures 2 and 3); the chains *c* and *d* are connected together by broad plates of iron *g*, with flanged ends, which are rivetted at *h* to the single links of chains; the edge of the plates *g* which project beyond the chains is bevilled, so as to form a scraper. The polygonal drums *c* and *d* have projections *i* formed upon them, which fall into the spaces between the double links of the chains, and insure the motion of them when the drums *c* and *d* are turned round. On the upper side of the retort there is fixed a hopper *j*. The lower part of the hopper in which the coal dust or small coal from which the fuel to be formed is placed is made to fit closely to the leaves or ribs projecting from the feeding drum *k*. There are bosses *l* formed on the sides of the hopper, in which the shaft *n* of the feeding drum revolves. There are also bosses (not seen in the Drawings, formed on each side of the retort for the axis of the polygonal drum *c* to revolve in, and on the outer projecting part of the retort are formed two other bosses *o* and *p*, for the axis *r* of the polygonal drum *d* to revolve in; one end of this axis is elongated, and passes through a stuffing box formed on the boss *p*, so that none of the volatile matters within the retort can make their escape at the part through which motion is transmitted to the

interior. The action of this part of the apparatus is as follows :—A fire having been lighted in the fire place *s*, the heat and products passing along under the retort will make their exit at the open end of the flue s^1, where they may be made to circulate about a steam boiler, for the purpose of generating the motive power required to work the apparatus. It will be preferable to set the retort so that the heat may ascend a narrow space between the sides of it and the brickwork of the furnace. I have shewn an enlargement of the fire chamber at s^2, for the purpose of transmitting radiant heat to the under side of the projecting part of the retort. The temperature of the furnace having brought the retort up to a heat approaching redness, the feeding drum is put in motion, when the small coal or coal dust will be deposited upon the shelf b^1; but the motion of the chains and scrapers in the direction indicated by arrows will move it along the shelf, and as each scraper comes in turn under the feeding drum, the coal which has fallen between each of them will be carried forward to the end of the shelf b^{1*}, off which it falls on to the lower and hotter part of the retort, and, as before, occupies the space between the scrapers. It will be observed that the entire weight of the chains and scrapers rest on the bottom of the retort, so that by their constant passage over it the coal is prevented from sticking to it, and rendering its interior surface uneven. The action of the scraper will not only impel the coal forward, but will so turn it over as it passes along as to present fresh portions of it to the heated surface of the retort, and thus insure an equal effect on the whole of the coal dust thus acted upon, and the same will become softened, and in that state will be moved over the opening b^3 in the lower side of the retort, and fall into the receptacle *t*, where it will become operated upon in the manner about to be described. A is the foundation plate or framing of the pressing apparatus; it is a sort of shallow box, having a flange A^1 around its upper edge, connected to the lower flange by vertical ribs A^2, which divide it externally into pannels; the interior portion of the framing being also divided by ribs A^3, by which its strength is increased. Upon the flange A^1 is bolted the plummer blocks B, which support the crank shaft C, which is made very strong, to withstand the strains to which it is subjected. The crank has but one throw formed on it, in the centre of which is attached by a gib head D the piston rod E of the oscillating steam cylinder F. The steam cylinder, with its induction and eduction pipes, slide valve, and other necessary appendages, may be constructed in the usual way, and therefore do not require any detailed description; and as these parts, if represented in the Drawings, would obscure others more necessary to be seen, I have omitted them in all the Figures, except in Figure 3, where the steam cylinder is represented in the position it would

occupy at the particular part of the crank's motion there represented. It will be observed that the steam cylinder is placed with its axis in a line vertically over the crank shaft, and is there supported by trunnions G, as usual, working in plummer blocks bolted to the two frames H, H; these frames have lugs cast on them at H*, through which stretchers are to pass in order to steady them. The frames H are bolted at foot to the flange A^1 of the bed plate, in order to regulate the motion of the apparatus. The fly wheels I, I, are keyed one on to each end of the crank C. A stout connecting rod J is made with a double gib head J* to embrace the gib head D, and thus to receive motion from the same crank throw. The other end of the connecting rod J is jointed by a gib head and pin to two lugs K*, which project from the stout cross-head K. The ends of this cross-head slide in guides L, L, which are secured by bolts to the flange A^1 of the bed plate. There are three plungers M, M, M, keyed into the cross-head K, and work in cylindrical holes bored truly through the massive block of iron N. This block N is bolted to the bed plate by a flange N*, and is keyed up between steps *z*, cast on the bed plate. The upper part of the cylinder block N has a large opening N^1 made in it, through the bottom of which the plungers M move, and immediately over the opening N^1 is the receptacle into which the softened coal falls from the retort. The cylindrical holes in the block N have another set of plungers P, P, P, working in the opposite end of the holes to that occupied by the plungers M, M, M. On the flange A^1 of the bed plate are bolted two guide bars Q and R, having holes bored in them of a size to fit the plungers P, P, P, which are made long enough to work through both these guides, so that when the plungers P, P, P, are entirely withdrawn from their respective cylinders in the block N, they will be so guided as to re-enter them without difficulty. The plungers P, P, P, are keyed to a cross-head S. On the ends of the cross-head S there are fitted with gib heads two long connecting rods T (see Figure 2, as they are omitted in the rest of the Figures to prevent obscurity of the other parts). The opposite ends of the connecting rods T are provided also with gib heads, and work on crank pins U, which project from one of the arms of each fly wheel I, I. These crank pins U, U, are so placed with reference to the central crank throw C, that the latter forms an angle of forty-five degrees to the crank pins, that is, the one is one-eighth part of a circle in advance of the other, and thus the action on their respective plungers will be such that they will alternately approach and recede from each other at each end of their respective strokes. I have before described how the small coal is made to traverse the retort, and be deposited in the receptacle. The means whereby the requisite motion is given to the chain and feeding drums is as follows:—Over one

of the fly wheels I a strap is passed, which works upon a drum V on the shaft W. On this shaft W there is a worm X, which works on the upper side of the worm wheel Y, which is keyed on to the shaft *r* of the polygonal drum *d*; the shaft W also carries another worm 1, which works into the lower side of the worm wheel 2, keyed on the axis *n* of the feeding drum. The shaft W is supported in bracketed plummer blocks 3, 3, which project from and are bolted to the side of the retort, so that whenever the fly wheel is put in motion the intermediate wheels and shaft last described will transmit the requisite motion to the scrapers and feeding drum, as before described. From what I have already said, it will have been understood how the steam piston acting upon its crank will put in motion the whole apparatus, which will be regulated by the fly wheels, and in what manner the cross-heads K and S will be acted upon by their respective connecting rods, and how the set of plungers M, M, M, and plungers P, P, P, are made to reciprocate in their respective ends of the block N; but lest the way in which they are made to approach and recede from each other be not already understood, I have given five sectional Figures on Sheet B, by which the relative positions of the two sets of plungers with reference to each other at different parts of their stroke will be seen. And to render this explanation more clear, let us suppose the operation to commence when the crank throw C and its connecting rod are in a horizontal position, and the plungers M, M, M, withdrawn as far as possible from the block N: this position is represented in Figure 5, where it will be seen that the fuel in an uncompressed state has fallen down, and occupies the space in the front of the plungers M: if we now make one-eighth part of a revolution, the plungers M will be moved forward a little, as shewn in Figures 6 and 3, where it will be seen that the crank pins U, U, have risen up to the horizontal line, and brought the plungers P nearer towards the centre of the block N: if we now give another eighth of a turn to the crank, the plungers N will have advanced a considerable distance, being at half stroke, and at the same time the plungers P will have receded into their starting position, as represented in Figure 7. Here it must be observed that the soft coal which was carried forward by the plungers M is compressed between the opposing ends of the two sets of plungers. In this position of the plungers there is a small space at Z, Figure 7, where any surplus quantity of coal may squeeze out before it is made to enter the close part of the cylinder, after which they will approach a very little nearer to each other, and thus give the final pressure. If another eighth of a revolution is now made, the relative positions of the crank and crank pins will give a quicker motion to the plungers P, which will commence receding from

the other plungers M, and thus leave no pressure on the solidified lump of coal X. Were not the pressure thus relieved, the lump of coal as it merges from its cylindrical hole in the block N would be broken, there being no longer any circumferential support for it. This position of the apparatus is shewn in Figure 8. Another eighth of a turn will complete a single stroke of the plungers M, and have entirely expelled the block of coal X, which is represented as falling down in Figure 9; the plungers P have receded still further, and allow ample space for the block of fuel to fall. Another eighth of a turn will commence the return stroke of the plungers, and by following on in the same way until one complete revolution is performed, the respective plungers will again have resumed the position represented in Figure 5, and be ready to renew the operation. If three plungers are made use of, as here represented, three blocks or cylinders of fuel of equal length and diameter will be formed at each complete stroke of the engine. As there is a tendency in the block of fuel to stick to the plungers M, I have placed a detaching frame at the end of the machine where the blocks are expelled. 4, 4, are thin bars of iron, fixed on an axis 5, the ends of which work in lugs 6, on the guide bar R. The other end of the bars 4, 4, are connected together by a rod 8, and upon the cross-head S there are bolted two small frames 9, 9, which carry rollers 10; upon these rollers the bars 4, 4, rest, and when in the position shewn in Figure 3, the bars are supported a little distance above the plungers P; but when the cross-head S moves backward, and allows the blocks of coal to be projected outward by the plungers M, then the roller will pass under the inclined part of the bars 4*, when they will descend by their own weight, and the rod 8 will come in contact with the blocks of coal, and detach them from the ends of the plungers; if they should adhere, the reverse motion of the cross-head *s* will again raise up the bars 4, in readiness for a repetition of the process.

From what has been before said in reference to the softening process by heat, it will have been understood that the coal dust may be made to traverse the shelf b^1, where it will receive a preparatory heating, and afterwards traverse the bottom of the retort so quickly as only to produce such a slight effect upon the bituminous portion of the coal as only to soften it a little, and render it fit for the operation of compressing it into solid lumps, possessing the general properties of the coal from which it was produced. But one of the great objects of this apparatus is to alter and modify the composition of the resulting fuel by driving off certain of the volatile constituents of coal, and thereby rendering such fuel more fitted for certain processes in the arts than ordinary coal. To effect this object, the speed of the feeding drum and polygonal drums

may be regulated so as to subject the coal to any assigned period of operation, and also the intensity of the fire being regulated, the extent to which the distillatory process is carried with be under perfect control, and the gaseous matters given off from the coal as it passes into the hottest part of the retort over the fire-place *s* will have to pass over the surface of the coal which is advancing in that direction, and will help to heat it, and will also assist in transmitting heat to the under side of the shelf b^1; it will ascend through the opening b^{1*}, and pass along over the coal dust spread upon the shelf, and further assist in heating it, and finally make its escape through the pipe *u*. This pipe should have an elbow, descending in the manner usually practiced in gas works, and known as the hydraulic main. In this vessel the liquifiable portion of the volatile matters will be condensed, and the gas may be passed into a gasometer, where it may be stored and used. The fuel resulting from this partial distillatory process will be found to be less fusible in the furnace than ordinary raw coal, and consequently the caking in the furnace will be prevented.

I have before described and represented on Sheet A a method of heating coal and compressing it differing from that herein last described and represented on Sheet B, and it will be obvious that either of the heating apparatus may be combined with either of the pressing apparatuses instead of the combination herein given.

In order to facilitate the evolution of gaseous matters from the coal at as low a temperature as possible, and to increase the density of the compressed fuel, I use an air pump, constructed in the manner generally employed for exhausting sugar vacuum pans, and which is well known and understood. I connect the pump with the pipe *u*, Sheet B, and by the application of steam or other motive power I keep the retort in a state of exhaustion, which should if possible be equal to twenty-four or twenty-five inches of mercury in the barometer. The effect of this exhaustion is to cause the liberation of the gas from the cells and interstices of the fuel, and to render it more dense and compact when pressed. When the air pump is used as before stated, the eduction valves must be made to communicate with the hydraulic main, so that the gaseous matters pumped out may pass off into the gasometer, as before described. And further, instead of applying fire direct to the under side of the retort, as shewn in Sheet B, I use highly heated steam for the purpose of heating and softening coal to be afterwards pressed into lumps or cylindrical pieces. For this purpose, a set of cast-iron pipes, arranged in a furnace in the same way as is now commonly used for heating air for hot blast furnaces, and also for heating steam for various purposes.

Into one end of this series of heating pipes the waste steam of the engine is allowed to pass, and the pipes being kept at a red heat the steam will acquire a very high temperature, and in that state is to be supplied to the interior of the retort, for the purpose of softening the coal. In this case the retort, which may be made in the same manner as that represented in Sheet B, but will not require any fire-place or flue beneath it, but should be enclosed in brickwork or other bad conductor of heat; the pipe which conveys the steam should enter at the hopper *t*, where the soft coal falls into and finds its escape with the gases through the pipe *u* into the hydraulic main, where condensation will take place, while the gas passes off to the gasometer. I am aware that the use of heated steam has been proposed for manufacturing coke, and for heating certain mixtures of pitch, tar, coal dust, &c.; I therefore do not claim it for those purposes; but what I consider new and of my Invention is, the application of highly heated steam for the purpose of softening coal, in order that it may be formed into a solid mass by pressure, and without requiring the admixture of any cementing material or foreign matter therewith.

Lastly, with regard to my improvements in supplying fuel to furnaces by a combination of revolving circular fire bars or wheels, which conduct the fuel into the furnace and progressively move it therein, and finally eject the clinkers or slag at the opposite end of the fire chamber:—Numerous plans for feeding furnace fires regularly with small coal and for consuming their smoke have been brought forward and used with more or less advantage, but there are still some particulars in which the present plans are deficient. In some of them the fire-place is shut up, so as to render it difficult to light the fire or to get at it in case of accident; most of them retain the fire bars too long in contact with the hot fuel, by which they become rapidly destroyed; while in other cases the complexity of the structure renders it liable to frequent derangement, and is also a very expensive apparatus. In order to avoid these disadvantages, I construct an apparatus as represented on Sheet B of the Drawings hereunto annexed; where Figure 1 is a front elevation of a steam boiler furnace to which this apparatus is applied; Figure 2 is a longitudinal section on the line A, B, of Figure 1; Figure 3 is a vertical cross section on the line C, D, of Figure 2; Figure 4 is a sectional plan on the line E, F, of Figure 2; and Figures 5, 6, and 7, enlarged views of one of the wheels. That part of the apparatus which answers the purpose of fire bars consists of a number of thin flat wheels, with a projecting boss cast on one side of them, the thickness of which regulates their distance apart from each other. In all cases this boss should a little exceed the thickness of the rest of the

wheel, so that when any number of them are placed next to each other on a shaft a sufficient space is left between them to allow another similar set of wheels to pass in between their intermediate spaces, as represented in the Drawings; where a is a rectangular cast-iron frame, having a flange a^1 extending around three of its sides, and in front is carried up higher at a^2, and there forms a sort of dead plate to the furnace. The front of the frame a is pannelled, and projects forward as far as the face of the two piers b, b. On the sides of the frame a are cast the bosses c, which are bored through, and form the bearings for the shafts d, which carry the "wheel grate;" these shafts d have a feather made along them, so as to insure the revolving of the wheels e with the shaft. When the shaft is put into the frame a, and its wheels placed upon it, the collars m and n are fixed in their places by a cross pin; the wheels e, which answer the purpose of fire bars, having been fixed, the worm wheels g and h are keyed on to the shafts d. These wheels are so made that they may all work into worms placed below them on the shaft f; but as their diameters are too great to allow of them all working in the same line, I have keyed on the three wheels g to their respective shafts in a line, and put the two worm wheels h further along their shafts, so as to run clear of the wheels g. It will be observed that these wheels are made with a slight curved bevil in such a way that they can work on either side of the centre of the worm shaft f (see Figure 2). The wheels g are driven by three worms i, and the wheels k by two other worms, which are not seen, because the bosses h^* of the wheels h obscure them. The end of the shaft f, which projects from the front of the furnace, may be provided with a wheel or drum, according to local circumstances, by which motion may be transmitted from the steam engine, and the worm wheels with their respective shafts and grate wheels be made to revolve in a direction indicated by arrows. On the wheels e, on the under side of that part of the frame a which forms the dead plate, there are a number of pieces r, moving on a joint at s, so as to bear freely down upon the wheels e^* on the second shaft. These pieces serve to fill up the interstices between the first set e^1, or feeding wheels, and form a continuation of the dead plate; but the wheels e^1, rising up through the pieces r, will carry forward any fuel that may fall upon them; and thus the movement of the whole of the wheels being in one direction, the fuel will be carried forward and consumed. At the fire bridge there is a square iron bar p, extending across the furnace, and having a hole through it, for the circulation of water; the clinkers that are carried to the back of the furnace can pass out between this bar and the last set of wheels in the front part of the furnace. I have left an arched opening t, of about the size usually made where

A.D. 1849. Sept. 20. N° 12,760.
BESSEMER'S Specification.

(3 SHEETS)
SHEET 1.

FIG. 1.

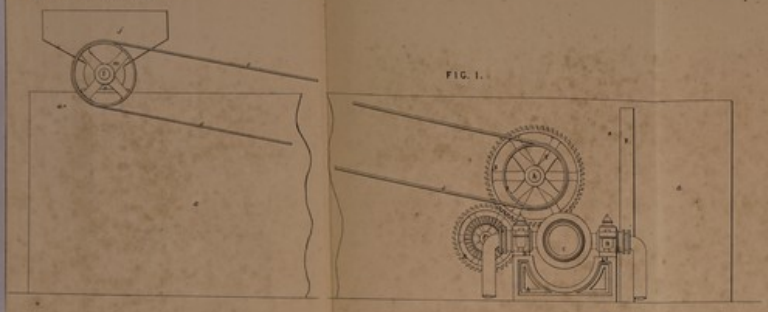


FIG. 5.

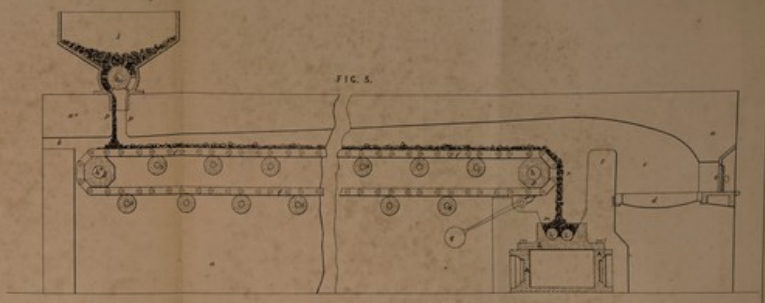


FIG. 6.

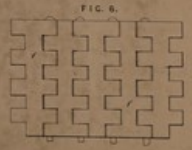


FIG. 2.

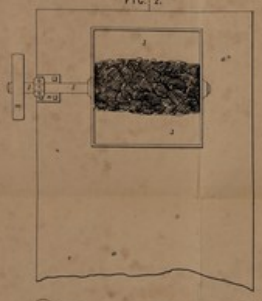


FIG. 4.

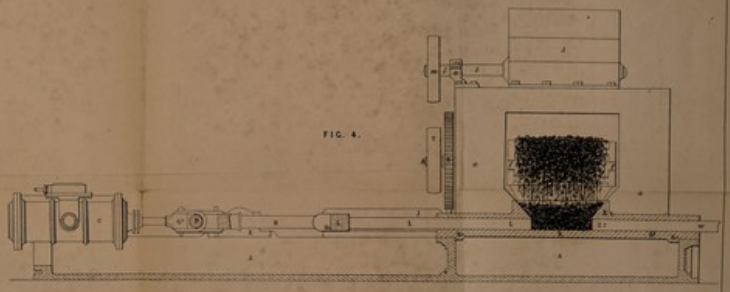


FIG. 7.

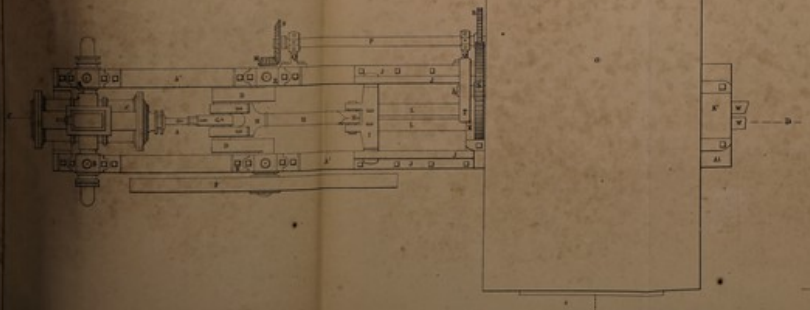
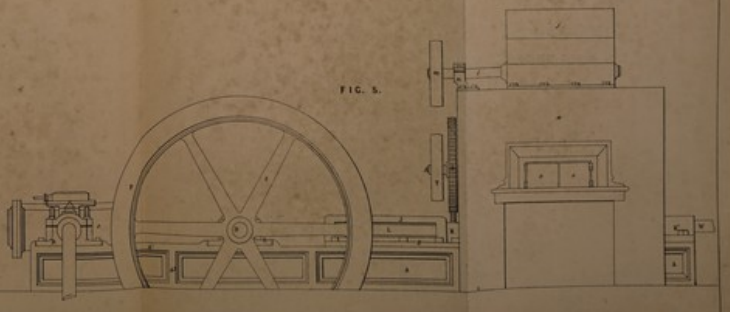


FIG. 3.



The vertical dressing is altered

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* Lowndes. Printed by George Edward Eyre and William Spottiswoode, Printers to the Queens most Excellent Majesty. 1850.

A.D. 1849. Sep. 20. N° 12,780.
BESSEMER'S Specification

FIG. 1.

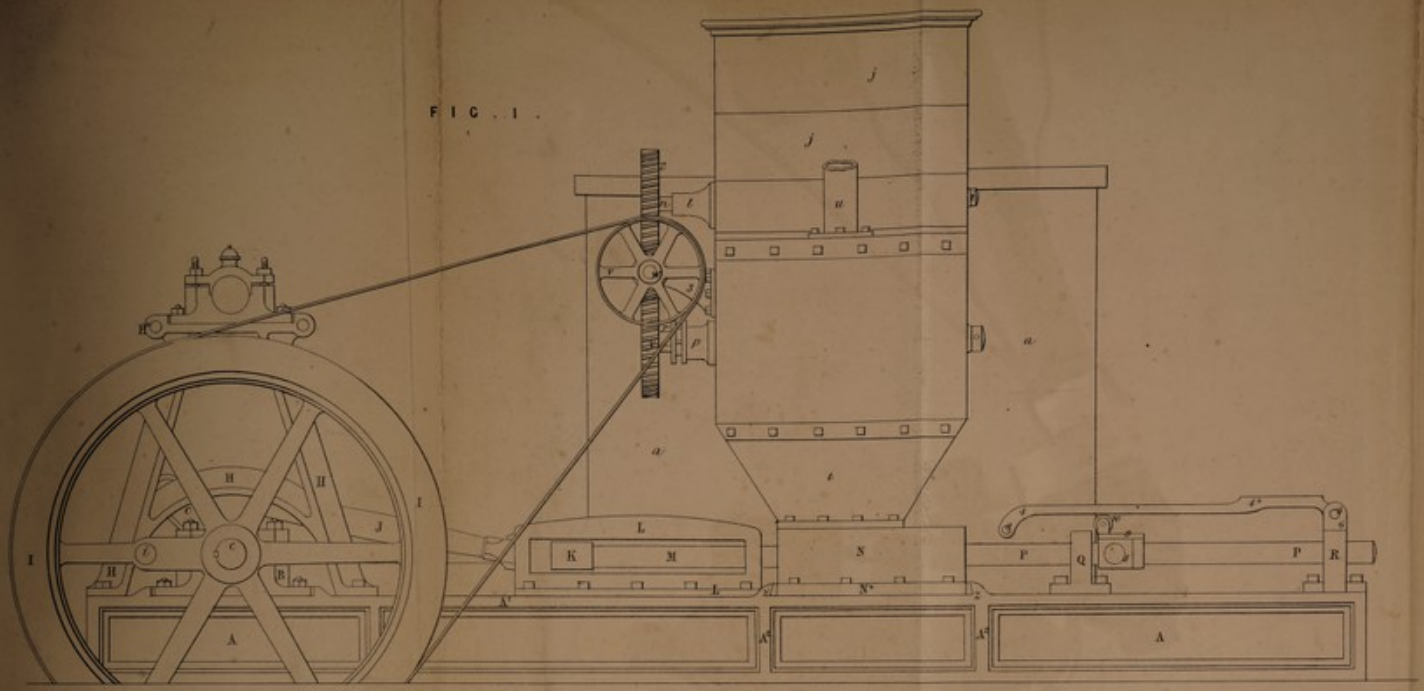


FIG. 2.

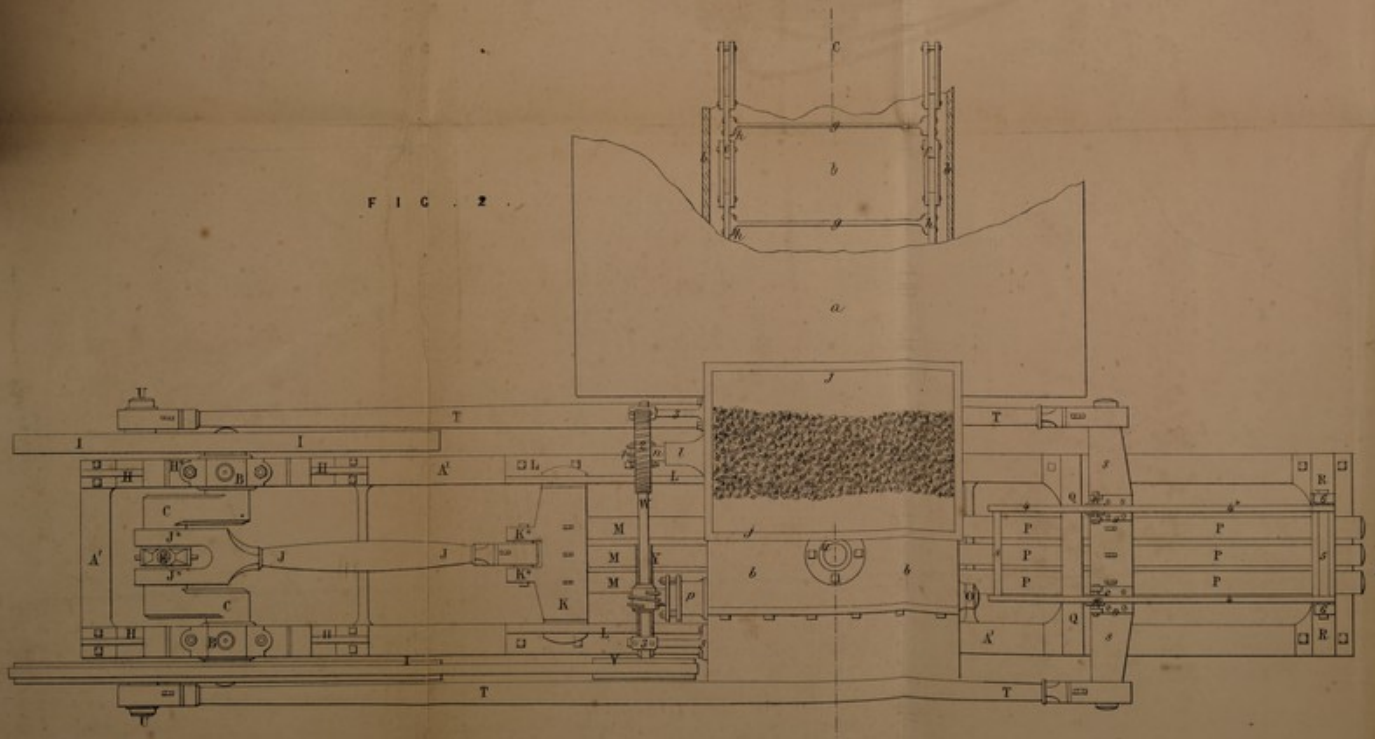


FIG. 7.

FIG. 6.

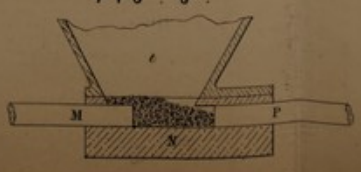
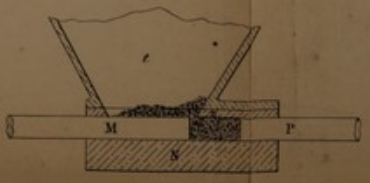


FIG. 7.



The enrolled drawing is colored.

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FIG. 3.

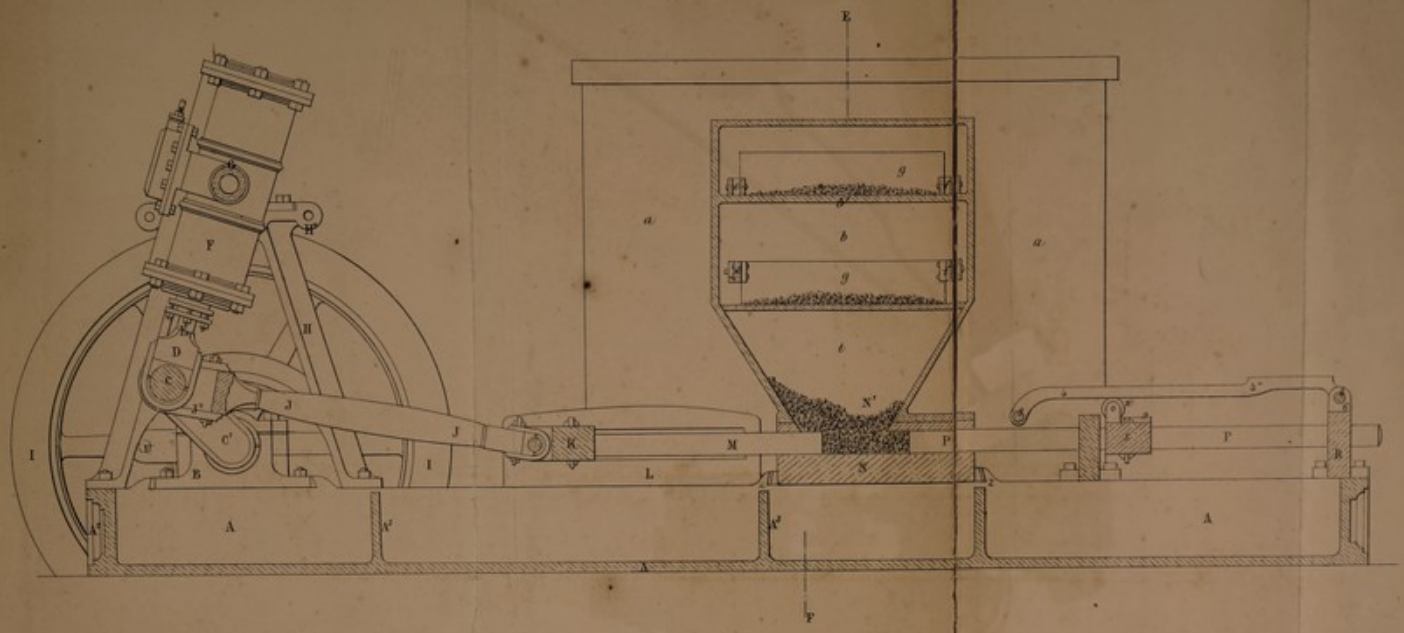


FIG. 4.

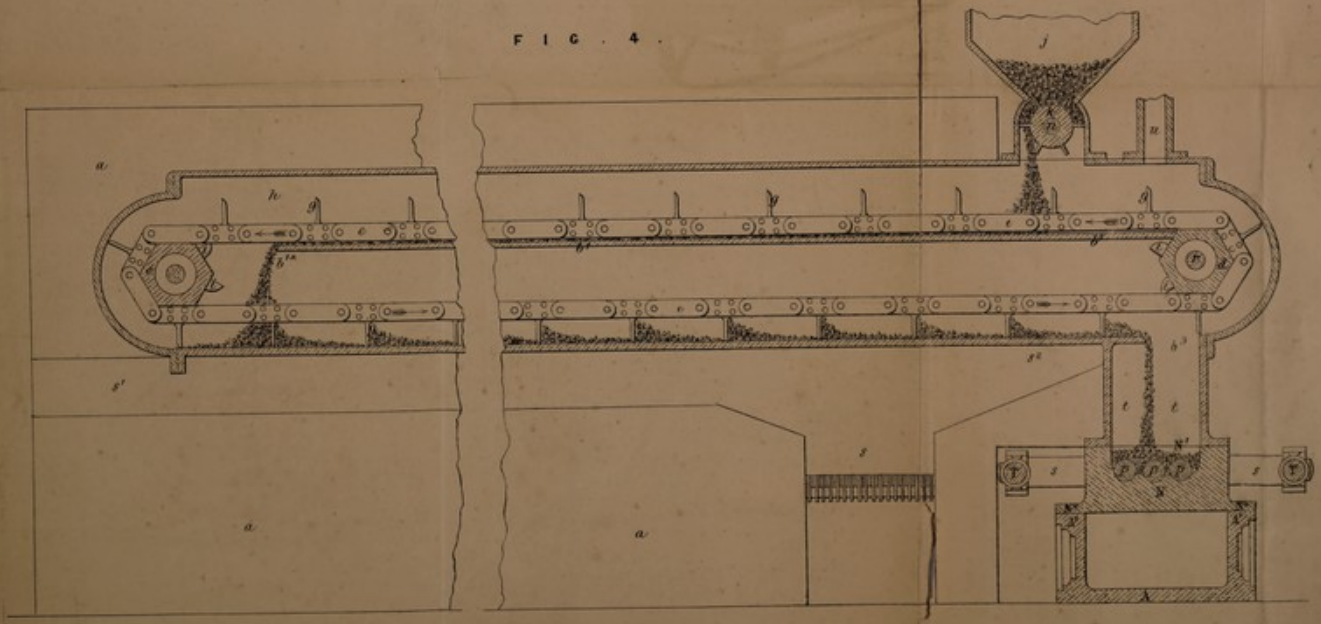


FIG. 7.

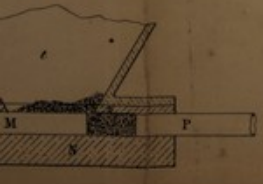


FIG. 8.

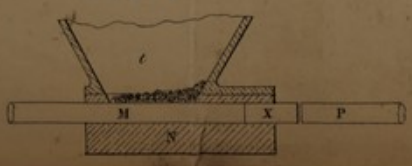
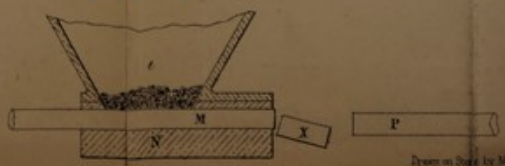


FIG. 9.



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BESSEMER'S SPECIFICATION.

(3 SHEETS)
SHEET C

FIG. 1.

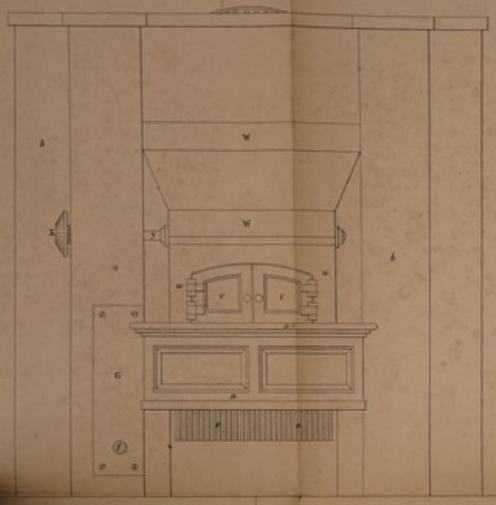

FIG. 2.

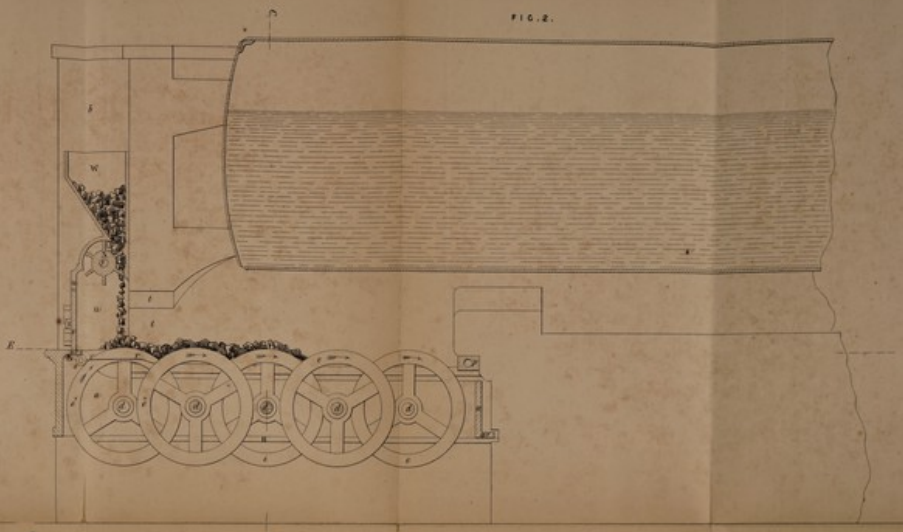

FIG. 3.

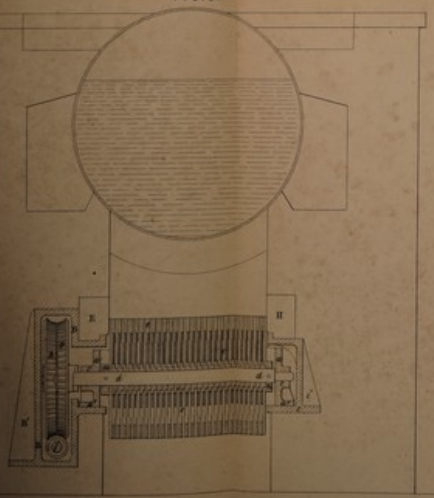

FIG. 4.

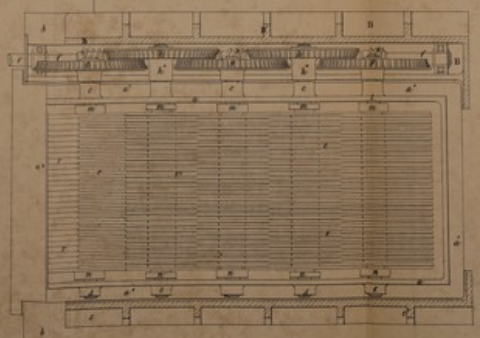

FIG. 5.

FIG. 6.

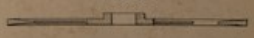

FIG. 7.

The certified drawing is colored.

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Printers to the Queen's most Excellent Majesty. 1855.

ordinary fire doors are used, and in advance of this a foot or so I fix the door frame *u* and fire doors V, so that the fire may be looked at or supplied with fuel with as much facility as in a common furnace if required at any time. Above the door frame *t* there is placed a hopper W, having a feeding drum X, with vanes or ribs extending along it. The axis *y* of this drum passes out through the pier *b*, and there has a bevilled wheel *x* keyed on it, by which motion may be transmitted to it in any convenient way, and the supply of small coal to the furnace regulated. To facilitate the removal of the frame *a* and its wheels from the furnace, two long pieces or slides of iron B and C are let into the side walls of the furnace; the piece B is made so as to receive the side of the frame *a* and its projecting wheels; the back of the piece is strengthened by ribs B^1, and along the side nearest the fire there is a small flange, behind which the fire lump E is placed, which protects the portion of the iron work from any injurious effects of the heat. In Figure 1 is shewn a plate G, which covers over the opening into this slide, and allows the worm shaft *f* to pass out through it. The iron slide C has also ribs C^1 cast upon it to give it strength, and has a flange along the side nearest the fire, to retain the fire lump H in its place, so that the whole apparatus fitting into these two fixed slides may at any time be taken out of the furnace and again replaced. I have shewn on a larger scale at Figure 5 a side elevation of one of the wheels *e*, a section of it at Figure 6, and a side elevation of it at Figure 7. Although I have herein shewn, as an example, the application of the combined wheel grate to a steam boiler furnace, it is obvious that it will be equally applicable to numerous other furnaces used for manufacturing purposes.

Having thus described the nature of my Invention, I desire it to be understood that I do not confine myself to the precise details, so long as the peculiar character of either part of my Invention be retained; but what I do claim is,—

First, the softening of small coals or coal dust by heat, and then forming it into blocks or masses by pressure. I also claim the arrangement of machinery for heating and compressing small coal or coal dust, represented in Sheet A.

Secondly, I claim the heating small coal or coal dust in retorts or close vessels, so as to soften such coal, and then to form the same by pressure into blocks or forms, whereby I am enabled to drive off and collect gaseous and other products from the coal, and to modify the character of fuel produced therefrom. I also claim the direct application of highly heated steam in such manner as to soften small coal as a preparatory process, and then to form the same into blocks or masses by pressure. I also claim the method or

arrangement of machinery, represented in Sheet B of the annexed Drawings, for compressing fuel between plungers, herein described and set forth. I also claim, in the preparation of coal heated for the purpose of softening the same, the use of exhausting apparatus, for the purpose of facilitating the evolution of gaseous matters thereform, and for the purpose of rendering the fuel more dense, as herein described.

And, lastly, I claim the supplying furnaces with fuel by the combined use of a series of circular revolving wheels of fire bars and intersecting each other, as explained.

In witness whereof, I, the said Henry Bessemer, have hereunto set my hand and seal, this Twentieth day of March, in the year of our Lord One thousand eight hundred and fifty.

HENRY (L.S.) BESSEMER.

AND BE IT REMEMBERED, that on the Twentieth day of March, in the year of our Lord 1850, the aforesaid Henry Bessemer came before our said Lady the Queen in Her Chancery, and acknowledged the Specification aforesaid, and all and everything therein contained and specified, in form above written. And also the Specification aforesaid was stamped according to the tenor of the Statute made for that purpose.

Enrolled the Twentieth day of March, in the year of our Lord One thousand eight hundred and fifty.

JEFFERSON.

LONDON:
Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1855.