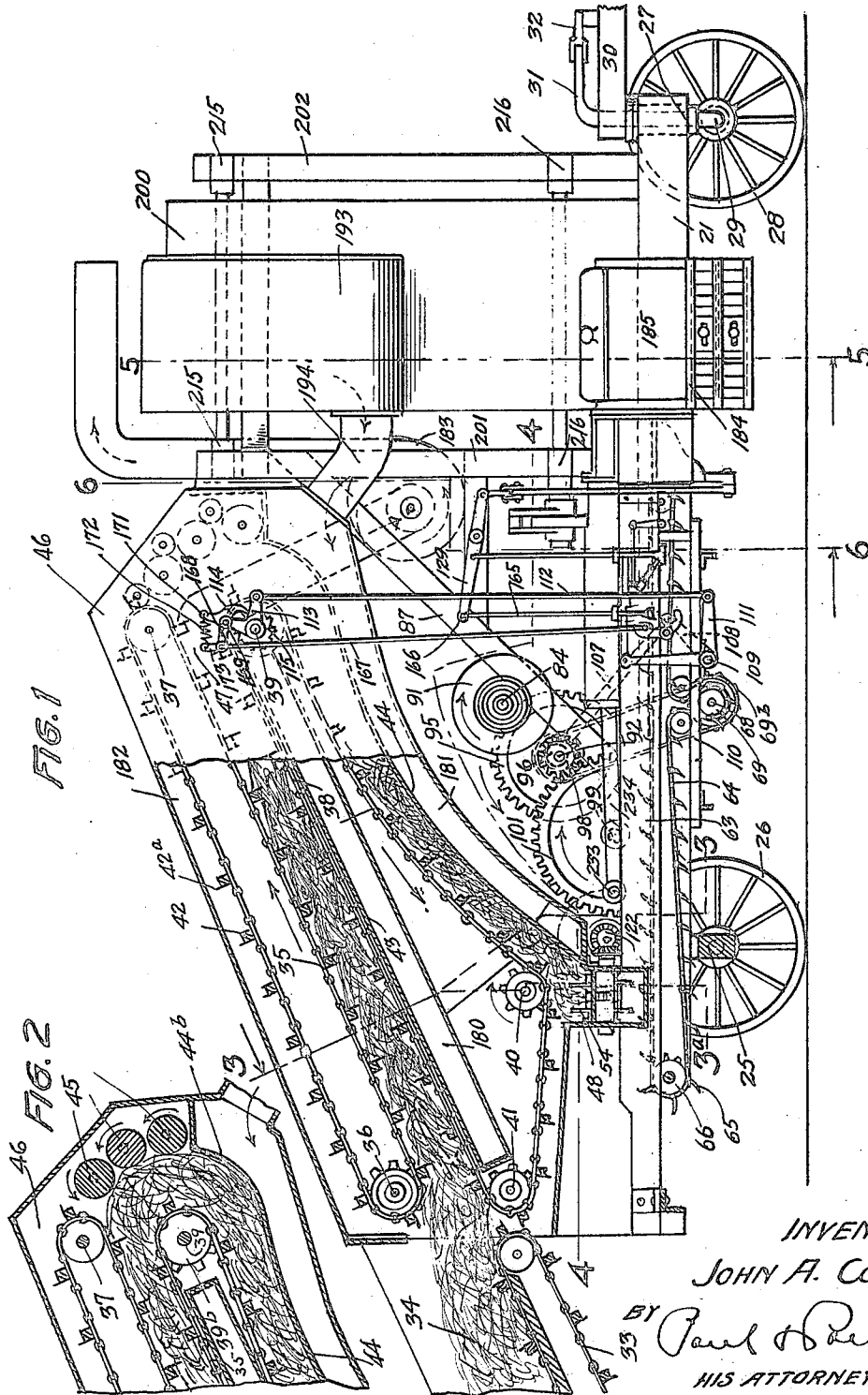


J. A. COWAN.  
STRAW BRIQUETTING MACHINE.  
APPLICATION FILED NOV. 30, 1920.

1,403,294.

Patented Jan. 10, 1922.

8 SHEETS—SHEET 1.

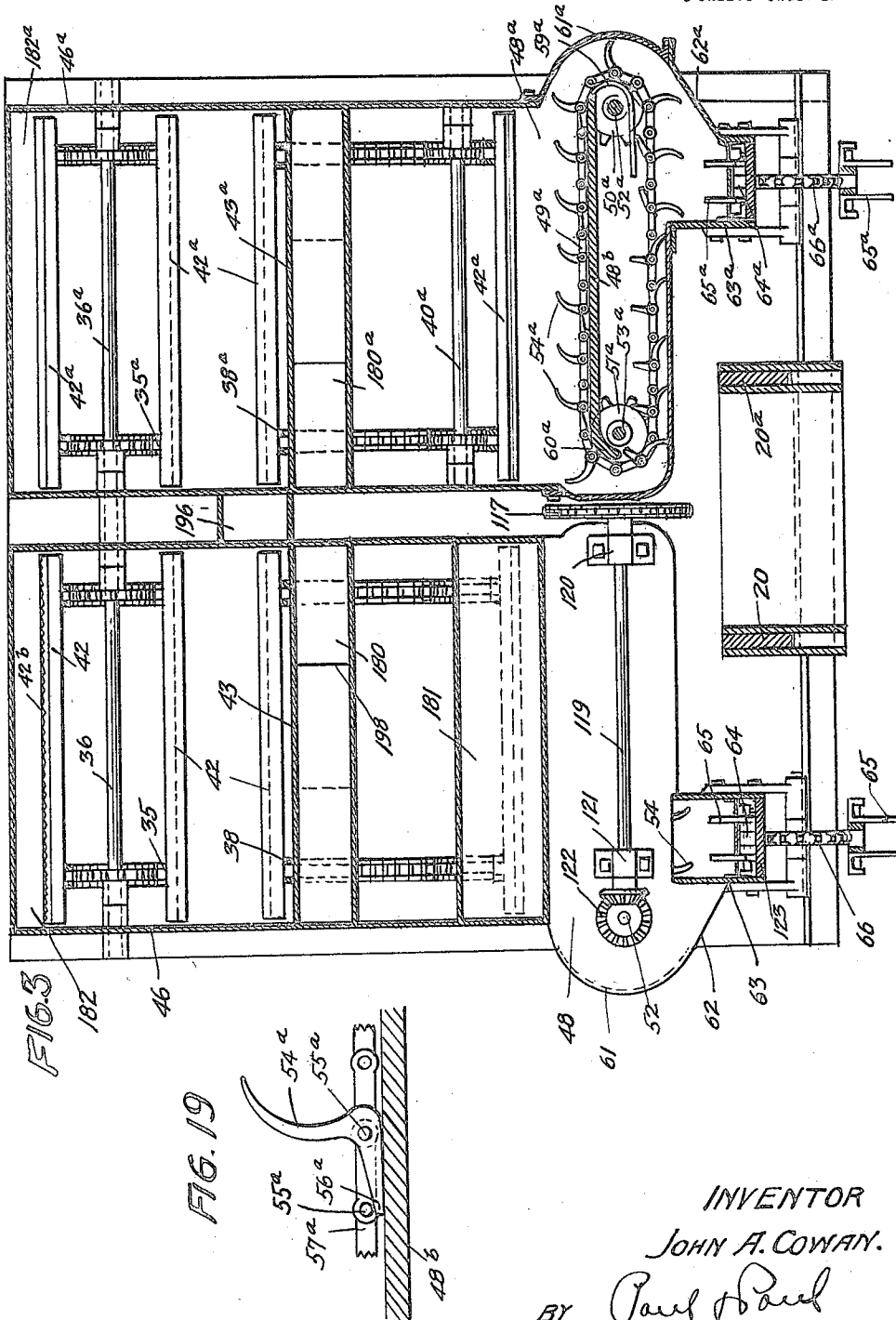


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8 SHEETS—SHEET 2.



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8 SHEETS—SHEET 3.

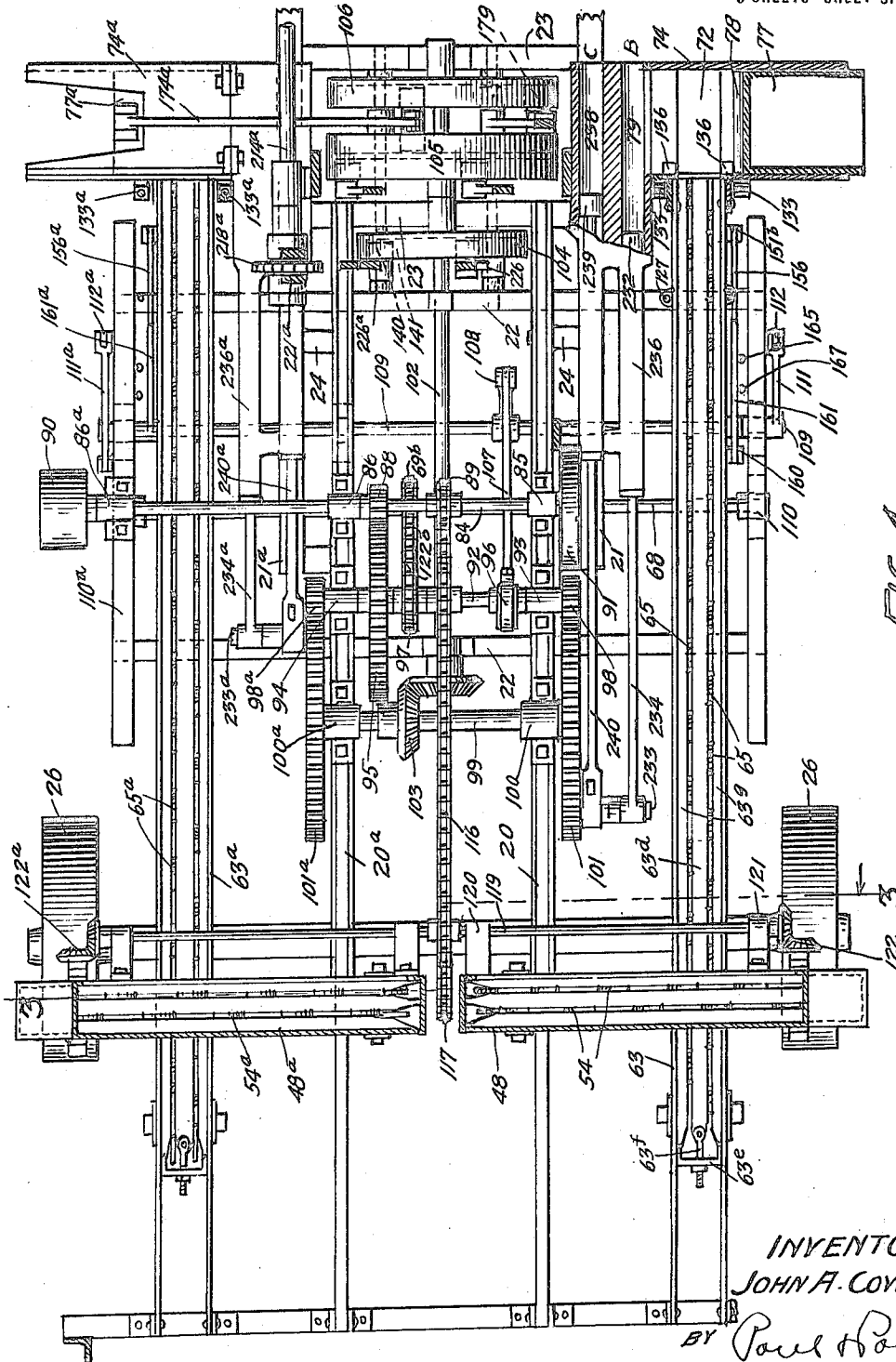


FIG. 4

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1,403,294.

8 SHEETS—SHEET 4.



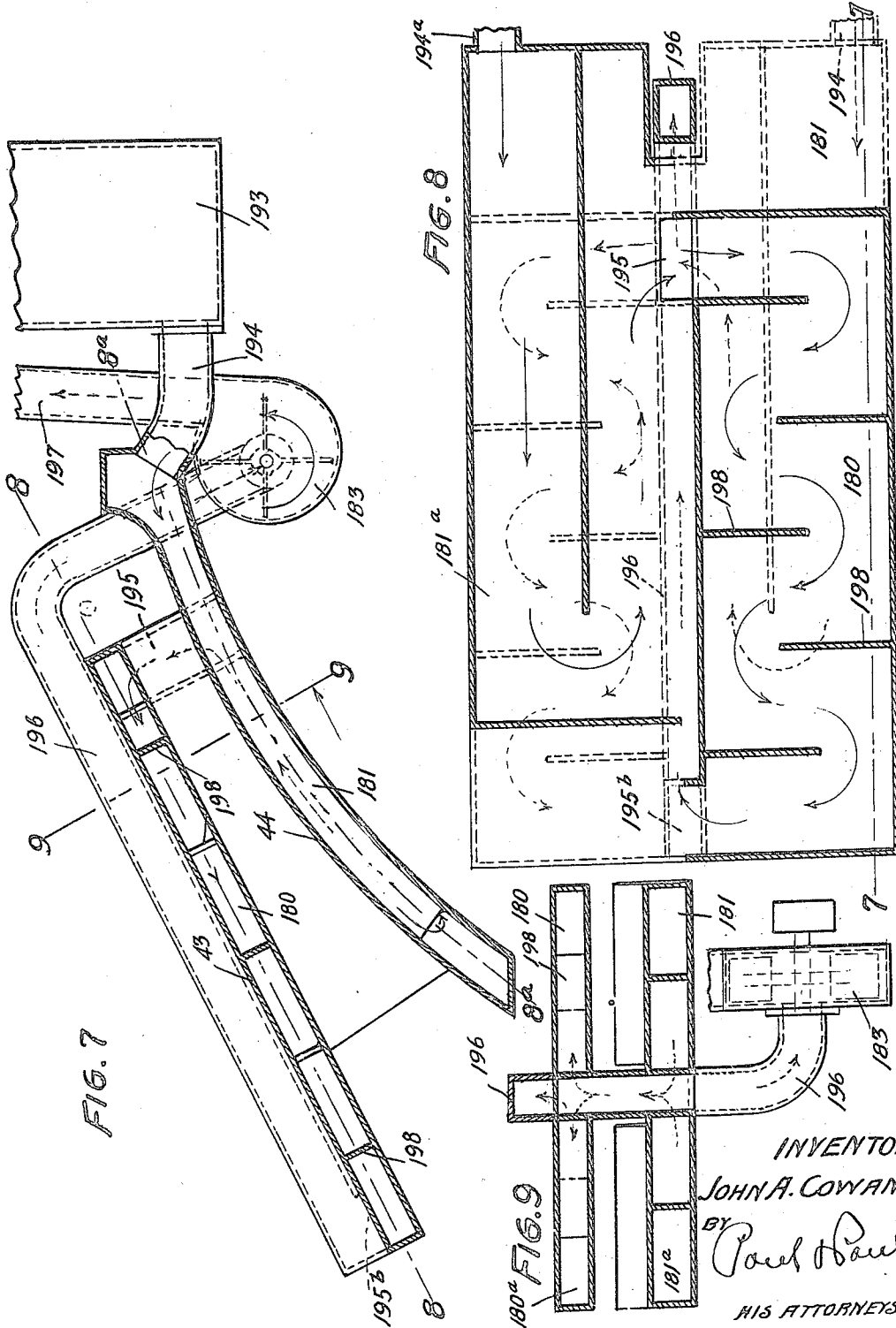
JOHN A. COWAN.  
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8 SHEETS—SHEET 5.



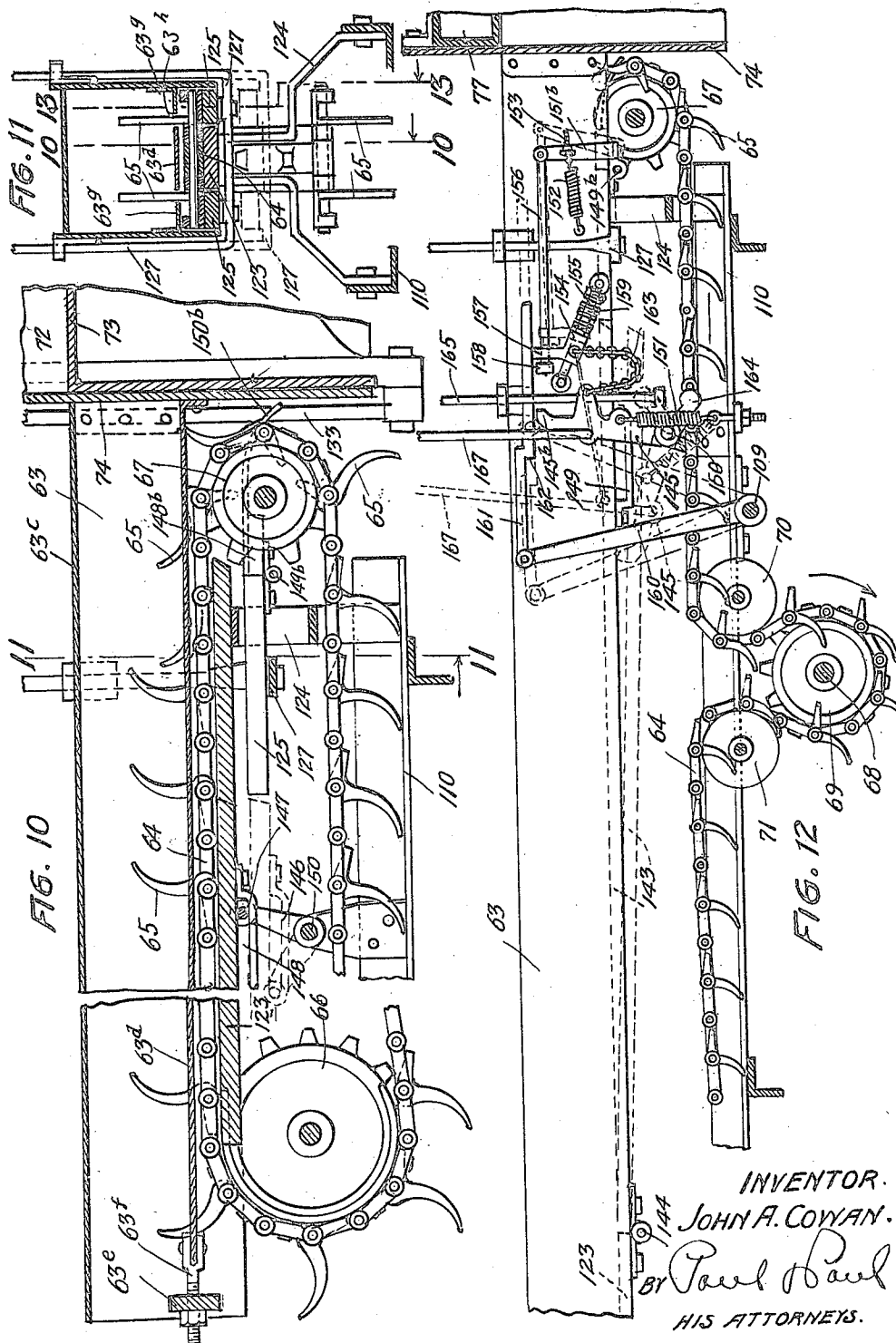
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8 SHEETS—SHEET 6.



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JOHN A. COWAN.

BY Paul Paul

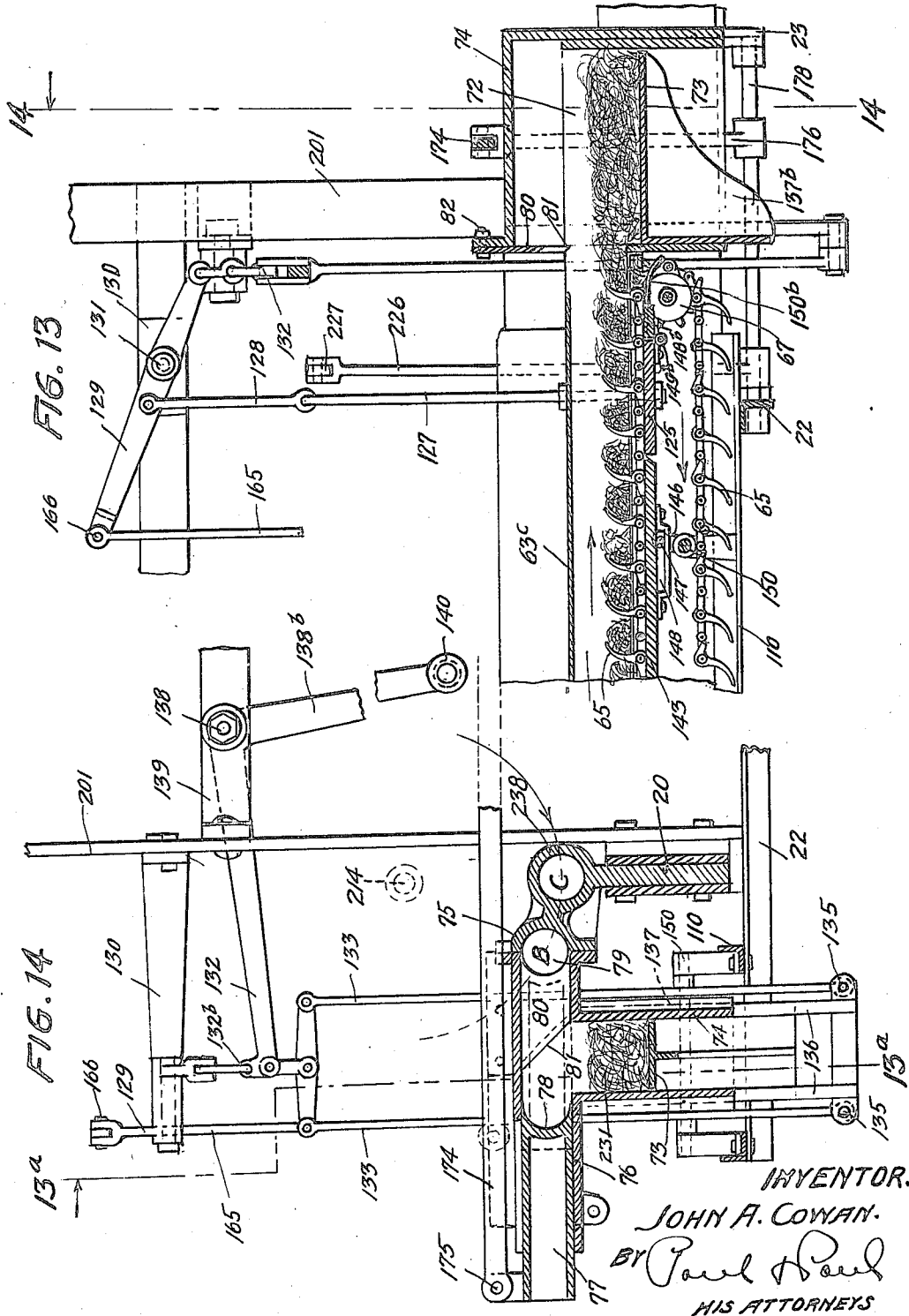
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8 SHEETS—SHEET 7.



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8 SHEETS—SHEET 8.

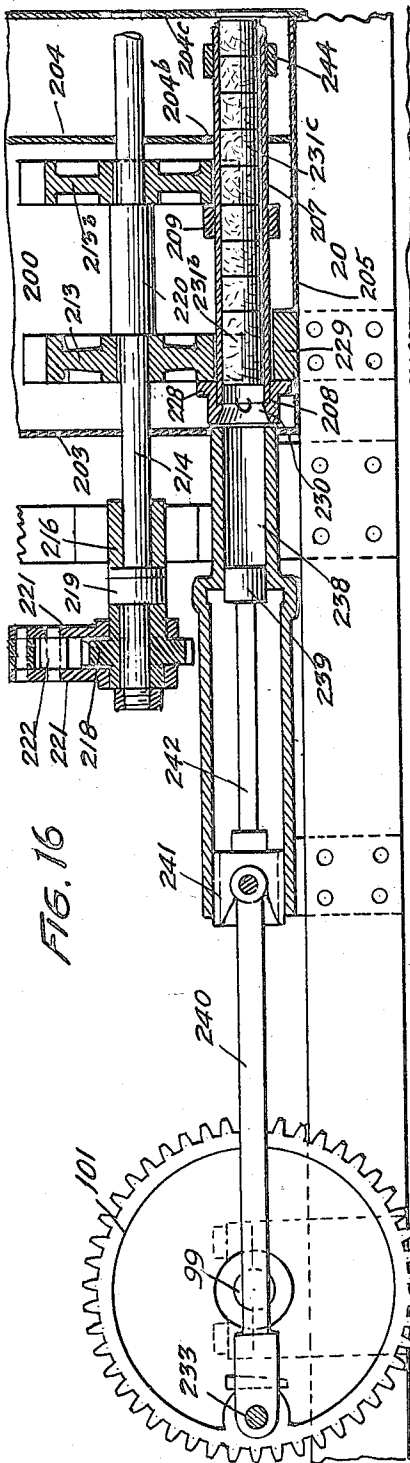


FIG. 16

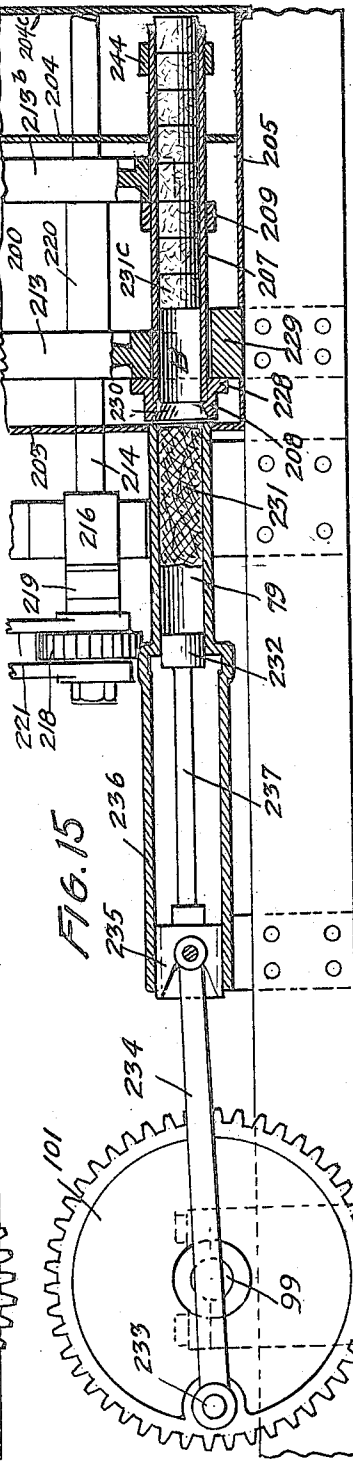


FIG. 15

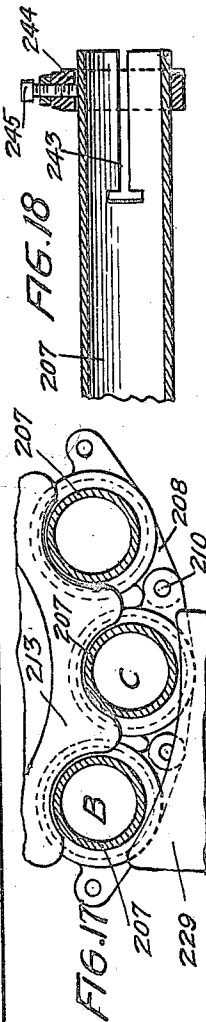


FIG. 17

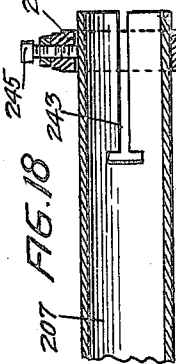


FIG. 18

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# UNITED STATES PATENT OFFICE.

JOHN A. COWAN, OF MINNEAPOLIS, MINNESOTA.

## STRAW-BRIQUETTING MACHINE.

1,403,294.

Specification of Letters Patent. Patented Jan. 10, 1922.

Application filed November 30, 1920. Serial No. 427,303.

*To all whom it may concern:*

Be it known that I, JOHN A. COWAN, a citizen of the Dominion of Canada, resident of Minneapolis, county of Hennepin, State of Minnesota, have invented certain new and useful Improvements in Straw-Briquetting Machines, of which the following is a specification.

My invention relates to machines for manufacturing briquettes of straw from grain or other similar fibrous material and the object of the invention is to produce a machine for converting the great amount of such material that is now going to waste on the farms and elsewhere, into compressed briquettes in which form it may readily be utilized as a fuel product in stoves, furnaces and other heating agencies.

Another object is to provide a machine which will produce a briquette from this material which will not need a separate binding material in its manufacture and which will be held together in the process of combustion and not disintegrate during exposure to heat or moisture.

A further object is to provide a machine of this class which will adapt itself readily to be placed on a portable conveyance to be moved from place to place, thereby obviating the necessity for transporting the straw in a bulky form to central briquetting plants and saving transportation cost, as the producers of straw may also utilize the briquetted product.

A still further object is to provide a portable machine of large capacity, light of weight, compact and readily removable by motor or animal power.

My invention consists in general in a machine for carrying out a two stage process of briquetting the straw without the addition of a binding material, and which briefly comprises an emulsifying and binding stage and a solidifying and baking stage.

It further consists in means for conveying, forming and compressing the straw in one continuous, automatic operation and means for automatically controlling the operation.

In the process of softening the fiber of the straw, I make use of the natural oily, glutinous or gummy matter, which I find is contained in a dry state in the fiber of the straw and especially concentrated at or near the inner surface of the hollow straw body.

When this substance becomes heated to a certain degree, it emulsifies or liquefies by absorbing a slight degree of moisture, and generally takes the form of a yellow semi-liquid which softens the fibers, destroys their rigidity, and elasticity, and transforms the straw into a pliable substance easily formed and compressed into a solid body.

The temperature at which the emulsion or liquefaction occurs is at or below the boiling point and this is the temperature at which initial and partial compression of the product should take place, by which the semi-liquid matter is forced through the fibers of the straw to the outward surface so that when final compression takes place the adhesive matter is evenly distributed throughout the whole mass.

If the process and compression were concluded at this point a briquette would be produced which would be held together only by an adhesive substance which could again to a degree be liquefied by the application of a certain degree of heat, or softened appreciably by exposure to warm or moist atmosphere. As a result of this, when the temperature was raised in the process of combustion in the stove or furnace, the briquette would have a tendency to expand and disintegrate and reform into a semblance of loose straw, and its value, especially as a stove fuel, would be reduced. A similar disintegrating tendency would exist with a long exposure of the briquettes to moist atmosphere and in order to overcome this tendency it is necessary to solidify the briquette by a subsequent high compression followed by a thorough baking process while subject to the high compression. The first stage, therefore, of the briquetting process consists in the emulsifying of the natural oily gummy substance by the primary application of moderate heat, for softening the straw and distributing the adhesive substance throughout the mass, the binding together by a preliminary partial compression of the softened straw and the exposure of the compressed straw to a short period of heating above the boiling point for the evaporation of the natural moisture to a point before the natural oily substance begins to distill; the second stage beginning at this point and comprising final compression under high pressure of the partially compressed and adhesive briquette, and a subsequent baking and solidifying process

applied an extended length of time under high compression subject to the higher degree of temperature, thereby fusing and consolidating the mass into a solid body that cannot be disintegrated by heat or moisture.

The invention generally consists in the methods, constructions and combinations hereinafter described and particularly pointed out in the claims, with reference to the accompanying drawings, forming a part of this specification, in which—

Figure 1 is a vertical side elevation, partially in section, of a machine embodying my invention,

Figure 2 is a sectional view of parts shown in elevation in Figure 1,

Figure 3 is a transverse section of the machine on the lines 3—3<sup>a</sup> and 3—3 of Figure 1, and 3—3 of Figure 4,

Figure 4 is a horizontal sectional view on the line 4—4 of Figure 1,

Figure 5 is a vertical cross section of the machine on the line 5—5 of Figure 1,

Figure 6 is a similar section on the line 6—6 of Figure 1,

Figure 7 is a longitudinal section of the primary heating chambers taken on the line 7—7 of Figure 8,

Figure 8 is a semi-horizontal section of the chambers and the lines 8—8 and 8<sup>a</sup>—8<sup>a</sup> of Figure 7,

Figure 9 is a cross section on the line 9—9 of Figure 7,

Figure 10 is a sectional view of one of the straw feeding conveyers, the section being taken on the line 10—10 of Figure 11,

Figure 11 is a cross section on the line 11—11 of Figure 10,

Figure 12 is a side elevation of the straw feeding conveyer, shown in Figures 10 and 11, illustrating the automatic feed control mechanism,

Figure 13 is a sectional view on a smaller scale of one end of the straw feed conveyer and gathering hopper, the section being taken on the lines 13—13 of Figure 11 and 13<sup>a</sup>—13<sup>a</sup> of Figure 14,

Figure 14 is a cross section on the line 14—14 of Figure 13,

Figure 15 is a vertical section through the preliminary compressor cylinder and one of the compression tubes of the traveling magazine in the baking chamber,

Figure 16 is a similar section through the final or finishing compressor cylinder and the corresponding compressor tube in the magazine,

Figures 17 and 18 are details of the compressor tubes in the traveling magazine, showing the method of driving the magazine and adjusting the pressure in the tubes,

Figure 19 is a detail of the straw conveying means.

The machine as here illustrated is mounted on a portable sub-frame of any suitable

construction, but preferably comprising longitudinal main carrying beams 20 and 20<sup>a</sup> and 21 and 21<sup>a</sup> (see Figures 1 to 4) rigidly joined together by cross girders 22 and 23 and suitable spacers 24. The frame is secured to a rear axle 25 having ground wheels 26 and is supported in front on an axle 27 provided with wheels 28 preferably mounted upon steering axles 29. A suitable tongue or draw bar 30 is connected to the axle 27 to which power may be applied to propel the machine and suitable knuckle arms 31 and links 32 are provided by which the machine may be steered.

For the purpose of providing for large capacity in compact form and balanced operation, I preferably provide two complete working units on the same frame or chassis, although the machine may be built with one unit only. These two units are substantially independent except for certain parts of the drive, and identical in construction and operation and I will therefore only describe one of them and designate the similar parts of the other on the drawings with the addition of the letter "a" to the reference numerals.

#### *The feeding and forming mechanism.*

Referring to Figures 1 to 3, an endless carrier 33, driven in any suitable manner, is mounted on the rear end of the machine to which the straw 34 is pitched or otherwise supplied. This carrier delivers the straw to the mouth of an inclined carrier or feeder formed by the endless carrier belts or chains 35, mounted upon shafts 36 and 37 and similar carrier belts 38, one side of which is parallel to the carrier belts 35, are mounted upon a driving shaft 39 and idler shafts 40 and 41. The carrier belts are provided with suitable cross bars 42, preferably having a serrated projecting edge 42<sup>a</sup> on the forward side to engage and carry the straw forward. Below the carrier belts 35 and 38 are arranged tables or plates 43 and 44, upon which the straw is partially resting while being carried forward by the cross bars 42, the table 44 being preferably slightly convex on the upper side for reasons which will hereinafter appear. As shown in Figure 2, the straw is carried up and around the driving shaft 39 and its sprocket wheel 39<sup>b</sup> and then downward over the convex table 44. This table is at its upper end provided with a curved section 44<sup>b</sup> which may extend around to the upper carrier belt 35 to guide the straw around the curve, but I prefer to arrange a series of rollers 45, suitably journaled in the enclosing casing 46 and either idling or driven in the direction of the arrows by a train of gears or other similar means, not shown on the drawings. The upper carrier shaft 37 is driven from the shaft 39 and in the same direction, preferably through an idler gear 47, and both carrier belts 35 and

38 are driven by mechanism which will hereinafter be more fully described, intermittently or in a step by step movement, which delivers the straw to a cross conveyer 48, the details of which are shown most clearly in Figure 3, it being understood that the construction of the conveyer 48 is identically the same as shown in the conveyer 48<sup>a</sup>.

The conveyer consists of a trough or housing in which runs an endless chain belt 49<sup>a</sup> mounted upon sprocket wheels 50<sup>a</sup> and 51<sup>a</sup> and shafts 52<sup>a</sup> and 53<sup>a</sup>. The links of the chain are provided with projecting carrier dogs 54<sup>a</sup>, the preferred construction of which is shown in Figure 19, where the dog 54<sup>a</sup> is shown pivotally mounted upon a projecting end of the link pin 55<sup>a</sup> and having a tail piece 56<sup>a</sup> which normally extends backwards under the projecting end of the following link pin 57<sup>a</sup>. This prevents the upper end of the dog from tilting forward and the bottom plate 48<sup>b</sup> upon which the chain slides normally prevents their backward tilting.

To the forward end of the plate 48<sup>a</sup> is secured a strap 59<sup>a</sup> curving backwards under the shaft 52<sup>a</sup> and guiding the dogs in a carrying position for a certain distance until released or tilted to any convenient position, from which they are again brought to a working position by passing around the curved rear end 60<sup>a</sup> of the bottom plate 48<sup>b</sup>. The straw is discharged into the conveyer trough 48<sup>a</sup> by the inclined carrier belts 38<sup>a</sup> and is conveyed by the chain belt 49<sup>a</sup> around the curved hood 61<sup>a</sup> and through the chute 62<sup>a</sup> into a longitudinal conveyer trough 63<sup>a</sup> in which operates an endless conveying chain belt 64<sup>a</sup> having carrier dogs 65<sup>a</sup> of substantially the same construction as the carrier dogs 54<sup>a</sup>. The conveyers 48 and 48<sup>a</sup> being identical in construction and function as parts of two similar units, the straw is also delivered from the conveyer 48 in a like manner to the longitudinal conveyer 63. The endless chain belt 64 operating in this conveyer, having carrier dogs 65, is mounted upon sprocket wheels 66 and 67 (see Figures 10 to 13) and is preferably driven from a shaft 68 journaled upon the main frame and having a sprocket wheel 69, around which the under section of the chain runs, passing over idler wheels 70 and 71, as shown most clearly in Figure 12. The chain belt 64 conveys the straw into the rectangular charging chamber 72, (see Figures 13 and 14) the bottom of which is formed by the plunger head 73 upon which the straw is deposited. The housing 74 of the chamber 72 may be supported upon the main frame in any suitable way, but preferably by being rigidly secured to the compression chamber housing 75, which in turn is securely bolted to the frame beams 20. The forming chamber housing 74 includes a rectangular guideway 76, open to the

chamber 72, in which operates a forming plunger 77 at a right angle to the plunger 73 and passing through the chamber 72. The forward end of the plunger 77 is formed in a semi-circular concave 78 which is adapted, when the plunger is advanced, to register with and form one side wall of the initial compressor cylinder 79 (see Figures 4 and 14). A knife blade 80, having an inclined sharpened edge 81, is removably fastened to a flange of the housing 74 by bolts or screws 82. When a predetermined amount or charge of straw has been deposited upon the plunger head 73 by the conveyer 63, the plunger is automatically raised to the position shown in Figure 10, when the charge will have been transferred to the upper portion of the chamber 72 in a horizontal line with the plunger 77 and slightly compressed. The plunger will then advance past the knife edge 81 to the limit of its stroke, as indicated by dotted lines in Figure 14, and any straws protruding beyond the knife will be cut off and the charge of straw will be formed into a loosely compressed cylindrical body in the initial compressor cylinder 79.

#### *The drive and feed control.*

Referring again to Figures 1 and 4, the main driving shaft 84, mounted in suitable bearings 85, 86 and 86<sup>a</sup> upon diagonally disposed frame members 87, carries a pinion 88, a sprocket wheel 89, a driving pulley 90 and preferably a fly wheel 91. Power may be applied to the pulley from any suitable source, such as an internal combustion or steam engine. A transmission or counter shaft 92 is journaled in bearings 93 and 94, below the shaft 84, and is provided with a gear 95 meshing with the pinion 88, an eccentric 96, a sprocket wheel 97 and pinions 98 and 98<sup>a</sup>. The compressor shaft 99 is mounted in bearings 100 and 100<sup>a</sup> upon the main frame beams 20 and 20<sup>a</sup> and is driven from the shaft 92 by means of large gears 101 and 101<sup>a</sup> meshing with the pinions 98 and 98<sup>a</sup> respectively. The shaft 99 drives a longitudinally and centrally mounted cam shaft 102 by means of a pair of miter gears 103 and this shaft carries cams 104, 105, and 106 which actuate the forming and feed control mechanism, as will hereinafter be more fully described. The feeding movement of the rear carrying chain belts 35 and 38 must be slow, for reasons which will hereinafter appear, and for the purpose of simplifying the speed reduction gearing I prefer to move the carriers by a step by step movement which is actuated by the eccentric 96. A connecting rod 107 is rigidly secured to the strap of the eccentric 96 and pivotally to a rocker arm 108 upon a rock shaft 109 mounted in suitable bearings in the auxiliary frames 110 and 110<sup>a</sup>.

An arm 111 is secured to the rock shaft 109, to which is connected a vertical rod 112 having pivoted connections with a bell crank lever 113. This lever carries a gravity pawl 5 114, normally engaging a ratchet wheel 115 secured to the carrier drive shaft 39, by which means this shaft is actuated by a forward intermittent movement by the eccentric 96. The conveyer 48 to which the 10 straw is delivered by this movement is driven at a constant and considerably higher speed by means of the sprocket wheel 89, above referred to, which is shown mounted on the main driving shaft 84 but may be 15 as readily secured upon the transmission shaft 92 and which transmits rotary motion through a chain 116 and large sprocket wheel 117 to a shaft 119 journaled in bearings 120 and 121, preferably arranged upon 20 the housing of the conveyers 48 and 48<sup>a</sup>. The shaft 119 is shown in Figure 4 extending the full width of the machine, driving both the conveyer 48 and 48<sup>a</sup> through the bevel gears 122 and 122<sup>a</sup> geared to drive 25 the conveyer shafts 52 and 52<sup>a</sup>. The longitudinal conveyer 63, to which the straw is delivered from the cross conveyer chain 49, is preferably driven from the sprocket wheel 97 upon the transmission shaft 92 by 30 means of the chain 122<sup>b</sup> passing from the sprocket wheel 97 around a sprocket 69<sup>b</sup> upon the shaft 68. It will be seen that the straw is conveyed by the above described means in a continuous stream to the forming chamber 72 and that, therefore, when 35 the plunger head 72 is raised, the straw is barred from entering the chamber by the intervening side of the plunger. To prevent undue strain on the chain and other 40 parts, I provide means so that when the plunger is raised, the carrier dogs on the portion of the chain next to the forming chamber will be automatically and temporarily brought out of action, and the straw 45 permitted to freely accumulate some distance in the rear of the entrance to the forming chamber, while the plunger is raised.

Referring now to Figures 10 to 13 inclusive, the bottom or drag plate 123 of the 50 conveyer housing upon which the chain belt slides is for a considerable distance from the rear composed of a single piece supported by or fastened to the side walls of 55 the conveyer trough. At the forward end, however, I divide the bottom longitudinally into three sections, the middle section supported upon the bracket 124 being a continuation of the rear end portion and the 60 short guide sections 125, upon which the tail pieces of the carrier dogs slide, being fastened to a yoked vertically movable rod 127. This rod is connected by a link 128 (see Figures 13 and 14) to a lever 129 pivoted to a bracket 130 at 131 and universally 65

linked to a bell crank lever 132 at 132<sup>b</sup> and to vertical plunger rods 133 which straddle the conveyer housing and are connected at 135 to the plunger guide bars 136. Guide- 70 ways 137 are provided in the plunger housing 74 in which the guide-bars 136 slide, and the side walls of the plunger head 73 to which the guide bars 136 are secured are preferably braced to the head by a strengthening rib 137<sup>b</sup>. The bell crank 75 lever 132 is pivotally mounted at 138 upon the cross frame piece 139, as shown in Figures 6 and 14, and the downwardly extending crank arm 138<sup>b</sup> is at its lower end provided with a roller 140 which is en- 80 gaged in a cam slot 141 formed in one side of the cam 104 mounted upon the longitudinal shaft 102. The contour of the cam slot 141 is such that the plunger head 73 is alternately raised and lowered at each 85 revolution of the cam 104 and held in the raised and lowered positions a predetermined length of time. When the plunger head is in the lowered position, as shown in Figures 13 and 14, the yoked rod 127, 90 supporting the guide sections 125 of the conveyer bottom, will be raised, holding the carrier dogs 65 in a working position, as will be clearly seen by reference to these 95 figures, and when the plunger head is raised, as indicated in Figure 10, the guide sections 125 will be lowered and by thus permitting the dogs 65 to tilt backwards, will render them inoperative for carrying the straw forward, as shown in Figure 10, 100 and the straw will accumulate in the corresponding area of the conveyer with a slight pressure against the plunger side while it is raised, ready to quickly enter the chamber 72 in a body when the plun- 105 ger is lowered and the guide sections 125 simultaneously raised.

For the purpose of preventing an over- 110 feed of straw to the forming chamber 72, I provide means for automatically throwing another and greater section of the carrying dogs 65 in the conveyer 63 out of 115 feeding action and simultaneously stopping the intermittent feed movement of the rear carrier belts 35 and 38. Referring to Figures 1 and 10 to 12, separate guide sections 143 extend rearwards from the sections in the 120 bottom of the conveyer 63 and are pivoted to the permanent bottom plate at 144. The sections are held in a raised position by means of arms 145 and 146, having a pin 147 125 passing through slots 148 formed by straps 149 on the under side of the sections 143, the arms being supported upon a shaft 150. The pin 147 is held in position in the slots 148 slightly forward in a vertical line of the shaft 150 by means of a coiled spring 151 and in this position the guide sections 143 are raised to hold the dogs 65 in an upright working position, as shown by full lines in

Figures 10, 12 and 13. When, however, the arms 145 and 146 are tilted backwards, as indicated by dotted lines in Figure 12, the sections 143 will be lowered, throwing the carrier dogs 65 to inactive position at a gradually diminishing ratio rearwards towards the pivot point 144. The arms 145 and 146 are tilted backwards when the chamber 73 is filled excessively by a too rapid feed of straw, the excess exerting a backward and downward pressure against a pressure controlling section 148<sup>b</sup>, hinged to the guide sections 125 at 149<sup>b</sup> and provided with forwardly projected prongs 150<sup>b</sup> and an arm 151<sup>b</sup> to which a coiled spring 152 is connected for holding the section 148<sup>b</sup> in a yielding raised position. The tension of the spring 152 may be adjustable by any suitable means, such as a threaded I-bolt and adjusting nut 153, so as to regulate the tension required on the prongs 150<sup>b</sup> to press the section 148<sup>b</sup> downwards by the accumulating straw. When this occurs, the arm 151<sup>b</sup> moves forward, as shown by dotted lines in Figure 12, carrying with it a collar 154, sliding upon an inclined rod 155, through a rod 156, connected to the arm 151<sup>b</sup> and having a sliding connection with a lug 157 of the collar 154. The rod 156 is provided with a head 158 which engages the lug 157 when the arm 151 is moved forward and slides the collar 154 in a downward direction against the light tension of a spring 159. A vertical arm 160 is keyed to the rock shaft 109 and carries at its upper end a gravity detent or pawl 161 resting upon the lug 157 of the collar 154 and having a shoulder or hook 162. Normally, the detent 161 slides forwards and backwards on the lug 157 with the shoulder 162 passing directly over the projecting end 145<sup>b</sup> of the arm 145, but when the collar 154 moves forward and downward, as a consequence of abnormal pressure of the straw on the section, the shoulder 162 on its backward movement will engage the upper end 145<sup>b</sup> of the arm 145 and swinging it backward past the vertical center of the tension line of the spring 151, the arm 145 and guide sections 143 will assume the dotted line position in Figure 12 in which the carrier dogs 65 are inactive, as heretofore explained. A suitable chain 163 or other connection between the arm 145 and collar 154 restores the collar to its original elevated position when the arm 145 is tilted backwards, as the spring 151 is of sufficient tension to overcome the tension of the straw on the hinged section 148<sup>b</sup> until the plunger is raised and the hinged section lowered, thereby releasing the tension. This movement also restores the arm 145 to its normal vertical position by means of a projecting arm 164 being struck by the enlarged lower end of a vertical rod 165 which is connected to

the lever 129 at 166 (see Figures 1 and 13). Simultaneously, with the backward tilting of the arm 145 to throw the conveyer feed out of action, the rear carrying wheels 35 and 38 feeding straw to the conveyer 48 are also brought out of action by automatically disengaging the pawl 114 from the ratchet 115. This I preferably accomplish by a vertical rod 167 connected to the arm 145 below and to an arm 168 above pivoted on the pin 169 of the bell crank lever 113. The pawl 114 is provided with a lug 171 and a coiled tension spring 172 connects this lug to a projecting end 173 of the rod 167. When the arm 145 is tilted backwards, the rod 167 puts this spring under sufficient tension to raise the pawl out of engagement with the ratchet wheel 115, stopping the feed of the carrier chains 35 and 38. With the restoration of the arm 145, the tension of the spring 172 is released, permitting the pawl 114 to again contact with the ratchet 115 and start the feed.

Referring to Figures 4, 6 and 14, the horizontal forming plunger 77, directing the straw from the chamber 72 to the initial compressor cylinder 79, is operated periodically by means of a link 174 connected to the plunger 77 at 175 and to a follower arm 176, preferably pivotally connected to a frame piece 177 at 178, and having rollers 179 traveling in cam grooves (not shown) formed in the cam 106 and also preferably in similar grooves formed in the cam 105. The contour of these cam grooves is substantially like that of the grooves in the cam 104 for the operation of the vertical plunger head 73, producing a rapid movement in both directions and a pause at either end of the movement, the sequence of movements being as follows: The vertical charging plunger 73 moves upwards, carrying the measure of straw necessary for a briquette of the adopted size. It pauses while the horizontal forming plunger 77 moves across the chamber 72 to the dotted line position shown in Figure 14 carrying the straw charge to the compression chamber 79. The forming plunger 77 pauses in this position while the charge is loosely compressed, forming one semi-cylindrical side of the compression chamber 79, while the charging plunger 73 immediately drops to its lowest position and then pauses while the charge enters the chamber 72. The forming plunger 77 returns to the full line position in Figure 14, pausing there until the charging plunger is again raised.

*The emulsifying, compressing and solidifying mechanism.*

Referring now to Figures 1, 2 and 5, the straw in its slow and long passage from the carrier 33 to the conveyer 48 over the plates 43 and 44 is subjected to a primary heating

process by passing over heating chambers 180 and 181, the upper radiating wall of which is formed by the plates 43 and 44 respectively. The straw carriers 35 and 38 and heating chambers 180 and 181 are enclosed by a sheet steel or other housing, forming a general heater 182 which may be suitably insulated to preserve the heat of the circulating gases which are supplied by a fan or blower 183 from a furnace or combustion chamber 184. The fuel for the furnace 184 may be any suitable material, but I prefer generally to use some of the straw briquettes made by the machine, which are fed through chutes 185 to the grate 186 forming the bottom of the combustion chamber. An ash pit 187 is provided under the grate and air is supplied to the furnace through suitable regulating dampers 188. In the center of the combustion chamber 184 I prefer to arrange converging plates 189 and 190, separated by a narrow slot 191 at the top through which additional air enters the combustion chamber 184 from an opening 192 to aid in the more perfect combustion of the fuel. Induced by the suction of the fan 183, the hot products of combustion pass upwards through a heating flue 193 surrounding a baking chamber, then downwards, and out from the flue through a pipe 194 to the primary heating chamber 181. (See also Figures 7 to 9). They pass from this chamber to the heating chamber 180 through a passage 195 and from the chamber 180 through an opening 195<sup>b</sup> and a duct or pipe 196 to the fan 183 from which it is exhausted through a pipe 197.

For the purpose of retarding the passage of the heated gases and distributing the heat equally through the chambers 180 and 181 and to radiate a maximum amount of heat to the straw, I enlarge the area of the carrier, and heating chambers as far as practical and provide the chambers with a series of baffle plates 198. The heating chambers may be constructed and the plates 198 may be arranged in various ways and I do not confine myself to the construction shown, but in general the circulation of the heated gases follows the path indicated by the arrows in Figures 1, 5, 7 and 8. The initial temperature of the gases passing from the furnace 184 is considerably above the boiling point, but a great deal of this heat is given off in the flue 193 before reaching the heating chambers 181 and 180 and generally the degree of heat maintained in these chambers is at or near boiling temperature. The degree of heat is, of course, greatest in the chamber 181, gradually lessening towards and in the chamber 180 as the heat is transferred and taken up by the straw above the chamber. As the straw first enters above the chamber 180, this heat distribution provides for a gradual increase in the

degree of heat to which the straw is subjected as it progresses through the heater 182. The effect of this heating process on the straw is to soften or emulsify the fiber of the straw by liquefying the oily, gummy matter contained in the straw. This is necessary preparatory to forming and partially compressing the straw by which operation the straw is brought into a smaller compass for exposure to heat and the liquefied matter is made to further penetrate the cells of the straw and bind it together as the gummy matter is solidifying by the removal of the contained moisture during the following exposure to a higher degree of heat before the final compression and solidification. In order to preserve the heat in the material in its passage through the conveyers 48 and 63 to the forming chamber 72, I prefer to provide a cover 63<sup>c</sup> (see Figures 10 and 11) and I also cover the chain 64 by means of strips 63<sup>d</sup> stretched between the chamber wall 74 and a bar 63<sup>e</sup> by means of a threaded eyebolt 63<sup>f</sup>. Angle strips 63<sup>g</sup> projecting over the tail portion of the carrier dogs 65, are fastened to the conveyor sides, leaving slots 63<sup>h</sup> through which the vertical part of the dogs 65 pass.

The final compression and solidification is accomplished within a chamber or oven 200, surrounded by the heating flue 193 and supported by vertical frame members 201 and 202 and enclosed by side walls 203 and 204 to which are tightly connected a wall 205 surrounding an endless belt magazine 206 in the oven 200 containing semi-compressed and fully compressed briquettes. The magazine is composed of a series of traveling briquetting tubes 207 which are fastened to chain blocks or links 208 and 209 having pin connections 210, as shown more particularly in Figure 17, and is mounted upon upper sprocket wheels 211 on an idling shaft 212 and lower driving sprocket wheels 213 and 213<sup>b</sup> secured to a driving shaft 214. The shafts 212 and 214 are journaled in bearings 215 and 216 respectively and the driving shaft 216 carries a ratchet wheel 218, a thrust collar 219 and a shoulder or enlarged portion 220 abutting the sprocket wheels 213 and 213<sup>b</sup>. A step by step movement is imparted to the endless belt magazine by means of the arms 221 loosely mounted upon the hub of the ratchet wheel 218 and provided with a pawl 222 which engages the ratchet wheel 218. The tubes preferably project out beyond the wall 204 and a slot 204<sup>b</sup> is provided in the wall through which the tubes pass, and an outer door or removable cover 204<sup>c</sup> is provided by which access may be had to the tubes.

Periodic reciprocating motion is imparted to the arms 221 from the cam 104 (see Figure 6) having a groove 224 in which operates a roller 225 fastened on a

follower arm 226, which arm is swingingly connected to the frame at 178 and connected to the ratchet arms 221 by a link 227.

Both the preliminary and final compression takes place in the tubes 207 comprising the endless belt magazine 206 and in order to provide against displacement of the tubes, due to the force of the compression, I provide the tubes 207 with shouldered heads 228 which, as the tubes are consecutively placed in position for compression with the travel of the magazine, contact against a bearing block 229 rigidly connected to the frame beams 20. The heads 228 are provided with a flaring mouth 230 registering with the inner cylindrical contour of the tubes 207, through which the loosely formed and softened heated straw charge 231 is introduced for preliminary compression in the tube by the compressor plunger or piston 232, working in the cylinder 79. This piston is operated from a crank pin 233, rigidly secured to the gear wheel 101 and having a connecting rod 234 pivotally connected to a cross head 235 operating in a suitable guideway 236, the said cross head 235 being connected to the piston 232 by a rod 237. As the gear wheel 101 rotates from the position shown in Figure 15 to that shown by the gear wheel 101<sup>a</sup> in Figure 4, the piston 232 is advanced and the straw charge 231 is forced into the tube 207 being in alignment with the cylinder 79 at the point B until it assumes the partially compressed briquette form shown at 231<sup>b</sup> in Figure 16. The briquette in this form is loosely bound together by the emulsified matter contained in the straw and this matter will be partially dried and the moisture removed from the mass during the time consumed for one revolution of the endless belt magazine 206 or until the briquette arrives at the final compression point at C. It will be understood that for each stroke of the plunger 232 in the operation of the machine, the magazine will advance one step in the direction of the arrows in Figures 5 and 14 and that therefore each tube in the magazine will contain a briquette 231<sup>b</sup> partially compressed until it arrives and stops at the final compression point at C. The final compression cylinder 238 is in accurate axial alinement with this point and simultaneously with the compression stroke of the piston 232, the crank pin 233 impels a piston 239 operating in the cylinder 238 to a forward stroke through the connecting rod 240, crosshead 241 and rod 242, thereby recompressing the briquette 231<sup>b</sup> against the high frictional resistance of a series of briquettes 231<sup>c</sup> previously compressed in the tube, and thoroughly fusing the gummy substance with the fiber of the straw. In order to regulate the frictional resistance of the briquettes in the tube 231, I provide

a longitudinal slot 243 in the forward end of the tubes and a clamping collar 244 provided with an adjusting screw 245 embraces the slotted portion of the tube by which the tube may be compressed at its end to any degree for furnishing the desired resistance to the emerging briquettes. After their final compression the briquettes remain in the tube for as many revolutions of the endless magazine as there are number of briquettes in each tube, as one briquette is introduced and only one ejected each time a tube passes the compression point C. During the whole period of this number of revolutions, which will vary according to the ratio of length of the tubes and briquettes, the briquettes are subjected to the high degree of heat existing in the oven 193 which bakes and solidifies the compressed adhesive substance and straw fiber into a hard, homogeneous body which will not again disintegrate. It will be seen from the foregoing that the heated and partially compressed briquettes are exposed to a period of heat from the highest degree of heat near the furnace, lasting for one revolution of the endless belt magazine for the purpose of drying the natural binding substance, and that the completely compressed briquettes are exposed to the same degree of heat for a much longer period to bake and solidify the compressed product.

It is evident that various modifications may be made in the construction of the machine without departing from the principle and scope of the invention, and I do not, therefore, limit myself to the construction shown.

I claim as my invention:

1. A process of making straw briquettes which consists in first heating the straw to soften the inherent glutinous constituent, then compressing the briquettes formed from the straw to cause the particles thereof to adhere together, and finally baking the briquettes to set or harden the glutinous binder.

2. A process of making straw briquettes which consists first in heating the straw to soften the inherent glutinous constituent, shaping the briquette and then compressing it to cause the softened fibers to adhere together, and finally baking the briquette to harden or set the glutinous binder.

3. A process of making straw briquettes which consists in heating the straw to a temperature at or near the boiling point and softening the inherent glutinous constituent, then shaping the briquette and subjecting it to pressure, and finally baking the briquette to set or harden the glutinous constituent.

4. A process of making straw briquettes which consists in feeding and heating the straw to soften the glutinous constituent

therein, shaping the softened straw in a former, then subjecting the material to pressure to cause the particles to adhere together, and finally baking the compressed 5 briquette to set or harden the glutinous constituent.

5. A process of making straw briquettes which consists first in heating the straw to soften the inherent glutinous constituent, 10 then shaping the briquette and compressing the softened fibrous matter, and finally passing the briquette through a baking oven to harden or set the glutinous element.

6. A process of making straw briquettes 15 which consists first in heating the straw to soften the inherent glutinous constituent, shaping the briquette in a suitable former, then forcing the briquette from the former into a mold and partially compressing it, 20 and finally baking and compressing the briquette to harden or set the glutinous element.

7. A process of making straw briquettes which consists in heating the straw to soften 25 or release the inherent glutinous constituent, shaping the briquette in a suitable former, then forcing the briquette into intermittently moving molds and partially compressing it and finally subjecting the bri- 30 quettes to a compressing and baking operation while in said molds.

8. A process of making briquettes of straw which consists first in softening the straw to release the glutinous constituent, then 35 subjecting the straw to pressure to form it into briquettes, and finally baking the briquettes to set or harden said glutinous constituent.

9. A machine of the class described comprising means for feeding straw and heating it during the feeding operation to soften 40 the inherent glutinous constituent, a former whereto the softened straw is delivered for shaping into a briquette, a traveling mold mounted to receive the briquette so formed 45 from said former, means for compressing the briquette in said mold to cause the elements thereof to adhere together, and means through which the mold is passed for baking 50 the briquette to harden or set the glutinous constituent while contained in said mold.

10. A machine of the class described comprising means for feeding straw and heating it during the feeding operation to soften 55 the inherent glutinous constituent, a former whereto the softened straw is delivered for shaping into a briquette, a plurality of molds mounted to register successively with said former and receive briquettes intermit- 60 tently therefrom, and means for compressing and baking the briquettes while contained in said molds.

11. An apparatus of the class described comprising means for feeding straw, and 65 heating the same to soften or release its

glutinous constituent, a former mounted to receive and shape the straw into a briquette, a plurality of molds mounted to travel past said former and receive the briquettes suc- 70 cessively therefrom, means for forcing the partially formed briquettes into said molds, and compressing them therein, and a heating oven through which the molds are mounted to travel.

12. An apparatus of the class described 75 comprising means for feeding straw and heating it during the feeding operation to soften the glutinous material therein, a former whereto the straw is delivered and shaped into a briquette, a plurality of molds 80 mounted to travel past said former and intermittently pause in register with said former to receive the incomplete briquette therefrom, means for compressing the bri- 85 quette in said molds and a baking oven through which the molds are successively passed with the briquettes contained therein.

13. An apparatus for making straw bri- quettes comprising means for feeding and heating the straw to soften the glutinous 90 constituent, a former whereto the straw is delivered having vertically and horizontally moving plungers for shaping the straw in said former, and molds mounted to inter- 95 mittently register with said former and receive the partially compressed briquettes therefrom, means for compressing the bri- quettes in said molds, and a baking oven 100 through which the molds with the briquettes therein are passed.

14. The combination, with means for feed- ing and heating fibrous material to soften the glutinous inherent constituent, of a shap- 105 ing mold and means for forming a briquette of the softened material, an endless belt of compression molds having a step by step movement and mounted to register succes- 110 sively with said shaping mold to receive the incomplete briquette therefrom, means for compressing the briquette in said compres- sion mold, and means for baking it to set or harden the glutinous constituent.

15. The combination, with a shaping mold and means for feeding a fibrous material thereto and means for forming the briquette 115 in said mold, of a plurality of traveling molds mounted to register successively with said shaping mold, means for forcing the briquette from said shaping mold into said compression mold and compressing it there- 120 in, and a baking oven through which said traveling molds move.

16. The combination, with means for feed- ing and heating fibrous material to soften the glutinous constituent therein, of a shap- 125 ing mold whereto the fibrous material is delivered, means for partially forming the briquette in said shaping mold, a plurality of compression molds mounted to register successively with said shaping mold and

receive the incomplete briquette therefrom, means for forcing the incomplete briquette from said shaping mold into one of said compression molds and subjecting it to pressure therein, a baking oven wherein the compression molds travel for baking the briquettes and setting or hardening the glutinous material, each subsequently formed and baked briquette being discharged from its compression mold after a predetermined passage through said oven by the pressure of the later formed briquettes.

17. The combination, with the traveling briquette forming molds and means for feeding and heating a fibrous material and delivering it to said molds, of means for compressing the fibrous material in said molds and means through which the molds pass for baking the briquette to set or harden the glutinous material softened by the heating operation.

18. The combination, with the traveling briquette forming molds, of means for feeding and heating fibrous material and delivering it to said molds and subjecting it to pressure therein, and an oven through which said molds are passed following the compressing operation to bake or set the glutinous material softened by the heating operation.

19. The combination, with means for feeding and heating a fibrous material to soften the inherent glutinous constituent, of traveling briquette molds arranged in groups and mounted to receive the heated fibrous material, means for compressing the fibrous material in said molds to form briquettes, and a baking oven through which said molds are moved to harden the glutinous constituent.

20. The combination, with a pair of briquette shaping molds and means for de-

livering a heated fibrous material thereto, magazines of traveling compression molds arranged opposite the shaping molds and mounted respectively to register successively with said shaping molds and receive the incomplete briquettes in softened form therefrom, means for compressing the briquettes in said compression molds, a baking oven through which the groups of compression molds are slowly moved to set the glutinous constituent in the fibrous material, softened by the heating operation, the operation of forcing the briquets into said compression molds and compressing them therein ejecting the previously formed and baked briquettes from said compression molds.

21. The combination, with means for feeding fibrous material having a broad feeding surface and means for heating the fibrous material during the feeding movement, of a conveyer operating transversely with respect to said feeding means to receive the material therefrom, a conveyer operating longitudinally of said feeding means to receive the fibrous material from said transverse conveyer, means for forming the fibrous material into a briquette and means for subjecting the briquette to pressure and means for baking it.

22. An apparatus of the class described comprising means for feeding and heating a fibrous material to soften its gummy constituent, means for shaping the material and initially compressing it to form a briquette, means for finally compressing the briquette, means for baking it to set or harden the gummy constituent, and means for automatically regulating the feed of the material to said compressing and baking means.

In witness whereof, I have hereunto set my hand this 23d day of November, 1920.

JOHN A. COWAN.