C. A. CASE.

TUNNELING MACHINE.

APPLICATION FILED JAN. 13, 1908.

910,500.

Patented Jan. 26, 1909.

6 SHEETS—SHEET 1.

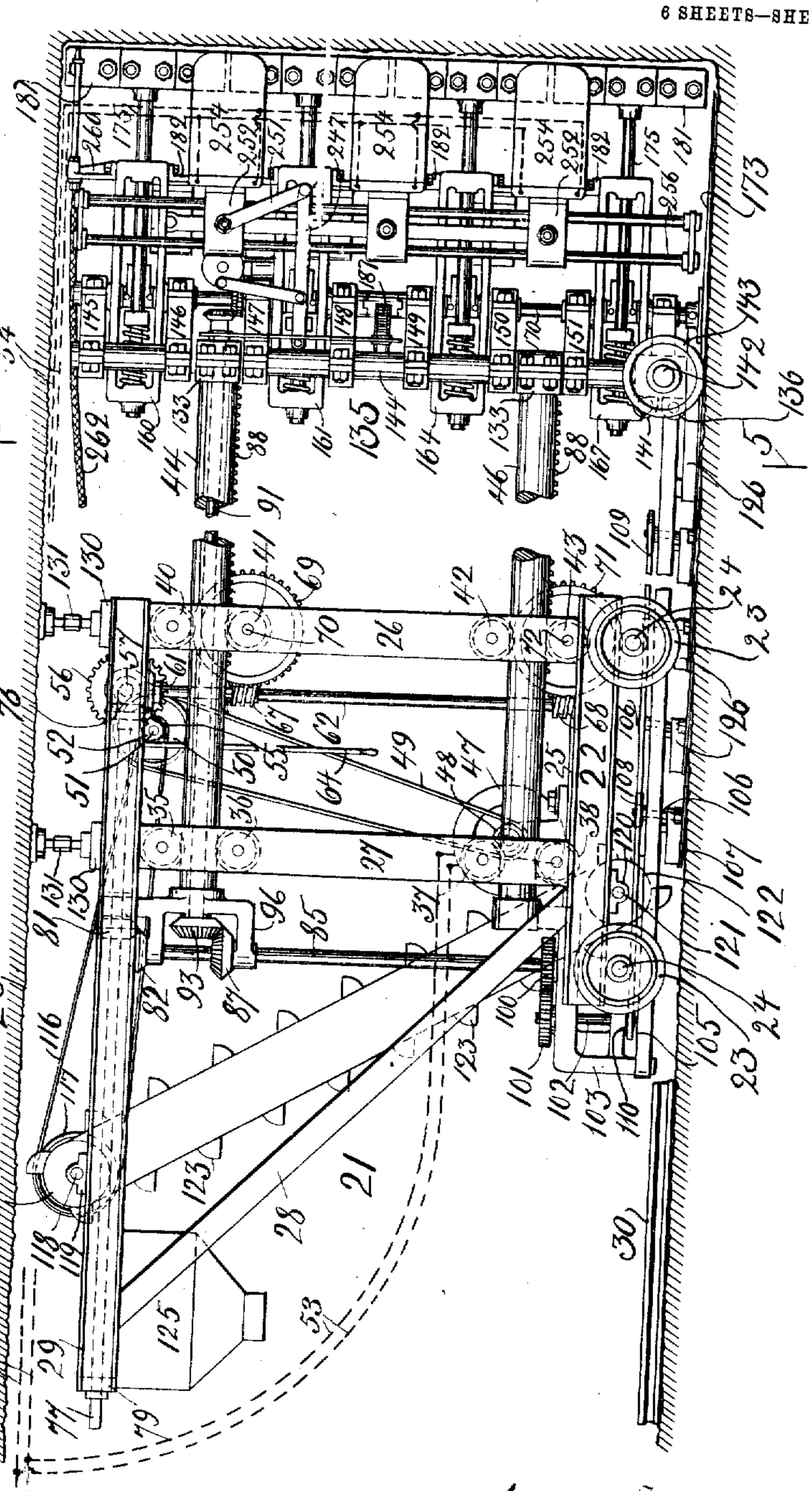

Fig 1

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6 SHEETS—SHEET 2.

Fig 2

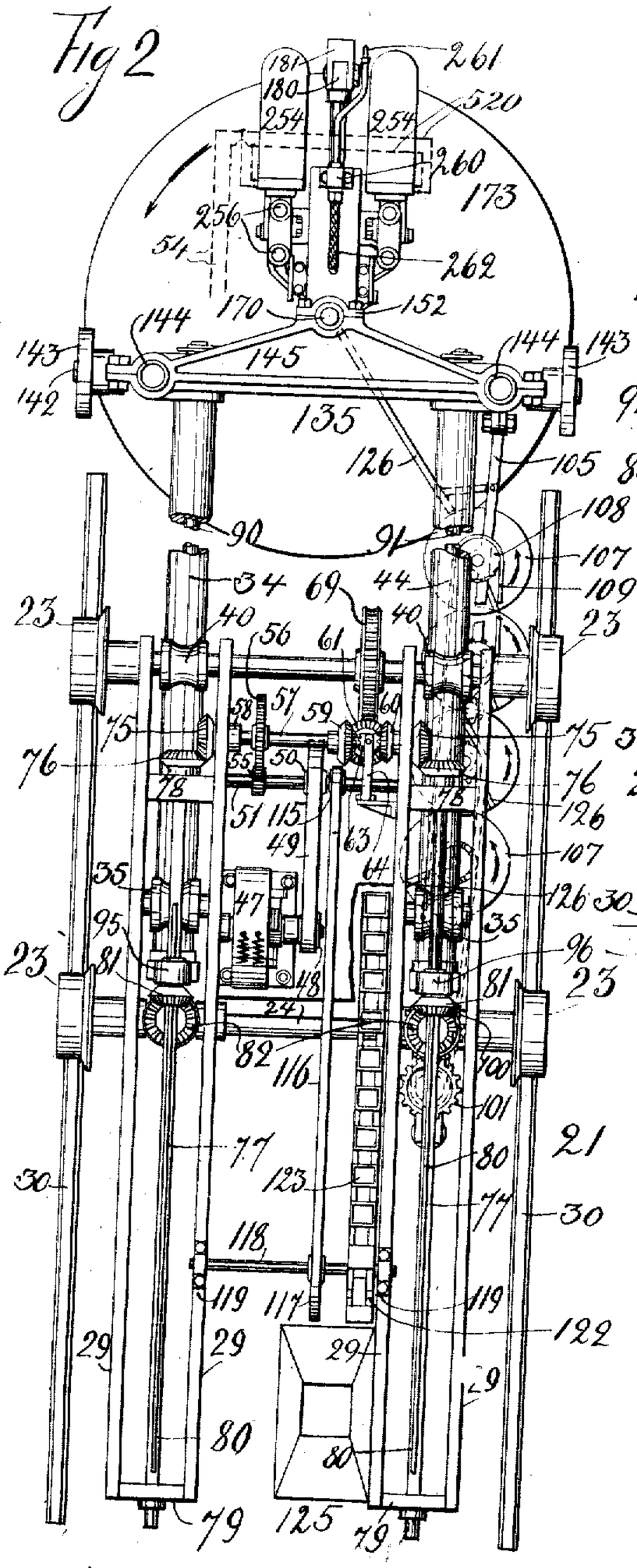
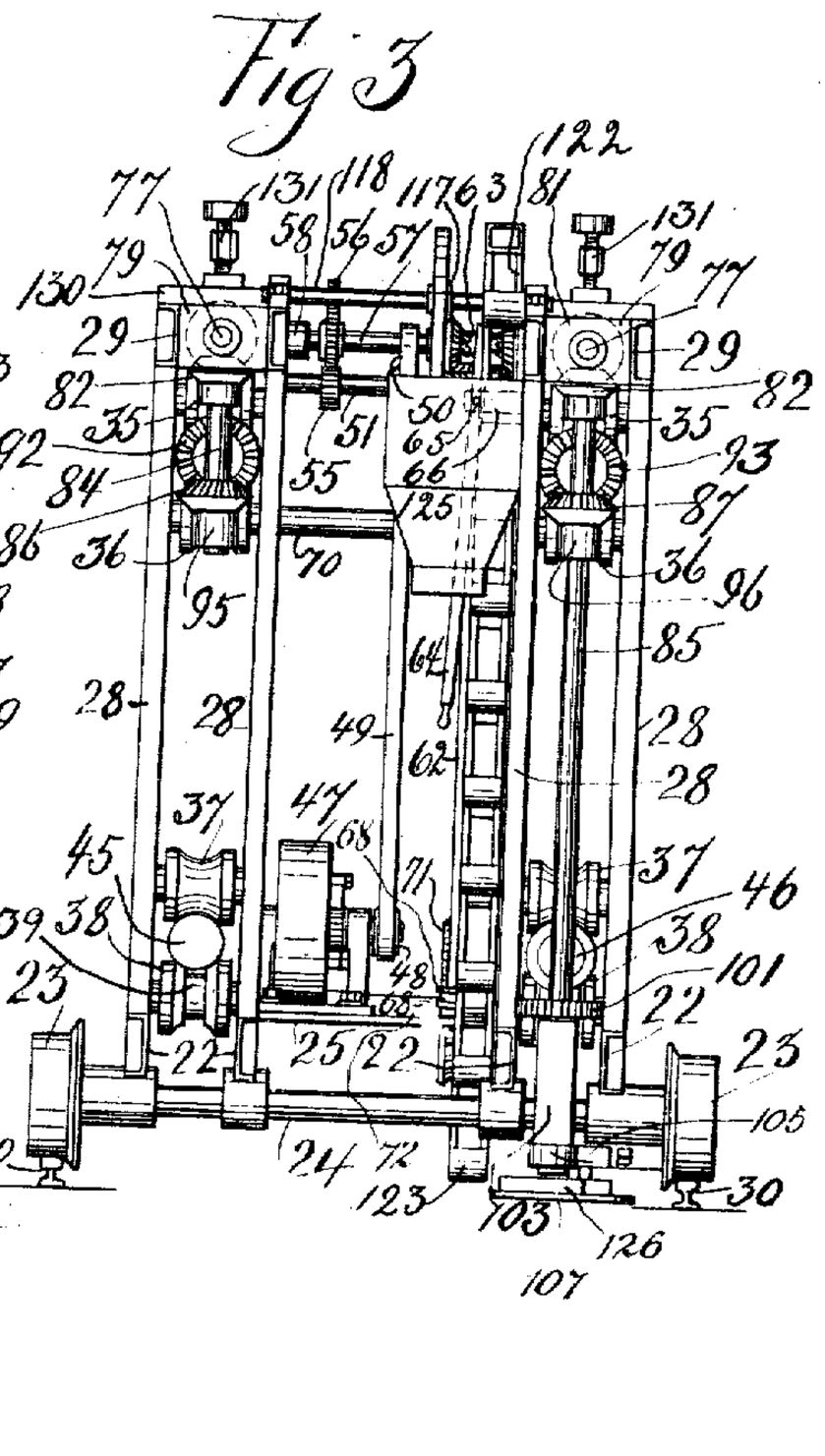


Fig 3



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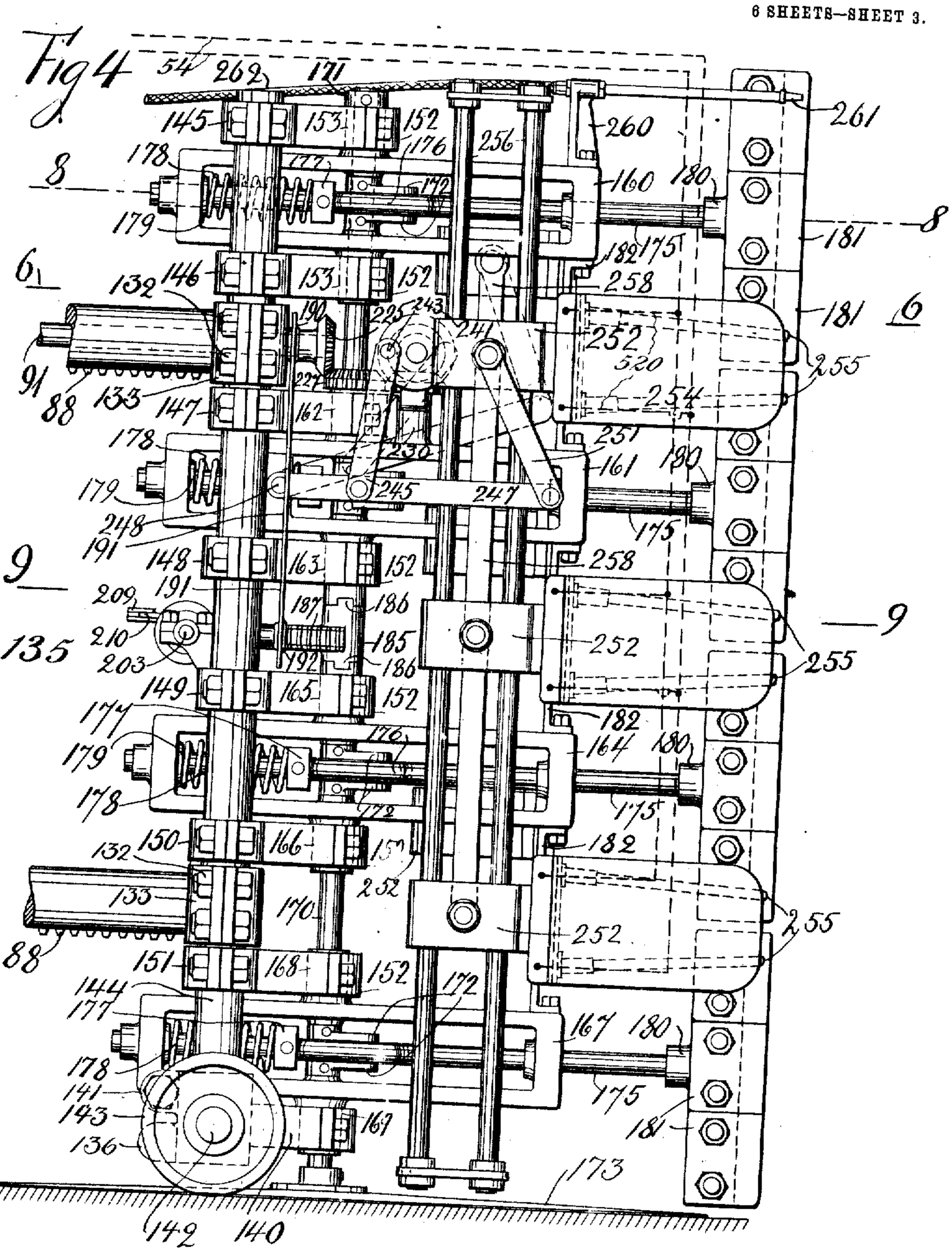
6 SHEETS—SHEET 3.

Fig 4



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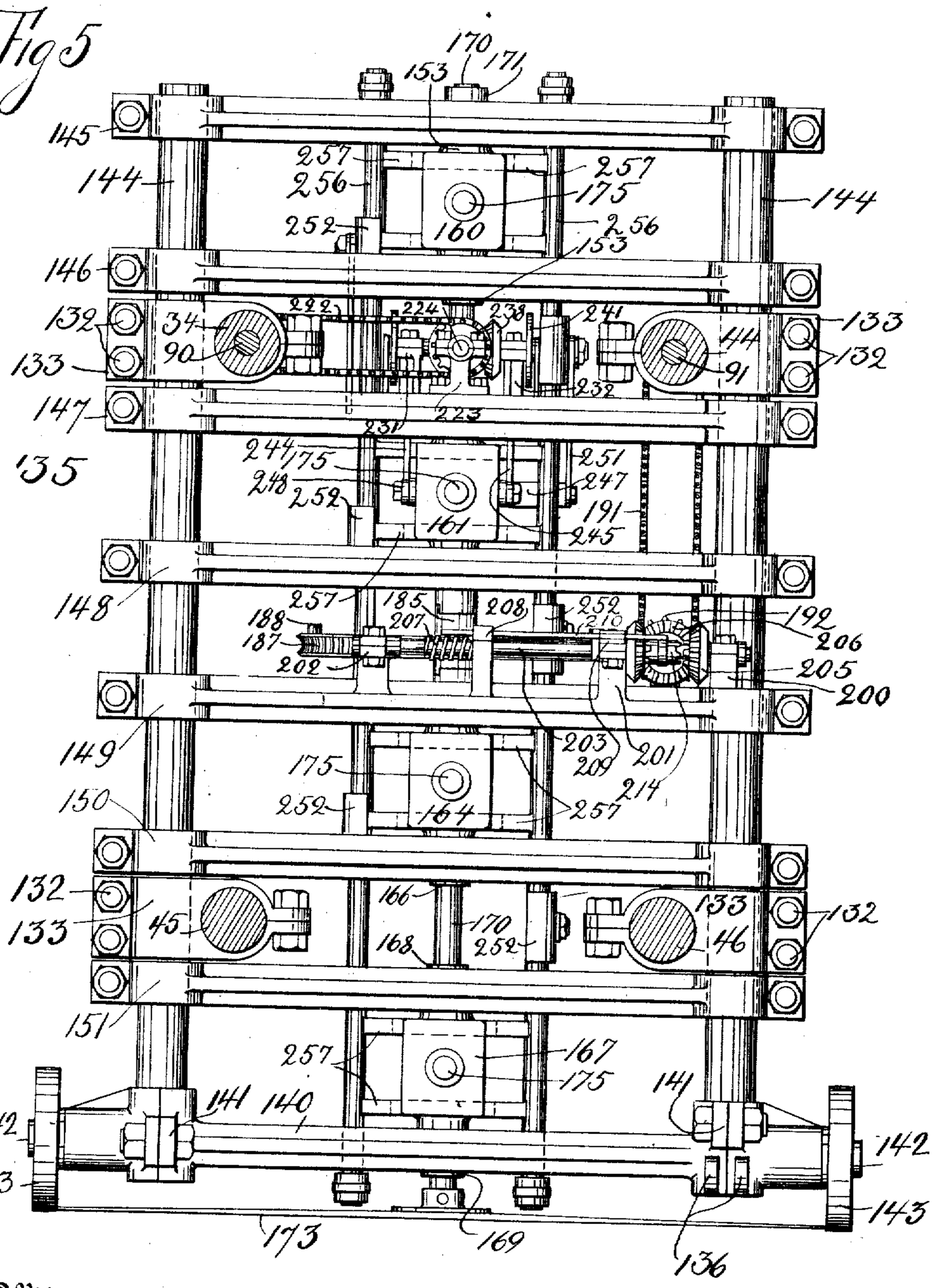
6 SHEETS—SHEET 4.

Fig 5



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6 SHEETS—SHEET 5.

Fig 6

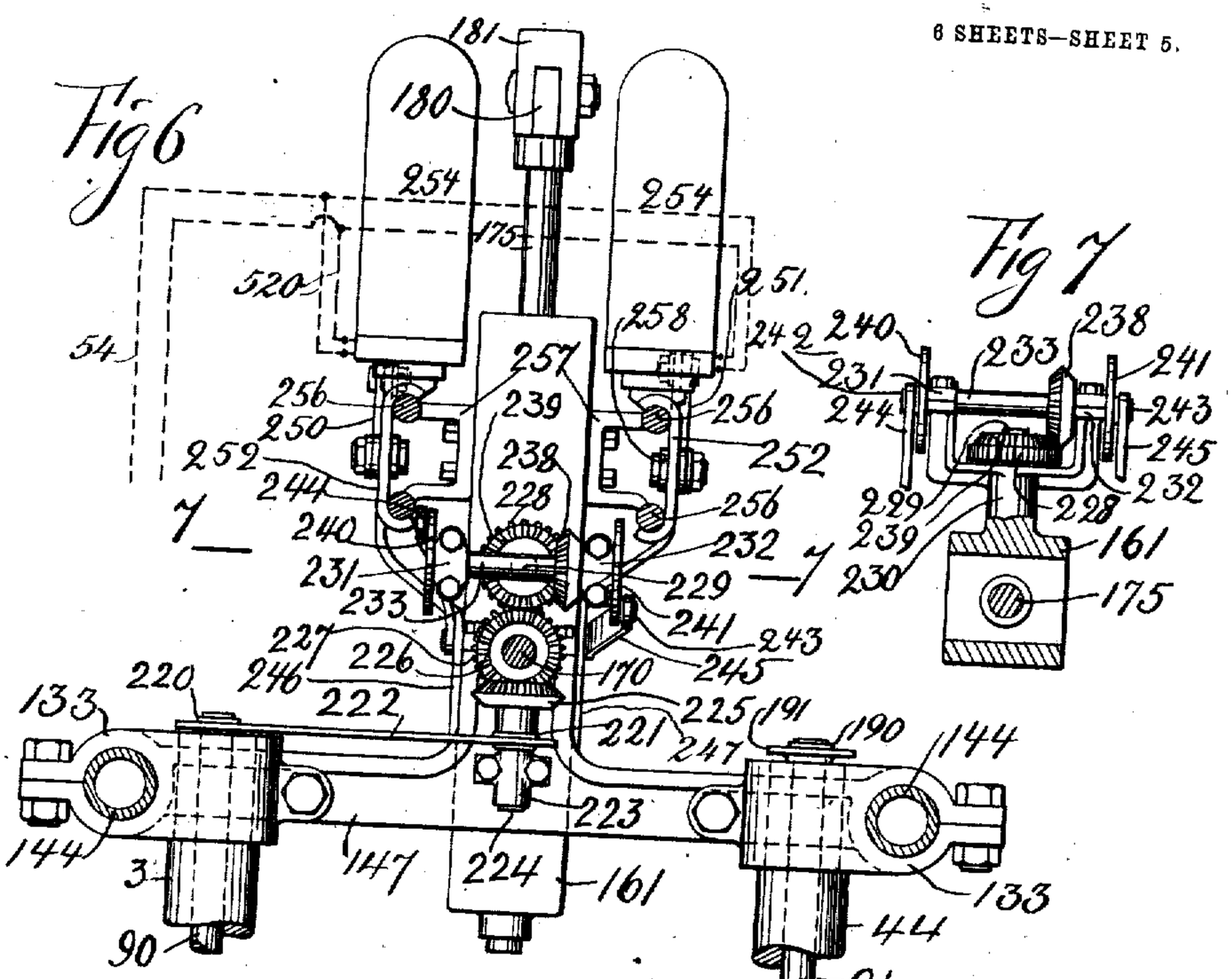


Fig 7

Fig 8

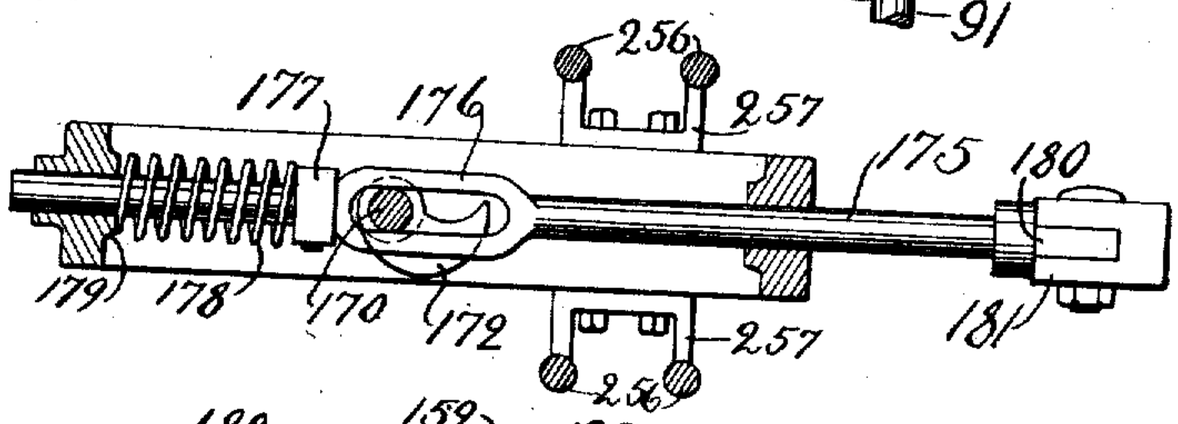
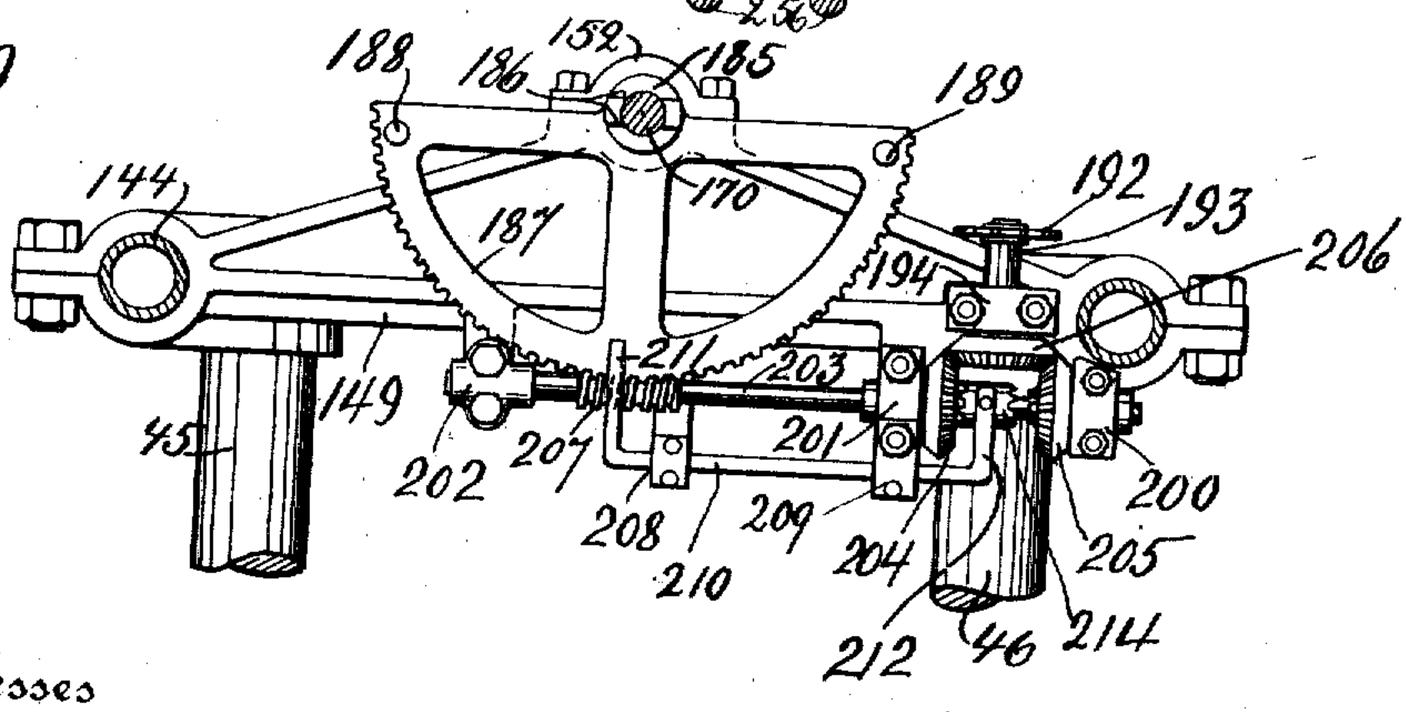


Fig 9



Witnesses

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6 SHEETS—SHEET 6.

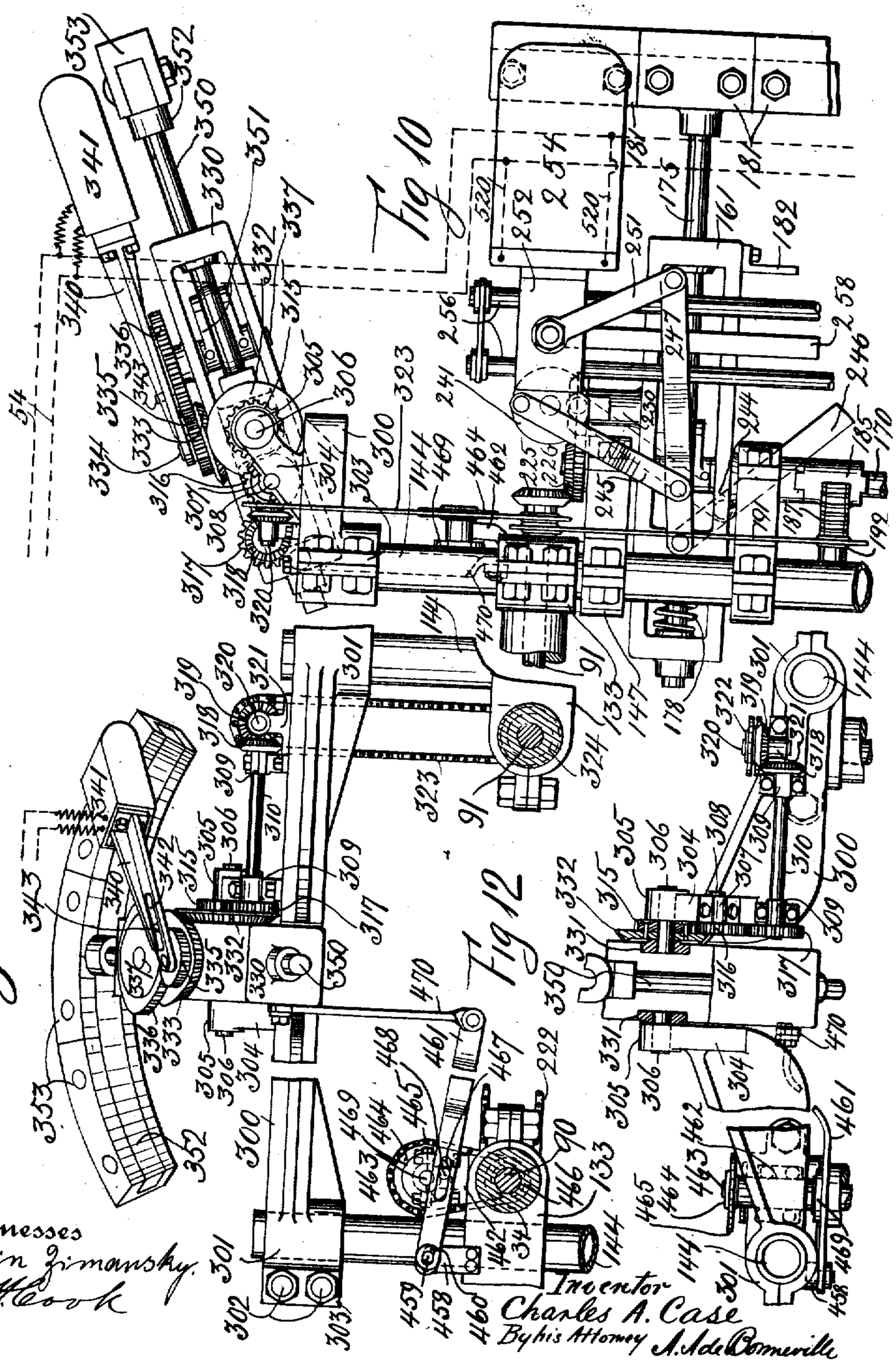

Fig 10

Fig 11

Fig 12

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UNITED STATES PATENT OFFICE.

CHARLES A. CASE, OF NEW YORK, N. Y., ASSIGNOR TO CASE TUNNEL & ENGINEERING COMPANY, OF NEW YORK, N. Y., A CORPORATION OF ARIZONA TERRITORY.

TUNNELING-MACHINE.

No. 910,500. Specification of Letters Patent. Patented Jan. 26, 1909.

Application filed January 13, 1908. Serial No. 410,689.

To all whom it may concern:

Be it known that I, CHARLES A. CASE, a citizen of the United States, and a resident of the borough of Manhattan, in the city and county of New York and State of New York, have invented a certain new and useful Tunneling-Machine, of which the following is a specification.

This invention relates to means for disintegrating rock and other materials, by suddenly changing their temperature and then by concussion, hammering or rasping effecting their disintegration.

To carry out the invention means are provided for heating and suddenly cooling or chilling the material to be operated upon and subjecting it to the force of blows.

The invention is exemplified in a tunneling machine, which may be constructed to dig tunnels of various cross-sections.

Figure 1 represents a longitudinal section of a tunnel with a side elevation of a tunneling machine exemplifying the invention, Fig. 2 shows a plan view of Fig. 1, Fig. 3 is an end view of Fig. 1, Fig. 4 represents an enlarged portion of Fig. 1, Fig. 5 shows an enlarged partial section of Fig. 1 on the line 5, 5, Fig. 6 is a partial section of Fig. 4 on the line 6, 6, Fig. 7 is a partial section of Fig. 6 on the line 7, 7, Fig. 8 represents a partial section of Fig. 4 on the line 8, 8, Fig. 9 shows a partial section of Fig. 4 on the line 9, 9, Fig. 10 represents a view similar to Fig. 4 with a modification, Fig. 11 is a partial section similar to Fig. 5 showing the modification of Fig. 10, and Fig. 12 is a partial top view of Fig. 11 partly in section.

Referring to the drawings a tunneling machine with the invention is represented in a tunnel 20, and consists essentially of a power truck 21, a hammer truck 135 and appurtenances connecting the same. Means are shown for heating and cooling the rock or other material to be disintegrated with the blows of the hammers of the hammer truck. Carbons for electric arcs are shown as heating means, but petroleum lamps, gas jets or other heating appurtenances may be used. Streams of water are described for cooling means, but refrigerated air, liquid air or other refrigerants may be employed.

The power truck 21 comprises the pairs of lower side sills 22 mounted with the truck wheels 23 that have the axles 24 and run on the tracks 30. Flooring 25 covers the sills 22 and vertical parts 26, 27 as also the inclined braces 28 extend up from said sills. The post and said braces support the pairs of upper side sills 29. To the posts 27 are journaled the upper guide rollers 35, 36 and the lower guide rollers 37, 38. The guide rollers 36 and 38 have grooves 39 in their cylindrical surfaces. In the posts 26 are journaled the upper guide rollers 40, upper feeding pinions 41, the lower guide rollers 42 and lower feeding pinions 43. Between the upper guide rollers 35, 36 the upper guide rollers 40 and upper feeding pinions 41 are supported the hollow feed arms 34, 44, and feed arms 45, 46 are supported between the lower guide rollers 37, 38, lower guide rollers 42 and the lower feeding pinons 43. A pair of conductors 53 extend from main feed wires 54 for conducting an electric current to the motor 47. The motor 47 is supported on the platform 25, its armature shaft supporting a pulley 48, which by means of the belt 49 is connected to the pulley 50, fastened on the shaft 51, which latter is journaled in journal brackets 52 secured to the inner upper sills 29. On the shaft 51 is fastened the pinion 55 the teeth of which mesh with the teeth of the spur gear 56 fastened to the shaft 57 journaled in journal brackets 58 that are supported on the inner upper sills 29. On the shaft 57 are journaled the vertical bevel gears 59, 60 that each mesh with the horizontal bevel gear 61 fastened to the worm shaft 62. A clutch 63 engages a spline on the shaft 57 and is connected to a lever 64 that is fulcrumed on a pin 65 extending from a bracket 66 fastened to one of the sills 29. The worm shaft 62 carries the upper worm 67 and lower worm 68, which respectively mesh with the upper worm wheel 69 fastened to the shaft 70 and the lower worm wheel 71 fastened to the shaft 72. On the shaft 57 are fastened the bevel gears 75 each of which gears with a bevel gear 76, fastened to the horizontal shafts 77, journaled in the journal brackets 78, 79 carried by the upper sills 29. The horizontal shafts 77 are provided with the splines 80 that engage the bevel gears 81, the teeth of which mesh with the teeth of the bevel gears 82. One of the bevel gears 82 is secured to the short vertical shaft 84, and the other is fastened to long vertical shaft 85. To the shafts 84, 85 are respectively fastened

the horizontal bevel gears 86, 87. In the feed arms 34, 44 are journaled the shafts 90, 91 and the feed arms 34, 44, 45, 46 have racks 88 formed with their outer surfaces which mesh with the teeth of feeding pinions 41, 43.

The shaft 90 carries the bevel gear 92 that gears with the bevel gear 86, and the shaft 91 carries the bevel gear 93 that gears with the bevel gear 87. Journal brackets 95, 96 are carried respectively on the feed arms 34 and 44. The bracket 95 supports one of the gears 81, the shafts 84 and 90, and the bracket 96 supports the other bevel gear 81, the vertical shaft 85 and the horizontal shaft 91. At the lower end of the vertical shaft 85 is fastened the spur gear 100, which gears with the spur gear 101 journaled on a shaft 102, supported in the bracket 103 fastened to the end of the feed arms 46 The bracket 103 also supports the lower end of the vertical shaft 85, and one end of a supporting bar 105 in which latter are journaled spindles 106 that carry the overlapping circular conveyer disks 107 The spindles 106 carry sprocket chain wheels 108 that are engaged by the sprocket chain 109. The latter is driven by a sprocket chain wheel 110 fastened to the shaft 102. The other end of the supporting bar 105 is fastened to lugs 136 of a cross brace 140 to be explained. Scrapers 126 fastened to the bar 105 are located over the disks 107 and disks 173 to be described.

On the shaft 51 is fastened a pulley 115, which by means of the belt 116 is connected to the pulley 117 fastened to the upper elevator shaft 118. The elevator shaft 118 is journaled in the journal brackets 119 supported on the inner upper sills 29. To the inner lower sills 22 are fastened brackets 120 in which is journaled the lower elevator shaft 121. The shafts 118 and 121, carry the elevator wheels 122 for the elevator with the buckets 123. A hopper 125 is fastened to one of the braces 28 and is located to receive the discharge from the said elevator. On each pair of upper sills 29 are located cross-sills 130 that support screw jacks 131, which bear up against the ceiling of the tunnel 20 and keep the driving truck in place when operating with the hammer truck.

The hammer truck 135 comprises the cross-brace 140 with split bearings having the jaws 141 and lugs 136. Axle pins 142 extend from the cross brace 140 for the truck wheels 143. Columns 144 are supported on the bearings of the cross brace 140, and are connected by the horizontal cross braces 145, 146, 147, 148, 149, 150 and 151, and have clamped thereto by means of the bolts 132 the brackets 133 that support the feed arms 34, 44, 45, 46. The cross bars 145 to 151 have each formed therewith journal bearings with the caps 152. The cross braces 145, 146 support in their bearings having the caps 152 the hollow bearings 153 of the hammer frame 160. A hammer frame 161 has the hollow bearings 162, 163 which latter are supported in the bearings having the caps 152 of the cross-braces 147, 148.

A hammer frame 164 has the hollow bearings 165, 166 which are supported in the bearings having the caps 152 of the cross-brace 149, 150. A hammer frame 167 has the hollow bearings 168, 169 which are respectively supported in the bearings having the caps 152 of the cross-braces 151 and 140. A vertical cam shaft 170 is supported in the hollow bearings of the said hammer frames and is held from vertical displacement by means of the collar 171. The shaft 170 carries the cams 172 and large conveyer disk 173. In the hammer frames 160, 161, 164, 167 are supported the hammer spindles 175 each of which have formed therewith a loop 176 to allow the cam shaft 170 to pass therethrough. Each hammer spindle 175 has fastened thereon a collar 177, and a spring 178 bears between said collar 177 and a boss 179 formed with each of said hammer frames. To the hammer spindles 175 are fastened the hammer supports 180 to which are fastened the hammers 181. The hammer frames are connected by the brackets 182.

Between the cross-braces 148, 149 there is located around the shaft 170 the hollow boss 185 with the jaws 186, that engage with the similar jaws formed with the hollow bearings 163 and 165 of the hammer frames 161, 164. With the hollow boss 185 is formed the worm-wheel sector 187 having the stops 188, 189 extending from its upper face.

On the shaft 91 is fastened the sprocket chain wheel 190 that carries the sprocket chain 191, and the latter engages a sprocket chain wheel 192 carried on a spindle 193 journaled in a journal bracket 194 extending up from the cross-brace 149. Journal brackets 200, 201, 202 are formed with the cross-brace 149 and support the horizontal worm shaft 203. On the latter shaft are journaled the bevel gears 204, 205 which gear with the bevel gear 206 fastened to the spindle 193. A worm 207 is formed on the worm shaft 203 and meshes with the worm wheel sector 187. Secondary brackets 208, 209 extend respectively from the cross-brace 149 and the bracket 201. A shifter rod 210 is supported in the said secondary brackets, and has the ends 211, 212 at right angles to the body thereof. The end 211 is in the path of the stops 188, 189, and to the end 212 is secured a jaw clutch 214 that can move on a spline connected to the worm shaft 203.

On the shaft 90 is fastened a sprocket chain wheel 220 which is connected to a second sprocket chain wheel 221 by means of the sprocket chain 222. The cross-brace 147 has formed therewith a journal bracket

223 in which is journaled the spindle 224, that carries the sprocket chain wheel 221, and also the bevel gear 225. The gear 225 gears with a bevel gear 226 fastened to the shaft 170. A spur gear 227 fastened to the shaft 170 gears with the spur gear 228, journaled on a pin 229 extending from a boss 230 formed with the hammer frame 161. From the boss 230 extend the journal brackets 231, 232 which carry the spindle 233. A bevel gear 238 on the spindle 233 meshes with the bevel gear 239 that is fastened to the spur gear 228. On the spindle 233 are fastened the disks 240, 241, from which latter extend pins 242, 243 that carry the links 244, 245. The lower ends of said links are pinned to the arms 246, 247 which are fulcrumed on pins 248 extending from the hammer frame 161. The outer ends of the arms 246, 247 are pinned to the links 250, 251 which in turn are pinned to the cross-heads 252, and to the latter are fastened the receptacles 254 for holding the heaters with carbons 255. Conductors 520 conduct electric current from the main conductors 53 to the carbons 255. The cross-heads 252 move on the vertical guide rods 256 that are fastened to the brackets 257 extending from the hammer frames. The cross heads 252 are connected by links 258. To the hammer frame 160 is secured the bracket 260 which supports the nozzle end 261 of a hose 262 and which is adjacent to upper most hammer.

To operate the invention and referring first to Fig. 1 the apparatus is shown in position after the hammer truck 135 has moved to the end of its forward stroke. Next the screw jacks 131 are lowered and the driving truck 21 is moved forward or to the right on the tracks 30, after which the said screw jacks are again placed in position to securely hold the driving truck 21 in place. The motor 47 is then started and rotates the pulley 48 which communicates its rotation to the pulley 50 on the shaft 51. The pinion 55 rotates with the shaft 51 and its teeth meshing with the teeth of the gear 56 rotates the shaft 57, which loosely supporting the bevel gears 59, 60 communicates rotation to either one, depending upon the location of the clutch 63, the latter being moved to engage either one of said bevel gears 59 and 60 by means of the handle 64. Either of the bevel gears 59 and 60 can communicate its rotations to the horizontal bevel gear 61 which is fastened to the worm shaft 62, so as to rotate the latter.

When the driving truck 21 and hammer truck 135 are adjacent to each other, the worm shaft 62 is rotated to push forward the said hammer truck, which is accomplished by the worms 67, 68 rotating the worm wheels 69 and 71. When the latter wheels rotate the feeding pinions 41 and 43 meshing with the racks 88 on the feed arms 34 to 46 push forward the hammer truck with its appurtenances. The rotations of the shaft 57 by means of the bevel gears 75, 76 are communicated to the shafts 77, which latter rotate the bevel gears 81 and therewith the vertical shafts 84, 85. The shaft 84 through the bevel gears 86 and 92 rotates the horizontal shaft 90. The shaft 85 through the bevel gears 87 and 93 rotates the horizontal shaft 91. The vertical shaft 85 through the spur gears 100, 101 rotates the vertical shaft 102 having the sprocket chain wheel 110, and the latter by means of the sprocket chain 109 rotates the sprocket wheels 108 on the spindles 106 of the conveyer disks 107. The shaft 51 by means of the pulley 115 and belt 116 rotates the upper elevator shaft 118, and thereby the upper elevator wheel 122 and consequently the elevator with the buckets 123. The horizontal shaft 90 by means of the sprocket wheel 220, sprocket chain 222 and sprocket chain wheel 221 rotates the spindle 224. The latter carries the bevel gear 225 that rotates the horizontal bevel gear 226 with the vertical shaft 170. Cams 172 on the shaft 170 bear against the collars 177 during a portion of each rotation of the vertical shaft 170, and thereby compress the springs 178. During the intervals that the cams 172 are free from the collars 177 the springs 178 again assume their normal lengths. The compression of the springs axially moves the hammer spindles 175 in one direction, and when they are again extended move the said spindles in an opposite direction, by virtue of which the hammers 181 are reciprocated. The hammers strike against the rock or other material operated upon. The shaft 170 also rotates the large conveyer disk 173.

The horizontal shaft 91 with the sprocket chain wheel 190, sprocket chain 191 and sprocket chain wheel 192 rotates the spindle 193, which latter through the bevel gear 206 communicates rotation to both the bevel gears 204 and 205. The jaw clutch 214 on the worm shaft 203 can be locked with either one of the latter bevel gears, rotating the worm shaft in opposite directions. The worm shaft 203 oscillates the worm sector 187 in one direction until the end 211 engages with one of the stops 188 or 189. In Fig. 9 the stop 188 will first come in contact with the end 211 and throw the clutch 214 into engagement with the clutch on the bevel gear 205, which will reverse the rotation of the worm shaft 203 until the stop 189 comes into contact with the said end 211. The reversals of the worm sector 187 are transmitted to the hollow bearings 163, 165 of the hammer frames 161 and 164, and the latter being in connection with all the other hammer frames, are consequently swung and reversed against the rock while they are striking blows.

The shaft 170 by means of the spur gear 227 gearing with the spur gear 228 rotates the bevel gear 239 and consequently the bevel gear 238 with the spindle 233 and the latter rotates the disks 240, 241. The rotations of the disk 241 move the link 245 which oscillates the arm 247, which latter by means of the link 251 reciprocates the link 258 that is connected with one line of cross-head 252. The disk 240 moves the link 244 which oscillates the arm 246 which with the link 250 reciprocates the other link 258 and consequently the other line of cross-heads 252. The cross-heads 252 being in connection with the receptacles 254 holding the heating appurtenances, in this case carbons, are vertically reciprocated against the rock while the hammers are in operation.

The alternate heating and cooling of the rock makes it brittle, and the blows of the hammers disintegrate the brittle portions of said rock which fall on the large conveyer disk 173 of the hammer truck from which they are taken by the conveyer disks 107, and from the latter are elevated by the elevator and discharged into the hopper 125, and from which latter they are loaded in any form of receptacle to be taken away.

In Figs. 10 to 12 which represent a modification of the upper portion of the hammer truck there is shown a cross-brace 300, having the split sleeves 301 that are clamped to the columns 144 by means of bolts 302 pinching the lugs 303. With the cross-brace 300 are formed the journal brackets 304 having the bearings 305 for the spindles 306. In one of the brackets 304 is formed the bearing 307 for the spindle 308. The cross-brace 300 also carries the journal bearings 309 for the shaft 310. On one of the spindles 306 is journaled the spur gear 315 the teeth of which mesh with the teeth of the spur gear 316 supported on the spindle 308. The spur gear 316 gears with the spur gear 317 fastened to the shaft 310. A bevel gear 318 fastened to the shaft 310 gears with the bevel gear 319 that is journaled on the pin 320 secured in the bracket 321 fastened to the cross-brace 300. A sprocket chain wheel 322 is fastened to the bevel gear 319, and by means of the sprocket chain 323 is connected with a sprocket chain wheel 324 fastened to the horizontal shaft 91.

A hammer frame 330 has the connecting side cheeks 331, by means of which it is supported on the spindles 306. A bevel gear 332 is fastened to the spur gear 315, and the teeth thereof mesh with the teeth of the bevel gear 333 journaled on a pin 334 extending from the top member of the hammer frame 330. A spur gear 335 is fastened to the bevel gear 333 and gears with a spur gear 336 fastened to the cam spindle 337, journaled in the hammer frame 330. On the pin 334 is fulcrumed the bracket 340 to which is bolted the receptacle 341 that carries the heating means. In the bracket 340 is formed an elongated slot 342 which engages with a pin 343, extending from the top face of the spur gear 336. In the frame 330 is supported a hammer spindle 350 similar to the hammer spindle 175. On the cam spindle 337 there are fastened the cams 351 similar to 172, and on the end of the hammer spindle 350 is fastened a segmental hammer support 352 to which latter are fastened the segmental hammers 353.

To the feed arm 34 is clamped the bracket 133 which supports the bracket 458 that carries the pin 459 engaging with an elongated opening 460 in the lever 461. A link 470 connects the other end of the lever 461 with the hammer frame 330. On the said bracket is also bolted the journal bracket 462 for the spindle 463 carrying the sprocket chain wheel 464 with which is engaged the sprocket chain 465, and the latter engages with a sprocket chain-wheel 466 on the horizontal shaft 90. In the lever 461 is formed an elongated slot 467 which engages with a pin 468 extending from a disk 469 supported on the spindle 463.

The object of the described modification is to form an arched-roofed tunnel, and its mode of operation is as follows: To give motion to the hammers 353 and their appurtenances the sprocket chain 323 transmits rotation from the horizontal shaft 91 to the spindle 320, the rotation of which latter is communicated to the spindle 310. The spindle 310 through the train of gears 317, 316 and 315 rotates the bevel gear 332, the teeth of the latter meshing with the teeth of the bevel gear 333, rotates the spur gear 335, which latter by means of the spur gear 336 rotates the cam spindle 337, and there is thereby operated or reciprocated the hammer spindle 350 with the segmental hammers 353. While the hammers are reciprocating the receptacle 341, with the heating means is oscillated or swung by the action of the pin 343 with the bracket 340. The hammer frame 330 with the hammers and appurtenances is swung on the spindles 306, by virtue of the horizontal shaft 90 through the sprocket chain wheel 466, chain 465 and chain wheel 464 rotating the spindle 463. The latter spindle rotates the disk 469 the pin 468 of which engaging the elongated slot 467 oscillates the lever 461, and which through the link 470 swings or oscillates the hammer frame 330 in a vertical plane.

It is evident that with slight modifications tunnels can be dug with the hammers of the machine oscillating in either horizontal, vertical or inclined planes.

Having described my invention I claim:

1. In a machine the combination of means to heat a material, means to chill said material, the heating and chilling alternating

with each other and means to strike blows against said material to disintegrate the same.

2. In a machine the combination of movable means to heat a material, means to chill the material, the heating and chilling alternating with each other, and movable means to strike blows against said material to disintegrate the same.

3. In a machine the combination of means to heat a material, means to chill the material, the heating and chilling alternating with each other, a hammer truck in the machine, a hammer on said truck, means to move said hammer over the surface of said material, means to reciprocate the hammer to strike blows against said material to disintegrate the same.

4. In a machine the combination of movable means to heat a material, means to chill the material, the heating and chilling alternating with each other, a hammer truck in the machine, a hammer on said truck, means to move said hammer over the surface of the said material, and means to reciprocate the hammer to strike blows against said material to disintegrate the same.

5. In a machine the combination of means to heat a material, means to chill the material, the heating and chilling alternating with each other, a hammer truck in the machine, a hammer frame on the truck, means to swing said frame, a hammer supported by means of said frame, and means to reciprocate the hammer to strike blows against the material to disintegrate the same.

6. In a machine the combination of reciprocating means to heat a material, means to chill the material, the heating and chilling alternating with each other, a hammer truck in the machine, hammer frames on the truck, means to swing said frames, a hammer supported by each frame, and means to reciprocate each hammer to strike blows against said material to disintegrate the same.

7. In a tunneling machine the combination of reciprocating means to heat a material, means to chill the material, the heating and chilling alternating with each other, a hammer truck in the machine, hammer frames on the truck, connections between the frames, means to swing said frames, a hammer spindle supported on each hammer frame, a hammer connected with each spindle, and means to reciprocate each hammer spindle and thereby strike blows against the material with the hammers to disintegrate the material.

8. In a tunneling machine the combination of a hammer truck, reciprocating means on the truck to heat the surface of rock operated upon, means to chill the rock, the heating and chilling alternating with each other, means to move the truck, a plurality of hammer frames supported on said truck, connections between said frames, a hammer spindle supported on each hammer frame, a hammer connected with each spindle, means to swing the hammer frames with their appurtenances, and other means to reciprocate the hammer spindles with their hammers to strike blows against the rock to disintegrate the same.

9. In a tunneling machine the combination of means to heat the material operated upon, means to chill said material, the heating and chilling alternating with each other, a hammer truck in the machine, hammer frames on the truck, means to swing said frames, reciprocating hammer spindles carried on the frames, hammers on said spindles to strike blows against the said material to disintegrate the same, and means to take away the material after having been disintegrated.

10. The combination in a tunneling machine of means to heat the material operated upon, means to chill said material, the heating and chilling alternating with each other, a hammer truck in the machine, hammer frames on the truck, means to swing said frames, reciprocating hammer spindles carried by the frames, hammers on said spindles to strike blows against the material to disintegrate the same, a rotary shaft supported in the truck and a conveyer connected with said shaft.

11. In a tunneling machine the combination of a power truck and a hammer truck, feed arms connecting the power truck and hammer truck, racks extending from some of the feed arms, and feeding pinions journaled on the power truck gearing with said racks, reciprocating hammers on the hammer truck, reciprocating heating means adjacent to the hammers, cooling means on the hammer truck, rotary shafts connecting the power truck and hammer truck, connections between said rotary shafts and said hammers and heating means.

12. In a tunneling machine the combination of a power truck and a hammer truck, feed arms extending from the hammer truck to the power truck, racks extending from the feed arms, feeding pinions on the power truck meshing with said racks, a plurality of hammer frames fulcrumed in the hammer truck, connections between the frames, a rotary shaft extending from the power truck to the hammer truck, a worm shaft on the latter truck, connections between the rotary shaft and the worm shaft, means to reverse the direction of rotation of the worm shaft, a worm wheel sector fulcrumed in the hammer truck meshing with the worm shaft, a reciprocating hammer supported on each hammer frame, and movable heating means adjacent to each hammer frame.

13. In a tunneling machine the combination of a power truck and a hammer truck,

feed arms extending from the hammer truck to the power truck to move the hammer truck, a rotary shaft extending from the power truck to the hammer truck, swinging hammer frames on the hammer truck, a reciprocating hammer on each hammer frame, guide rods connected with the hammer frames, cross-heads on the guide rods, heating means connected with the cross-heads, a spindle journaled on one of the hammer frames, connections between said spindle and said rotary shaft, a disk on said spindle and linked connections between said disk and one of said cross-heads to reciprocate the latter.

14. In a tunneling machine the combination of a power truck and a hammer truck, reciprocating swinging hammers and reciprocating swinging heating means on the hammer truck, chilling means connected with the hammer truck, a conveyer extending between the trucks and means to operate the conveyer.

15. In a tunneling machine the combination of a power truck and a hammer truck, feed arms fastened to the hammer truck and guided on the power truck, a source of power carried by the power truck, means between said source of power and the feed arms to move the same relatively to the power truck, a pair of rotary slidably supported shafts on the power truck, swinging reciprocating hammers on the hammer truck actuated by one of said rotary shafts, swinging reciprocating heating means on the hammer truck actuated by the other of said rotary shafts, and connections between said rotary shafts and said source of power.

16. In a tunneling machine the combination of a power truck and a hammer truck, a pair of hollow feed arms fastened to the hammer truck and guided in the power truck, a rotary shaft supported in each feed arm, a motor on the power truck, connections between said motor and each feed arm to move the hammer truck, connections between said motor and each of said rotary shafts, swinging reciprocating hammers on the hammer truck, connections between the hammers and one of the said rotary shafts, swinging reciprocating heating means on the hammer truck, and connections between said means and the other rotary shaft.

17. In a tunneling machine the combination of a power truck and a hammer truck, a motor on the power truck, feed arms fastened to the hammer truck and guided on the power truck, connections between the feed arms and said motor to move the hammer truck relatively to the power truck, means to hold the power truck in place, horizontally swinging hammer frames on the hammer truck, horizontally reciprocating hammers in the hammer frames, connections between the hammer frames and the reciprocating hammers with the said motor, vertically reciprocating heating means on the hammer truck, and connections between the latter means and the said motor.

18. In a tunneling machine the combination of a hammer truck, a hammer frame fulcrumed on said truck, means to oscillate the hammer frame about a vertical axis, a reciprocating hammer on the said hammer frame, heating means on the hammer frame and means to oscillate said heating means relatively to said hammer frame.

19. In a tunneling machine the combination of a power truck and a hammer truck, feed arms fastened to the hammer truck and guided on the power truck, a source of power on the power truck, connections between the source of power and the feed arms to move the hammer truck relatively to the power truck, rotating conveyer disks and scrapers extending from the hammer truck to the power truck, and connections between the source of power and said disks.

20. In a tunneling machine the combination of a power truck and a hammer truck, means to move the hammer truck relatively to the power truck, a rotary vertical shaft journaled on the hammer truck, a large conveyer disk secured to the vertical shaft below the hammer truck, a scraper above said large conveyer disk, a plurality of overlapping conveyer disks below and extending between the said trucks, scrapers over the said overlapping disks and one of the latter under the large conveyer disk, reciprocating hammers carried on the hammer truck, and heating means carried on the hammer truck.

Signed at the borough of Manhattan, in the county of New York and State of New York this 8th day of January, A. D. 1908.

CHARLES A. CASE.

Witnesses:

ARTHUR MARION,

M. H. COOK.