No. 608,517. Patented Aug. 2, 1898.

# S. B. GRAY.

## TRACTION ENGINE.

(Application filed Feb. 8, 1897.)

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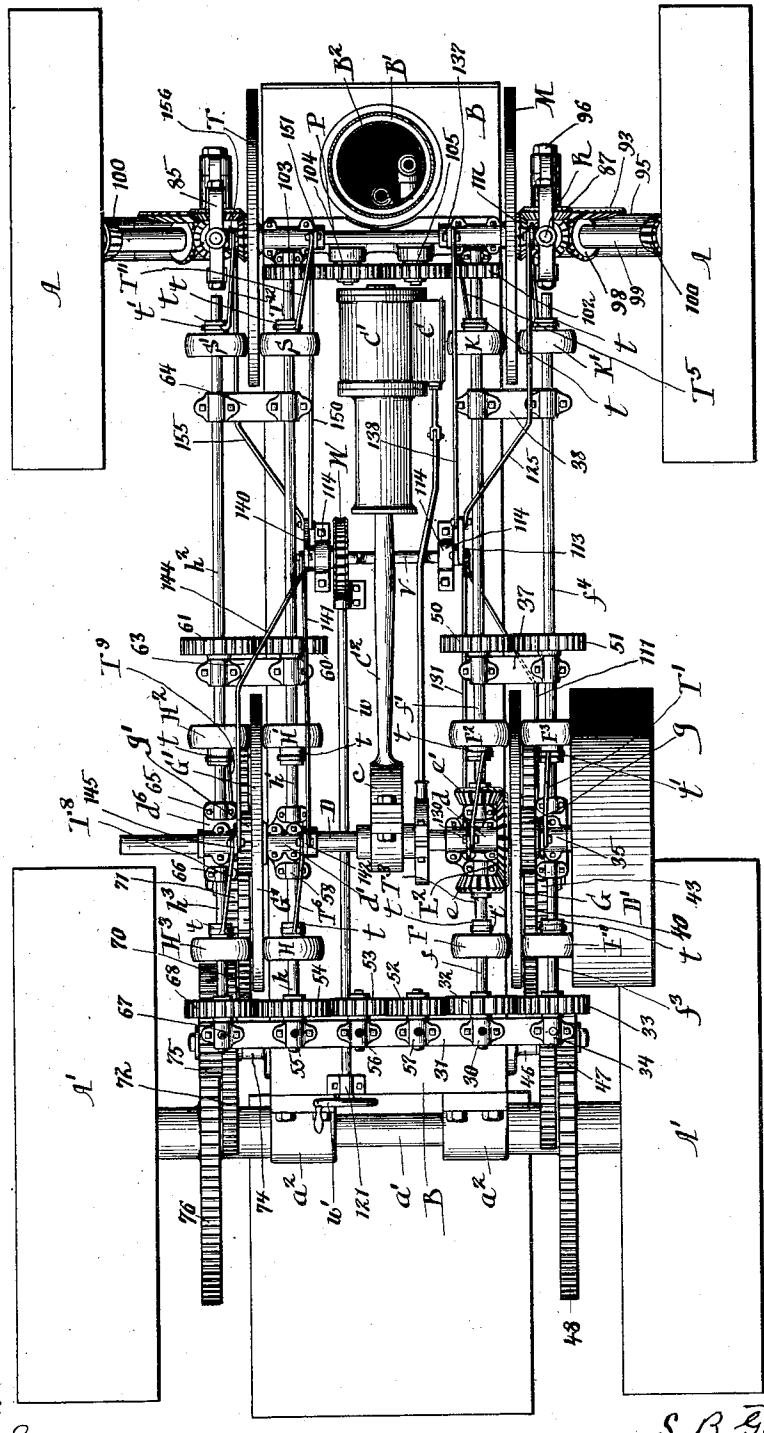


Fig. 1.

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Alberta Adamick.

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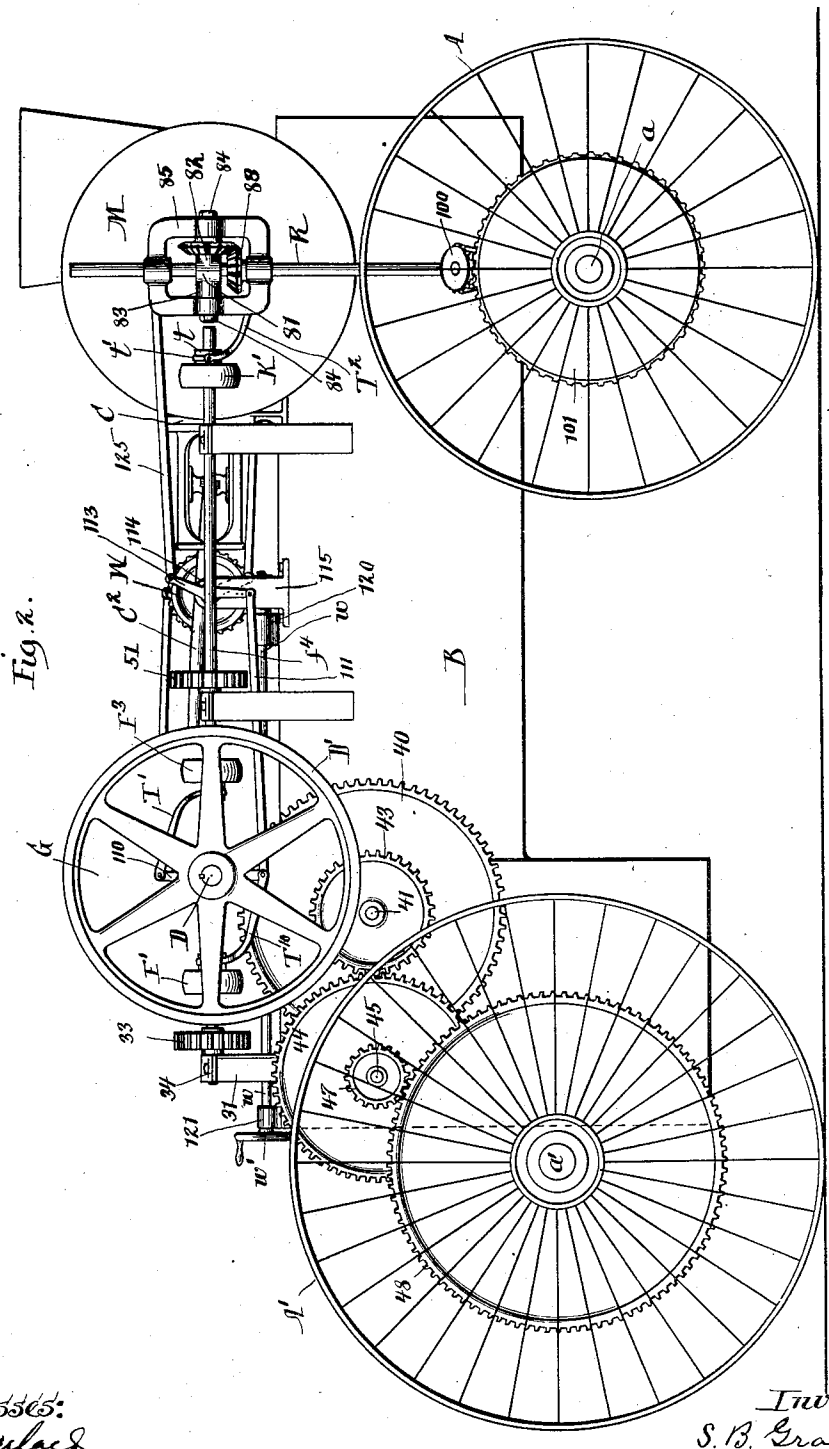
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(Application filed Feb. 8, 1897.)

(No Model.) 8 Sheets—Sheet 2.

Fig. 2.




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## TRACTION ENGINE.

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Fig. 4.

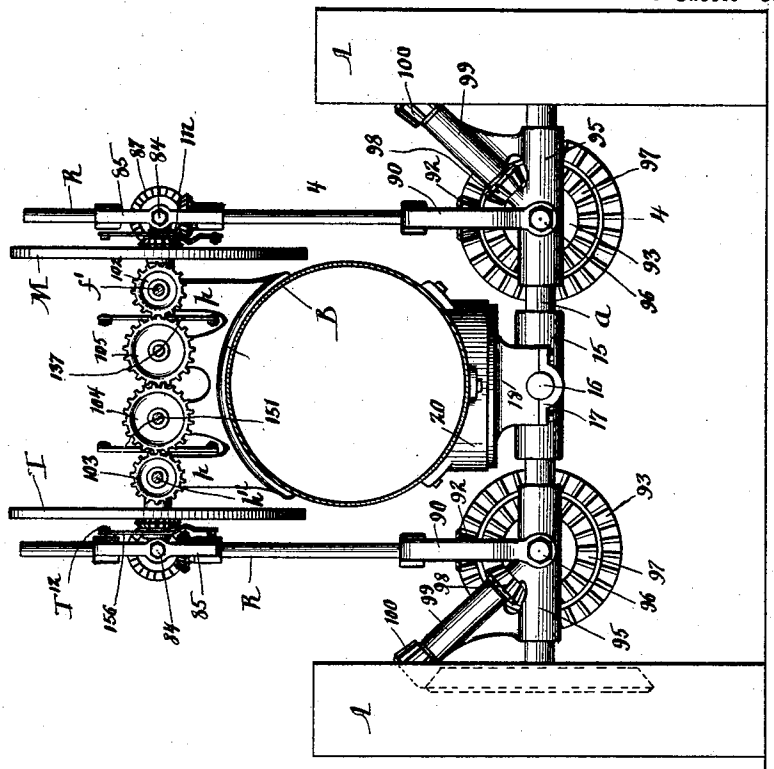
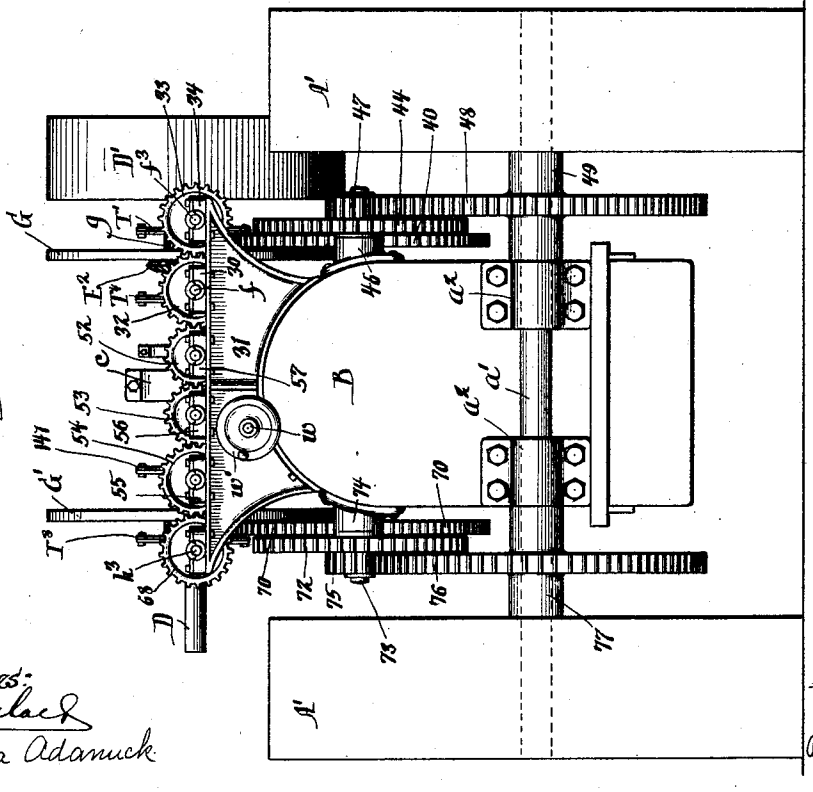


Fig. 3.



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Fig. 5.

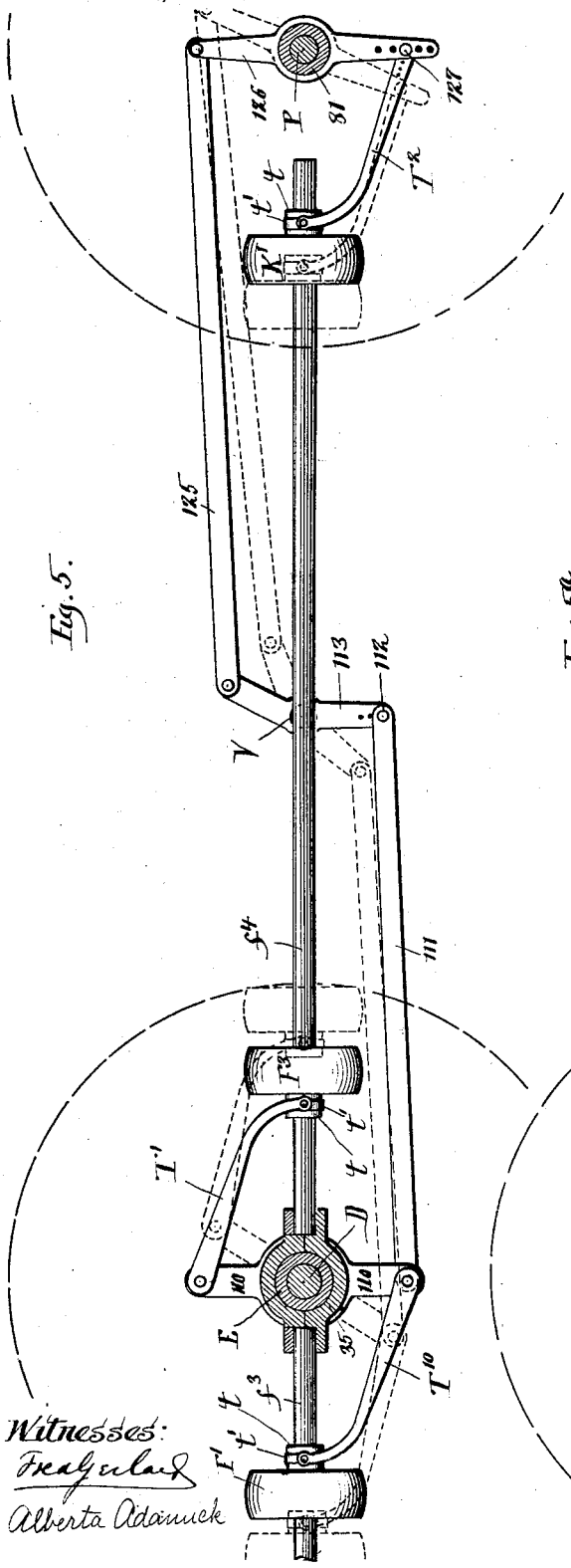
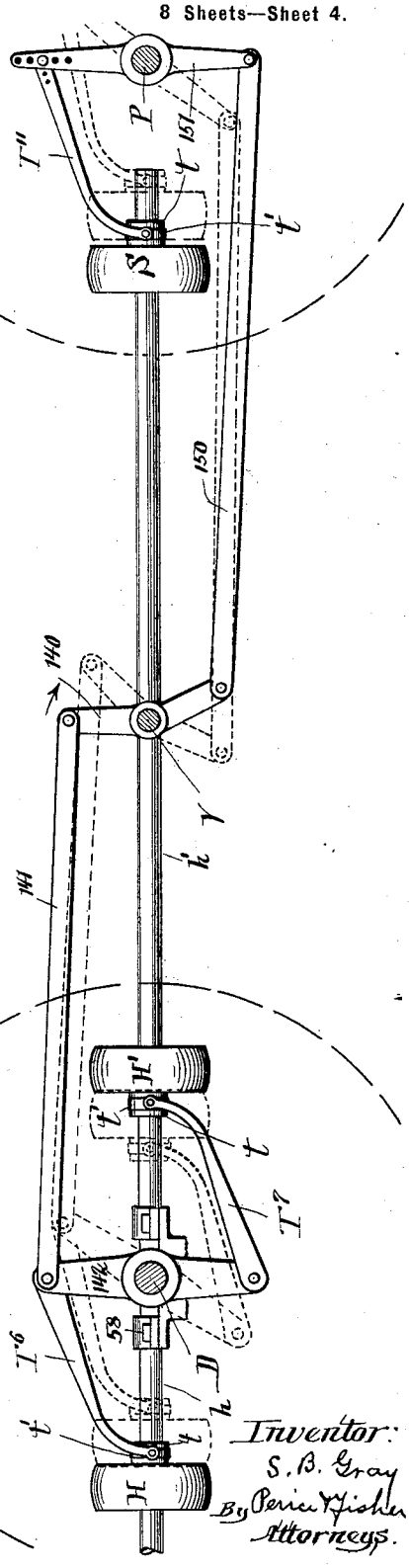



Fig. 5a.




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TRACTION ENGINE.

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Fig. 6.

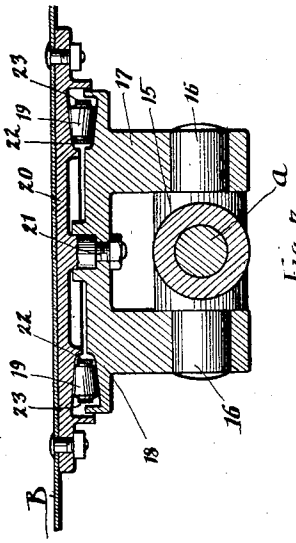



Fig. 7

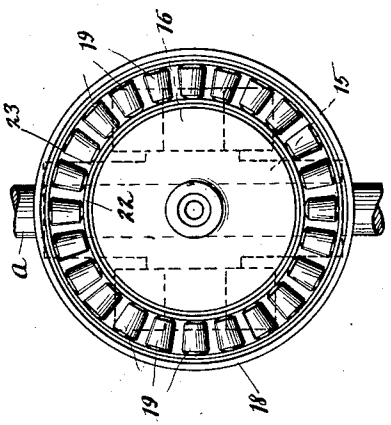
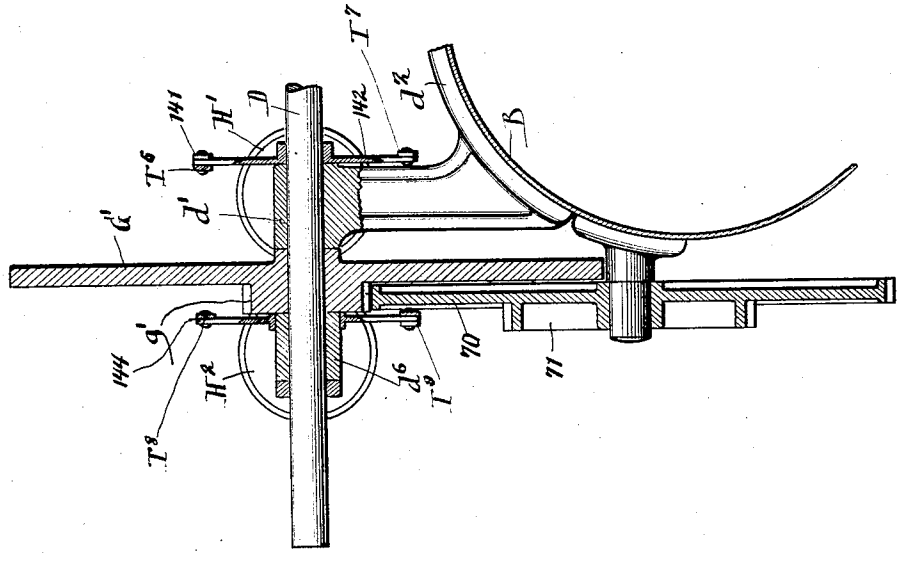



Fig. 8a.




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## TRACTION ENGINE.

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Fig. 11.

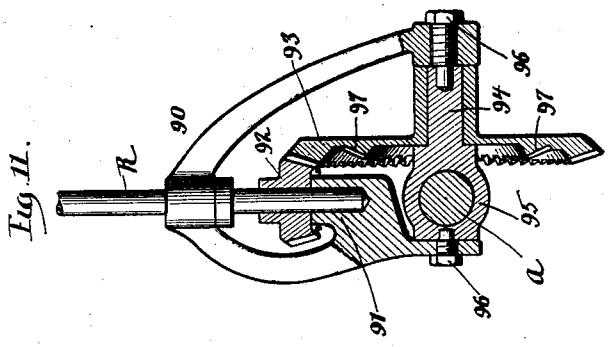



Fig. 9.

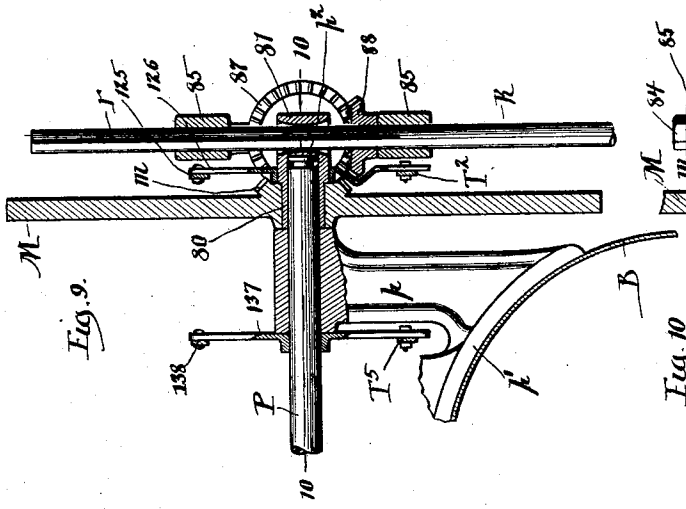



Fig. 10.

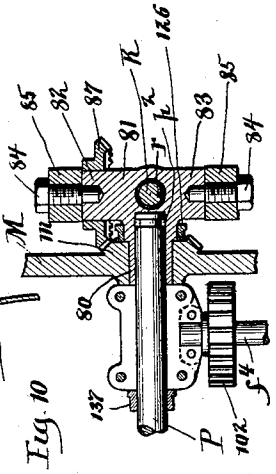
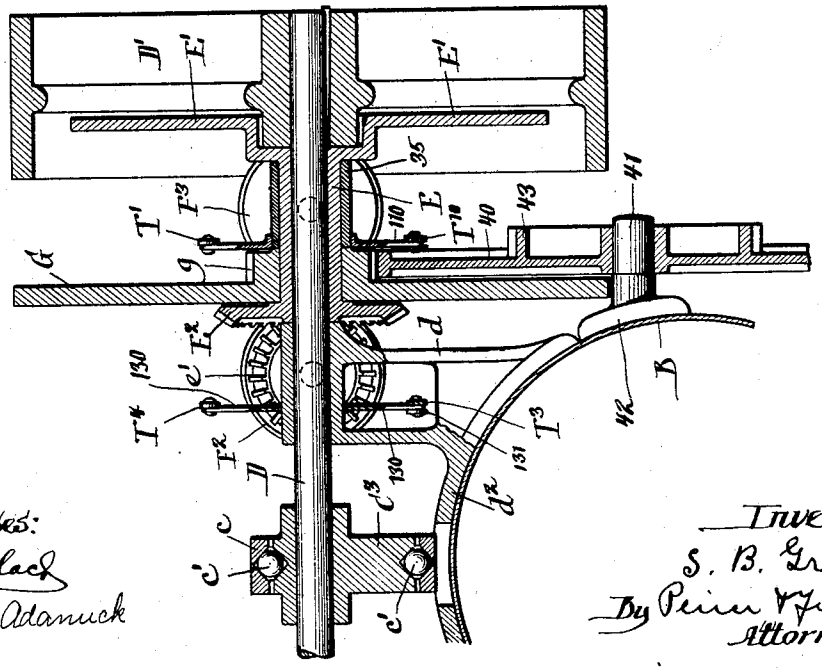



Fig. 8.




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TRACTION ENGINE.

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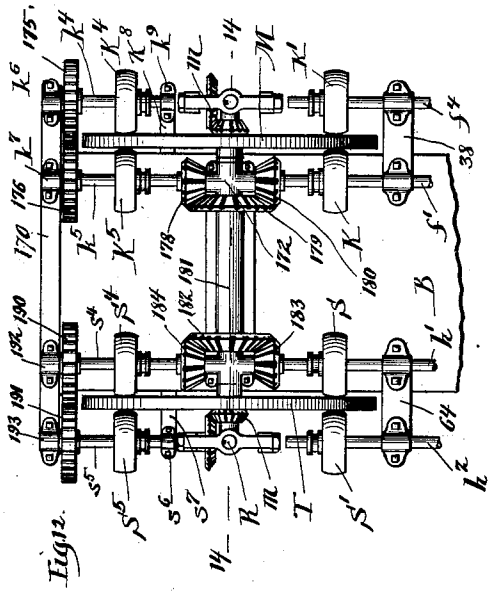


Fig. 12.

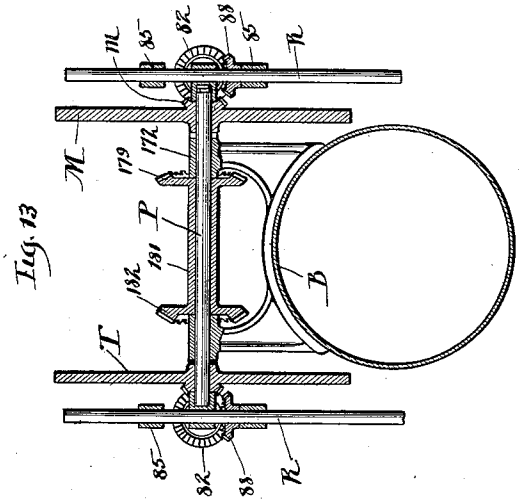


Fig. 13

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TRACTION ENGINE.

(Application filed Feb. 8, 1897.)

(No Model.) 8 Sheets—Sheet 8.

Fig. 14.

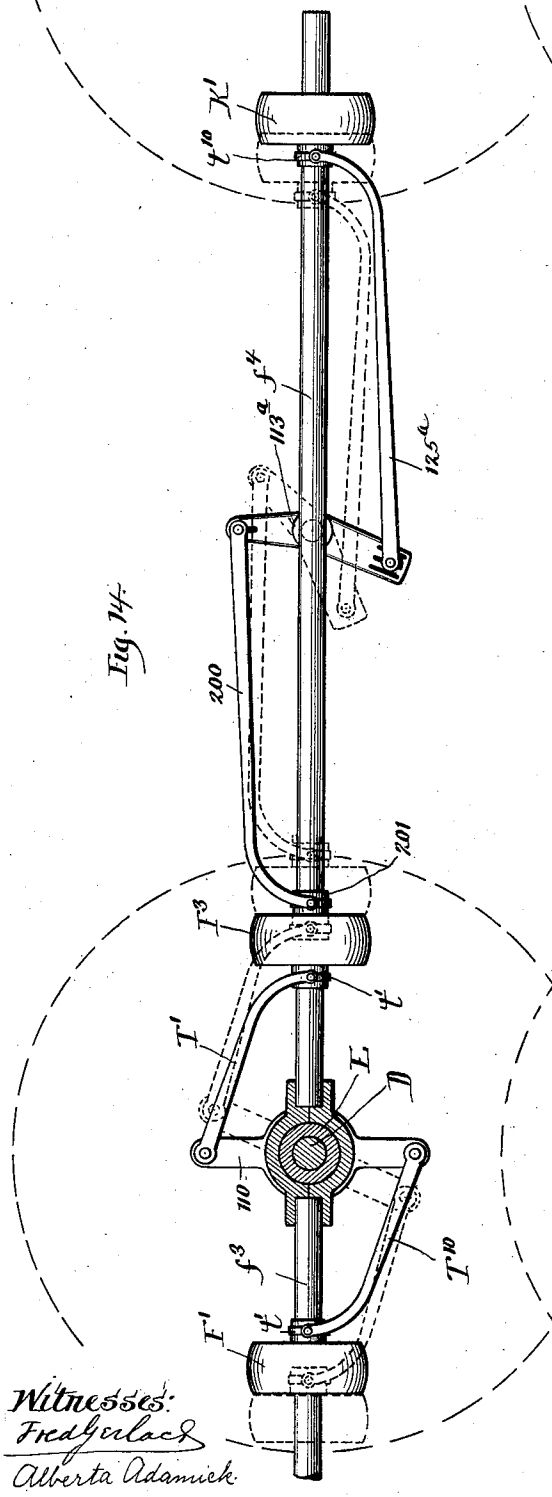
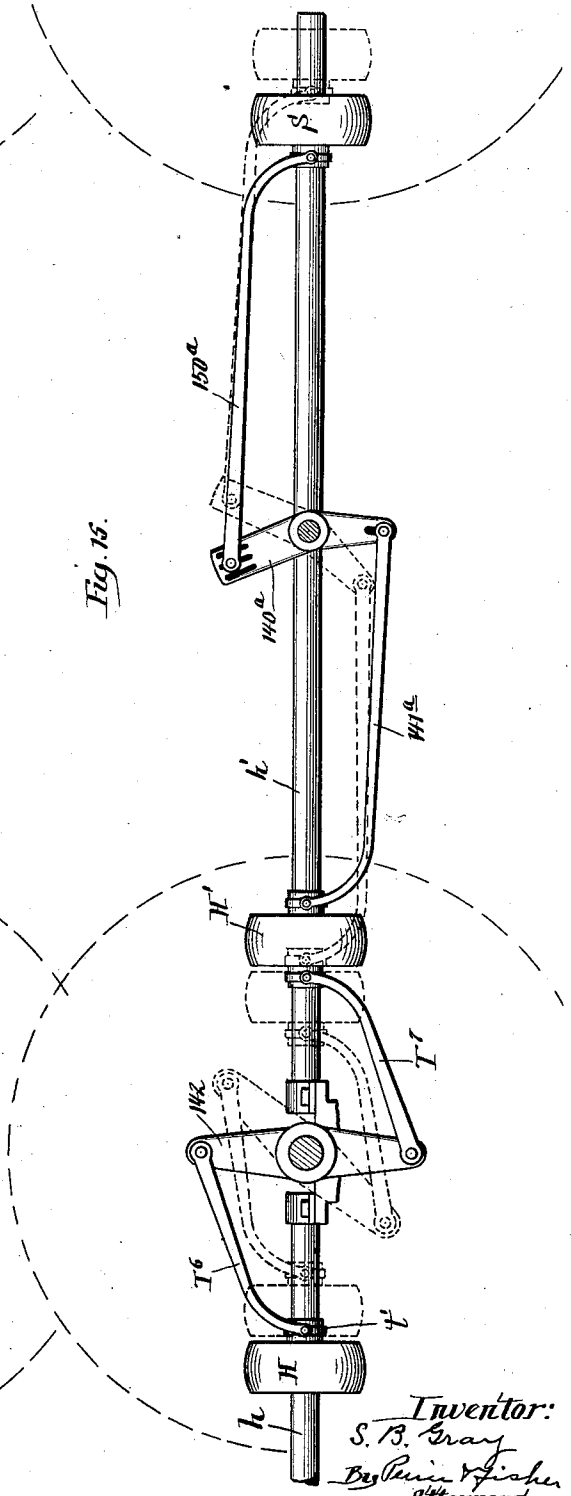



Fig. 15.




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# UNITED STATES PATENT OFFICE.

STEPHEN B. GRAY, OF JACKSONVILLE, ILLINOIS.

## TRACTION-ENGINE.

SPECIFICATION forming part of Letters Patent No. 608,517, dated August 2, 1898.

Application filed February 8, 1897. Serial No. 622,523. (No model.)

*To all whom it may concern:*

Be it known that I, STEPHEN B. GRAY, a citizen of the United States, and a resident of the city of Jacksonville, in the county of Morgan, State of Illinois, have invented certain new and useful Improvements in Traction-Engines, of which I do declare the following to be a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

The present invention relates to traction-engines, an example of such type of engine being illustrated in Letters Patent No. 556,346, granted to me March 17, 1896.

The present invention has for its object, primarily, to provide improved mechanism whereby the traction-wheels of the engine may be driven, one main feature of the invention being to provide driving mechanism of such character that both the front and rear wheels of the engine may be driven in unison not only when the engine is traveling in straight line, but as well also when the engine is traversing curves.

The invention consists also in various other features of invention that will be hereinafter described, illustrated in the accompanying drawings, and particularly pointed out in the various claims at the end of this specification.

Figure 1 is a plan view of a traction-engine embodying my invention. Fig. 2 is a view in side elevation. Fig. 3 is a rear end view. Fig. 4 is a view in vertical cross-section through the boiler at the point in the rear of the front axle and looking toward the front of the machine, the stack of the boiler being omitted and the friction-disks being shown in elevation. Fig. 5 is a detail view, upon an enlarged scale, of the differential mechanism for shifting the drive-rolls at the right-hand side of the engine, this view being partly in section and partly in elevation. Fig. $5^a$ is a detail view, upon an enlarged scale, of the differential mechanism for shifting the friction drive-rolls, this view being partly in section and partly in elevation and showing the mechanism at the left-hand side of the engine. Fig. 6 is a detail view, in vertical longitudinal section, through that part of the boiler immediately above the front axle and through the intermediate turn-table whereon the boiler rests; Fig. 7, a detail plan view of turn-table, shown in section, Fig. 6; Fig. 8, a detail view, in vertical cross-section, (along the main drive-shaft,) from center of shaft to and through the belt-pulley; Fig. $8^a$, a similar view showing the opposite end of the shaft. Fig. 9 is a detail view, in vertical section, through one of the front friction-disks and adjacent parts, parts also being shown in elevation; Fig. 10, a view in horizontal section on line 10 10 of Fig. 9. Fig. 11 is a detail view, in vertical cross-section, through the front axle on line 11 of Fig. 4. Fig. 12 is a plan view showing a modified construction of drive mechanism; Fig. 13, a view in vertical cross-section on line 14 14 of Fig. 12; Figs. 14 and 15, views similar to Figs. 5 and $5^a$, but showing modified construction of shifting mechanism for the drive-rolls.

A designates the front wheels, and A′ the rear wheels, whereby the engine is sustained and carried, the front wheels A being connected by an axle $a$, while the rear wheels are connected by an axle $a'$.

The boiler B is shown as united to the rear axle $a'$ (see Fig. 3) by suitable straps or yokes $a^2$, although any appropriate means may be employed for properly connecting the rear of the boiler with the rear axle of the machine. The front axle $a$ carries at its center (see Figs. 4 and 6) a sleeve 15, from which project the trunnions 16, that are held within bearings 17, that depend from the under side of a pedestal 18, this pedestal having its upper face formed with a circular inclined track to receive the conical rolls 19, that rest upon this track and sustain a superposed turn-table 20, that is bolted to the under side of the boiler and furnished with an inclined circular track corresponding to the track of the pedestal 18. The turn-table 20 is provided at its center with a stud 21, having a threaded portion passing centrally through the pedestal 18 and held in place with respect thereto by a nut. The conical friction-rolls 19 are united together by inner and outer rings 22 and 23, that serve to hold the rolls at proper distance apart, while permitting them to freely revolve. My purpose in thus sustaining the front end of the boiler is to allow not only for the inclination of the front axle in vertical

direction, but also to permit the axle to turn freely with respect to the boiler in horizontal plane.

In order to allow for more compact arrangement of the machinery above the boiler B, I prefer to form this boiler without the usual steam-dome, and inasmuch as this steam-dome is dispensed with I provide a jacket or steam-chamber B′ about the smoke-stack $B^2$ of the boiler, as indicated in Fig. 1. Inasmuch, however, as this forms no part of the present invention I do not deem it necessary to fully illustrate or describe the same.

The valve-chest C and cylinder C′ of the engine are preferably located immediately above the boiler, and the exhaust-steam from the valve-chest C will be delivered at the base of the smoke-stack $B^2$ by a suitable pipe.

To the main piston within the cylinder C′ is connected in usual manner a pitman $C^2$, the rear end of which is provided with a yoke *c*, (see Figs. 1 and 8,) that encircles an eccentric $C^3$, that is keyed to the main drive-shaft D of the engine, and between the yoke *c* and the eccentric $C^3$ are interposed the bearing-balls *c*′, that travel in grooves or ways formed, respectively, upon the inner face of the yoke *c* and the periphery of the eccentric $C^3$. These bearing-balls *c*′ serve not only to reduce to a minimum the friction between the yoke and the eccentric, but also serve to accurately retain these parts against lateral displacement. The main drive-shaft D is journaled in suitable bearings *d d*′ at the upper end of brackets rising from the top of the boiler B, (see Figs. 1 and 8,) and to one end of the drive-shaft D is keyed the drive-pulley D′. Between the pulley D′ and the adjacent bracket *d* and loosely mounted upon the drive-shaft D is a long sleeve E, (see Fig. 8,) the outer end of which is provided with radial arms E′, adapted to be connected by suitable or usual clutch mechanism with the drive-pulley D′. I have not deemed it necessary to illustrate the clutch mechanism, as any of the usual forms of clutch mechanism may be employed.

The inner end of the sleeve E is provided with a beveled gear-wheel $E^2$, that engages with oppositely-disposed beveled pinions *e* and *e*′, (see Fig. 1,) that are keyed, respectively, to the shafts *f* and *f*′, the inner ends of these shafts being journaled in suitable bearings formed at the top of the bracket *d*, (see Figs. 1 and 8,) that rise from the saddle-plate $d^2$, resting on top of the boiler B. The rear end of the shaft *f* is journaled in a bearing 30 on top of a saddle plate or bracket 31, that rests upon the top of the boiler B, as clearly shown in Fig. 3 of the drawings. Upon the shaft *f* is mounted a gear or friction drive-roll F, this friction drive-roll being connected to the shaft by a spline or like connection, whereby the roll F is caused to revolve with the shaft, but is permitted to be shifted lengthwise thereof. To the shaft *f* is also keyed a pinion 32, that engages with a pinion 33, keyed to the shaft $f^3$, this shaft $f^3$ having its rear end journaled in a suitable bearing 34 on top of the saddle-plate 31, while its front end is journaled in one side of the box 35, (see Figs. 1 and $8^a$,) the opposite side of which box forms a journal-bearing for the shaft $f^4$. The box 35 encircles the sleeve E (see Fig. 8) and is formed of upper and lower sections bolted together. The shaft $f^3$ carries a gear or friction drive-roll F′, that is keyed thereon in manner free to move lengthwise of the shaft. The shafts *f*′ and $f^4$ are provided, respectively, with the gear or friction drive-rolls $F^2$ and $F^3$, that are keyed to the shafts in manner permitting them to be shifted lengthwise thereof. The shafts *f*′ and $f^4$ rest in bearings formed at the top of brackets 37 and 38, (see Figs. 1 and 2,) and the front end of the shaft *f*′ is also journaled in a bearing to be presently described.

The gears or friction drive-rolls F $F^2$ and F′ and $F^3$ are disposed upon opposite sides of a wheel or friction-disk G, (see Figs. 1, 3, and 8,) this disk G being revolubly mounted upon the sleeve E. The hub of the disk G is provided with a pinion *g*, that meshes with a gear-wheel 40, journaled upon an axle 41, (see Fig. 8,) projecting from bracket 42, attached to the boiler B, and the hub of the gear-wheel 40 is provided with a pinion 43, that meshes with a gear-wheel 44, that is journaled upon an axle 45, projecting from a bracket 46, attached to the boiler, (see Figs. 2 and 3,) and the hub of the gear-wheel 44 is provided with a pinion 47, that meshes with a gear-wheel 48, attached to the elongated hub 49 of one of the rear drive-wheels A′.

From the construction of parts as thus far defined it will be seen that when revolution is imparted to the main drive-shaft D corresponding revolution will be given to the drive-wheel D′, and if the clutch E′ be in engagement with said drive-wheel it will serve to impart revolution to the sleeve E (see Fig. 8) and to the gear-wheel $E^2$. From the gear-wheel $E^2$ motion will be transmitted by the bevel-pinions *e* and *e*′ to the shafts *f* and *f*′ and through the pinions 32 and 33, and through pinions 50 and 51, (see Fig. 1,) that are fixed, respectively, to the shafts *f*′ and $f^4$, revolution will be imparted to the shaft $f^4$. In this way the friction drive-rolls F, F′, $F^2$, and $F^3$ will be driven, and by means of these drive-rolls revolution will be imparted to the friction-disk G, and from this disk motion will be transmitted by the pinions *g*, the gear-wheel 40, the pinion 43, the gear-wheel 44, and the pinion 47 and gear-wheel 48 to the connected traction-wheel A′.

The pinion 32, that is fixed to the shaft *f*, (see Fig. 1,) is connected by a train of gears 52 and 53 with a pinion 54, that is keyed to a shaft *h*. The rear end of the shaft *h* and the stud-shafts that carry the pinions 52 and 53 are journaled in the boxes 55, 56, and 57 at the top of the bracket-frame 31, as clearly shown by Figs. 1 and 3 of the drawings. The

shaft $h$ carries a gear or friction drive-roll H, that is keyed thereto in manner permitting the roll H to be shifted lengthwise of the shaft $h$, and the front end of the shaft $h$ is journaled in one side of the bearing 58, that encircles the main drive-shaft D, (see Figs. 1 and 5[a],) the opposite side of this bearing 58 having journaled therein the rear end of the shaft $h'$. The shaft $h'$ carries the friction drive-roll H', that is connected therewith in manner permitting it to be shifted longitudinally of the shaft, and the shaft $h'$ has fixed thereto a pinion 60, that meshes with a pinion 61 upon the shaft $h^2$, and the shafts $h'$ and $h^2$ are mounted in suitable bearings upon the tops of the brackets 63 and 64, that rise from and are bolted to the sides of the boiler. The shaft $h^2$ carries the friction drive-roll $H^2$, that is mounted in manner free to slide lengthwise of the shaft, and the rear end of the shaft $h^2$ is journaled in a bearing 65 at the top of the bracket $d^6$, (see Figs. 1 and 8,) and within a bearing 66 at the top of the bracket $d^6$ is journaled the front end of the shaft $h^3$, that carries the friction drive-roll $H^3$, the rear end of the shaft $h^3$ being journaled in a bearing 67 on the top of the saddle plate or bracket 31. The friction drive-roll $H^3$ is connected with the shaft $h^3$ in manner free to slide thereon, and to the shaft $h^3$ is keyed a pinion 68, that meshes with a pinion 54. (See Figs. 1 and 3.) The gears or friction drive-rolls H, H', $H^2$, and $H^3$ engage opposite sides of the wheel or friction-disk G', that is mounted in manner free to revolve upon the main drive-shaft D, and this friction-disk G' is provided with a pinion $g'$, that meshes with a gear-wheel 70, that is journaled upon a stud projecting from a bracket bolted to the side of the boiler in manner similar to the bracket 42, that sustains the gear-wheel 40, as shown in Fig. 8. The hub of the gear-wheel 70 is provided with a pinion 71, that meshes with a gear-wheel 72, journaled upon a stud 73, projecting from a bracket 74, (see Fig. 3,) and the hub of the gear-wheel 72 is furnished with a pinion 75, that engages a gear-wheel 76, fixed to the sleeve 77 of the rear drive-wheel A'.

From the foregoing description it will be seen that when motion is imparted to the drive-shaft D in manner hereinbefore described and is transmitted from said drive-shaft to the shaft $f$ (see Fig. 1) and to the train of gear-pinions 50, 51, 52, 53, 54, and 68 revolution will be imparted to the shafts $h$ and $h^3$, thus causing the friction drive-rolls H and $H^3$ to impart revolution to the friction-disk G'. The disk G' being thus revolved will, through the pinion $g'$ and gear wheels and pinions connected therewith, impart revolution to the rear traction-wheel A' at the left-hand side of the machine. It will thus be seen that both of the rear drive-wheels A' A' will be driven in unison.

The shafts $f'$ and $f^4$ are provided at their front ends, respectively, with the gears or friction drive-rolls K and K', arranged upon opposite sides of a wheel or friction-disk M, and these friction drive-rolls K K' are mounted upon their respective shafts in such manner that they can be shifted longitudinally of the shafts while revolving therewith. The friction-disk M is shown as mounted in a manner free to revolve on the hollow arm 80 of the swivel-block 81, (see Figs. 2, 9, and 10,) this hollow arm 80 setting over the end of the front shaft P, that is mounted upon brackets $p$, that rise from a saddle-plate $p'$ on top of the boiler. (See Figs. 1, 4, and 9.) Preferably one end of the shaft P is provided with an annular groove $p^2$, that receives a pin, whereby the swivel-block 81 is connected with the shaft. (See Figs. 9 and 10.) The swivel-block 81 has projecting arms 82 and 83, that are formed with sockets to receive pivot-pins at the inner ends of screw-bolts 84, (see Fig. 10,) these screw-bolts passing through the front and rear side bars of a frame 85. (See Fig. 2.) The top and bottom bars of the frame 85 are furnished with bearings, through which passes the vertical shaft R, that passes also through a hole formed in the swivel-block 81, this hole being in line with the shaft-holes in the frame 85, as clearly seen in Fig. 9 of the drawings. Upon the arm 82 of the swivel-block 81 is revolubly mounted a beveled pinion 87, that meshes with a corresponding pinion $m$ on the hub of the friction-wheel M, and this pinion 87 also engages a pinion 88, that is mounted upon the shaft R. The shaft R is shown as formed with a groove $r$, that receives a key-pin projecting from the pinion 88, and the shaft R is free to move in vertical direction through its bearings in the frame 85 and through the swivel-block 81 and the pinion 88. The purpose in thus mounting the pinions 87 and 88 within the frame 85 and the purpose in employing the swivel-block 81, about which the frame 85 can turn upon the pivot-pins 84, and the purpose also in permitting the vertical movement of these parts with respect to the shaft R is to allow for the rocking of the engine in passing over inequalities in the roadway. The lower end of the shaft R passes through an opening formed in a yoke 90 and is stepped in a boss 91 of said yoke, and to the lower end of this shaft is keyed a pinion 92, that meshes with the outer row of teeth of a bevel gear-wheel 93. The bevel gear-wheel 93 is journaled upon an arm 94, projecting forwardly from the sleeve 95, that is mounted upon the front axle $a$ of the machine, (see Fig. 11,) and to the sleeve 95 and to both of the ends of the arm 94 the yoke 90 is connected by means of pins formed in the inner ends of the screw-bolts 96. By reference to Figs. 4 and 11 it will be seen that the screw-bolts 96 afford a pivotal connection between the yoke 90 and the sleeve 95, so that upon any lifting of one of the wheels A or a canting of the front axle $a$ by reason of inequalities of the roadway the yoke 90 will

turn more or less about the sleeve 95, and thus avoid strain upon the shaft R or the parts connected therewith. The bevel gear-wheel 93 is provided with a second set of teeth 97, with which engages the pinion 98, (see Fig. 4,) carried upon the lower end of a shaft that extends through a bracket-sleeve 99, that rises from the sleeve 95. The upper end of this shaft is provided with a pinion 100, that engages with a bevel gear-wheel 101, (shown by full lines in Fig. 2,) that is attached to the hub of the axle of the traction-wheel A.

The shafts $f'$ and $h'$ have their forward ends journaled in suitable bearings at the top of the brackets $p$, (see Fig. 1,) and the forward ends of these shafts are provided with pinions 102 and 103, respectively, that are connected by the pinions 104 and 105. Upon the shaft $h'$ is keyed in manner permitting it to be shifted longitudinally a gear or friction drive-roll S, that engages with a wheel or friction-disk T, and the opposite side of this disk is engaged by a gear or friction drive-roll S', that is mounted upon the shaft $h^2$ in such manner that it can be adjusted lengthwise thereof. The friction-disk T is mounted upon the shaft P in the same manner as the friction-disk M, hereinbefore described, and at the end of the shaft P, adjacent the friction-disk T, there is provided a swivel-block, a frame 85, and bevel gear wheels and pinions, by which motion is transmitted to the front left-hand traction-wheel A; but as the connections are the same as hereinbefore described for the opposite side of the machine they need not be more particularly set forth.

From the foregoing description it will be seen that when revolution is imparted to the main drive-shaft D in manner above described motion will be transmitted therefrom to the shafts $f\,f'$, and from the shaft $f$, through the gear-wheels connected therewith, motion will be transmitted to the shafts $h$ and $h^3$, that carry the gear or friction drive-rolls H and H$^3$. From the shaft $f'$ motion will be transmitted to the shaft $f^4$, that carries the drive-rolls F$^3$ and K', and from the front end of the shaft $f'$ motion will be transmitted by the gear mechanism shown to the front end of the shaft $h'$ and from this shaft $h'$ to the shaft $h^2$. It will thus be seen that the several shafts to which the gear or friction drive-rolls are connected will be driven in unison from the common source of power, and from these drive-rolls rotation will be imparted to the several friction-disks at the front and rear of the machine.

With a traction-engine the front and rear wheels of which are both positively driven it is of vital importance that these wheels should be driven in unison, since if the front wheels move faster than the rear wheels there will be a tendency of the latter to drag, while, on the other hand, if the rear wheels move faster than the front wheels there will be a tendency to crowd such front wheels, and a very unequal and objectionable working of the engine will ensue. When running in straight course, there is no difficulty in insuring the unison movement of the front and rear wheels; but when a traction-engine or other four-wheeled vehicle is turning a curve it is found that the arc described by the front wheels is somewhat larger than that described by the rear wheels, and consequently the front wheels must travel somewhat faster than the rear wheels during the traverse of such curve. One of the main objects of my present invention is to provide means whereby the front and rear wheels can be differentially driven in order to compensate for the difference in curvature as they turn a corner or like curve in the roadway.

I shall next proceed to describe the means whereby I effect the differential driving of the front and rear traction-wheels; but it will be understood that the means whereby this result is accomplished may be varied within wide limits without departing from the spirit of the invention.

Each of the friction drive-rolls F F', &c., H H', &c., S S', and K K' is provided with a hub $t$, having an annular groove to receive a band $t'$, that is connected with the shifting-arm, whereby the corresponding drive-roll is moved lengthwise upon its shaft and radially with respect to its corresponding friction-disk. In Fig. 5 of the drawings is illustrated the mechanism whereby the friction drive-rolls at the right-hand side of the machine will be shifted. The shifting-arm T$^{10}$, that is connected to the hub $t$ of the drive-roll F', has its opposite end pivotally connected to a rocking lever 110, that encircles one end of the box 35, (see Fig. 8,) wherein the inner ends of the shafts $f^3$ and $f^4$ are journaled, and the upper arm of this rocking lever 110 is pivotally connected to the rear end of a shifting-arm T', the forward end of which is connected to the ring or band $t'$, that encircles the hub $t$ of the friction drive-roll F$^3$. To the lower arm of the rocking lever 110 is pivotally united a connecting-rod 111, the front end of this rod being pivoted, as at 112, at either one of a series of perforations formed in the lower arm of a rocking lever 113, (see Fig. 5,) that is fixed upon one end of a rock-shaft V, (see Fig. 1,) that is journaled in suitable bearings 114 on the brackets 115, rising from the top of the boiler. (See Fig. 2.) The shaft V is shown as cranked in order to permit it to avoid the pitman C$^2$, and upon this shaft is fixed a worm-wheel W, with which engages a worm on the end of a rod $w$, that is mounted in suitable bearings 120 and 121 and is provided at its rear end with a hand-wheel $w'$. The upper arm of the rocking lever 113 is pivotally connected to the rear end of a connecting-rod 125, the front end of which rod is pivoted to the upper arm of a rocking lever 126, that is mounted upon the hollow sleeve of the swivel-box 81, (see Figs. 5 and 9,) and the lower arm of this rocking

lever 126 is provided with a series of holes through which passes a pin 127, whereby the rocking lever is connected with a shifting-arm $T^2$, the rear end of which is joined to the band $t'$ upon the hub $t$ of the friction drive-roll K'. It will thus be seen that by the turning of the shaft B the shifting of the drive-rolls F', $F^3$, and K' can be effected.

By reference to Figs. 1, 2, 5, 8, and 9 it will be seen that the friction drive-roll F is connected by a shifting-rod $T^8$ to the lower end of a rocking lever 130, that is pivotally mounted upon the top of the bracket $d$, (see Fig. 8,) and the upper end of this rocking lever 130 is pivotally connected to the shifting-arm $T^4$, that is joined to the band encircling the hub of the friction drive-roll $F^2$. To the lower end of the rocking lever 130 is also pivotally joined a connecting-rod 131, the front end of which is attached to one of the series of holes in the rocking lever 113. (See Fig. 5.)

By reference to Figs. 1, 2, and 9 of the drawings it will be seen that to the band that encircles the hub of the friction drive-roll K is connected a shifting-arm $T^5$, that is pivotally connected to the lower end of a rocking lever 137, that is mounted upon the front shaft P, (see Figs. 1 and 9,) the upper end of this lever being united to a connecting-rod 138, that is joined to the upper end of the rocking lever 113.

The mechanism whereby the friction drive-rolls at the left-hand side of the machine are shifted is similar to that hereinbefore described for shifting the drive-rolls at the right-hand side, but the arrangement of the levers and connections is such as to produce a shift of the drive-rolls reversely to that imparted to the drive-rolls at the opposite side of the machine. Thus by reference more particularly to Figs. 5 and $5^a$ of the drawings it will be seen that rocking lever 140, that is mounted at the left-hand end of the shaft V, has its upper arm normally vertical, while the lower arm of the rocking lever 113 at the opposite side of the machine is normally vertical, and the lower arm of the rocking lever 140 is at an angle from the vertical corresponding to the angle of the upper arm of the rocking lever 113. To the upper arm of the rocking lever 140 is pivotally united a connecting-rod 141, that leads to a rocking lever 142 on the main drive-shaft D, (see Fig. 1,) and to the upper arm of this lever 142 is pivotolly connected a shifting-arm $T^6$, that is joined to the band that encircles the hub of the friction drive-roll H. To the lower arm of the rocking lever 142 is connected a shifting-arm $T^7$, that is united to the sleeve of the friction drive-roll H'. To the upper end of the rocking lever 140 is also pivotally united a connecting-rod 144, that is joined to the upper arm of the rocking lever 145, mounted upon the drive-shaft D, and to the upper arm of this rocking lever 145 is also pivotally connected a shifting-arm $T^8$, that is united to the pin encircling the hub of the friction drive-roll $H^3$. To the lower arm of the rocking lever 145 is connected a shifting-arm $T^9$, that is united to the pin of a friction drive-roll $H^2$. The lower arm of the rocking lever 140 has pivotally joined thereto a connecting-rod 150, the front end of which is connected to the lower arm of the rocking-lever 151, mounted upon the front shaft P, and the upper arm of the rocking lever 151 is pivotally connected to a shifting-arm $T^{11}$, that is attached to the band encircling the hub of the friction drive-roll S. To the lower arm of the rocking lever 140 is also united a connecting-rod 155, the front end of which is pivotally joined to the lower end of a rocking lever 156, and the upper end of this rocking lever is pivotally connected to a shifting-arm $T^{12}$, the rear end of which is attached to the band that encircles the hub of the friction drive-roll S'.

From the foregoing description it will be seen that when the worm-wheel W is turned by means of the shaft $w$ and hand-wheel $w'$ a corresponding movement will be given to the shaft V and to the rocking levers 113 and 140, that are fixed to this shaft, and a shift of the friction drive-rolls with respect to their disks will be effected. The purpose of shifting the friction drive-rolls is to increase or diminish the speed of the traction-wheels at the opposite sides of the machine in order to enable the machine to be steered. In my Letters Patent hereinbefore referred to the broad idea of imparting a variable speed to the steering-wheels at opposite sides of the machine is fully set forth, and it will be readily understood that as the friction drive-rolls are moved toward or away from the centers of their respective disks the speed of the corresponding traction-wheels will be increased or diminished. Thus it will be seen that if the machine is to be turned toward the right the friction drive-rolls K K' should be shifted toward the periphery of their friction-disk M, while the friction drive-rolls S S' at the left-hand side of the machine should be shifted toward the center of their friction-disk T, and in like manner the friction drive-rolls F, F', $F^2$, and $F^3$ should be shifted toward the periphery of the friction-disk G, while the friction drive-rolls H, H', $H^2$, and $H^3$ should be shifted toward the center of the friction-disk G'. In view of the fact, however, that in traversing a curve the front traction-wheels A A of the engine describe a larger arc of a circle than is described by the rear traction-wheels A' A' it will be understood why I have made provision for imparting a differential movement to the front and rear traction-wheels of the engine. Thus, for example, if it be assumed that when the machine is running in a straight line each traction-wheel is running at the speed of six—*e. g.*, six feet per second—and it is desired to turn a corner toward the right the speed of the right-hand traction-wheels must be diminished, while the speed of the left-hand traction-wheels will be increased, and this will be ef-

fected by shifting the friction drive-rolls at the right-hand side of the machine toward the periphery of their friction-disks and by shifting the friction drive-rolls at the left-hand side of the machine toward the center of their friction-disks; but inasmuch as the front traction-wheels will travel upon a somewhat greater curvature than the rear traction-wheels a differential shift will be imparted to the friction drive-rolls whereby the front and rear wheels are driven. Thus, for example, the friction drive-rolls K K′ will be shifted toward the periphery of their friction-disk M, so that the speed of the wheel A, which was previously six, will become, for example, five and one-fourth, and the friction drive-rolls S S′ will be shifted toward the center of their friction-disk T, so that the speed of the adjacent traction-wheel A will be seven and one-fourth. The friction drive-rolls F, F′, $F^2$, and $F^3$ will be shifted toward the periphery of their friction-disk G, so that the speed of the adjacent traction-wheel A′ will be five and the friction drive-rolls H, H′, $H^2$, and $H^3$ will be shifted toward the center of their friction-disk G′, so that the adjacent rear traction-wheel A will be seven. It will thus be seen that the front traction-wheels will travel at a slightly-greater speed than the rear traction-wheels proportionate to the greater arc that is traversed by these front wheels. It is to allow for this differential shift of the front and rear friction drive-rolls that I have provided the arrangement of mechanism hereinbefore described, and by reference more particularly to Figs. 5 and $5^a$ of the drawings the operation of this mechanism will be readily understood. Thus if the machine is to turn toward the right the worm-wheel W will be shifted so as to bring the rocking levers 113 and 140 from the position shown by full lines to the position shown by dotted lines. Inasmuch as the lower arm of the rocking lever 113 is normally in vertical direction while the upper arm of this rocking lever is normally at an angle, it will be seen that when the rocking lever 113 is shifted from the position shown by the full lines in Fig. 5 to the position shown by dotted lines the lower arm of the rocking lever will shift the connecting-rod 111 to a greater extent than the upper arm of the rocking lever will shift the connecting-rod 125, because the end of the lower arm 113 is moved more nearly in a horizontal line, and consequently the friction drive-rolls F′ and $F^3$ will be moved to a greater extent toward the periphery of their friction-disk G than the friction drive-rolls K K′ are moved toward the periphery of their friction-disk M. Hence in this way the speed of the front right-hand traction-wheel A may be decreased to about five and one-fourth, for example, while the speed of the right rear traction-wheel A′ will be decreased to five. By reference to Fig. $5^a$ of the drawings it will be seen that when the worm-wheel W has been thus turned the rocking lever 140 will be shifted from the position shown by full lines to the position shown by dotted lines, and inasmuch as the upper arm of the rocking lever 140, which is normally vertical, will from the beginning of such movement travel downward in the direction of the arrow, Fig. $5^a$, while the lower arm, which is normally at a slight distance from the vertical, will travel toward and across the vertical it follows that the extent of movement of the connecting-rod attached to the upper arm of the rocking lever will be less than the extent of movement imparted to the connecting-rods attached to the lower arm of the rocking lever 140. Consequently the friction drive-rolls S S′, which are operated by the connecting-rods attached to the lower end of the rocking lever 140, will be shifted to a greater extent toward the center of their friction-disk T than the friction drive-rolls H, H′, $H^2$, and $H^3$ will be shifted toward the center of the friction-disk G′. Hence the speed of the left front traction-wheel A may be increased to about seven and one-fourth, for example, while the speed of the rear left traction-wheel will be increased to only seven. It will thus be seen that when the traction-engine is moving in straight line a uniform movement of the front and rear traction-wheels will be had; but when the machine is turning a curve the front traction-wheels will be caused to travel slightly faster than the rear wheels, and this increase in speed will be proportionate to the difference in the ares that will be described by the front and rear wheels. Hence all danger of cramping or crowding the gear mechanism is avoided.

So far as I am aware my invention presents the first instance of a traction-engine in which there is differential driving mechanism whereby the front and rear wheels of the engine can be caused to travel at different rates of speed when passing around curves. While I have described in this application, as in my prior patent, No. 556,346, friction drive-rolls and disks as the most suitable driving mechanism for imparting rotation to the traction-wheels from the engine, I do not wish the invention to be understood as restricted to a machine in which friction-gearing is employed as the means of communicating motion from the engine to the traction-wheels, except as such friction drive mechanism is specifically designated in the claims at the end of this specification. I should regard it as clearly within the scope of my invention to impart differential movement to the front and rear traction-wheels by any suitable style of driving mechanism whereby rotation could be transmitted to such traction-wheels from the drive-shaft of the engine.

In Figs. 12 and 13 of the drawings I have illustrated a slightly-modified construction of driving mechanism for the front traction or steering wheels of the engine. In this form of the invention the main shaft P has loosely mounted upon its ends friction-disks T and

M, the disk M being provided with a bevel-pinion $m$ and the disk T being provided with a similar bevel-pinion, these beveled pinions being connected with their respective traction or steering wheels A, as in the construction hereinbefore described. In this form of the invention also the disks M and T are driven by oppositely-disposed friction drive-rolls K K′ and S S′; but in addition to these drive-rolls there are also two additional pairs of drive-rolls $K^4$ and $K^5$ and $S^4$ and $S^5$, located in front of the front axle and bearing upon the friction-disks, as clearly seen in Fig. 13 of the drawings. The friction drive-rolls $K^4$ and $K^5$ are mounted upon short shafts $k^4$ and $k^5$, the front ends of which are journaled in bearings $k^6$ and $k^7$ upon the top of the standard 170 at the front of the engine. The rear end of the shaft $k^4$ is journaled in a bearing $k^9$ at the top of the bracket $k^8$, projecting upwardly and outwardly from the boiler. The short shaft $k^5$ has its inner end journaled in a bearing at the top of the bracket 172, that rises from the top of the saddle-plate on the top of the boiler, and the forward end of the shaft $f'$ is journaled in a similar bearing at the top of said bracket. The friction drive-rolls $K^4$ and $K^5$ are mounted in manner free to slide longitudinally upon their respective shafts $k^4$ and $k^5$ and will be connected with shifting levers in the same manner as the drive-rolls hereinbefore described or in other convenient manner. The shafts $k^4$ and $k^5$ are connected together by pinions 175 and 176, and upon the rear end of the shaft $k^5$ is fixed a bevel-pinion 178, that engages with a bevel gear-wheel 179, with which also engages the bevel-pinion 180 on the front end of the shaft $f'$. The bevel gear-wheel 179 is carried at the end of a long sleeve 181, that is mounted upon the front shaft P, and at the opposite end of this sleeve 181 is a similar bevel gear-wheel 182, with which engages a pinion 183, fixed to the front end of the shaft $h'$, and with this gear-wheel 182 also engages a pinion 184, fixed to the rear end of the shaft $s^4$, that carries the friction drive-roll $S^4$. The front portion of the shaft $s^4$ has connected thereto a pinion 190, that meshes with a pinion 191 upon the short shaft $s^5$, and the front ends of the shafts $s^4$ and $s^5$ are journaled in boxes 192 and 193 at the top of the bracket 170. The rear end of the shaft $s^5$ is sustained by a bearing $s^6$ at the top of a bracket $s^7$, projecting upwardly and downwardly from the boiler. By this construction it will be seen that the friction-disks M and T are each driven by two sets of friction drive-rolls from the common source of power.

In Figs. 14 and 15 of the drawings I have shown a somewhat modified and simplified construction of mechanism for shifting the friction drive-rolls. In Fig. 14 I have shown the shifting mechanism at the right-hand side of the engine and in Fig. 15 a corresponding mechanism at the left-hand side. F′ and $F^3$ designate the friction drive-rolls for the rear right-hand disk, and K′ designates one of the corresponding friction drive-rolls at the front of the machine. The drive-roll F′ is carried upon the shaft $f^3$, and the drive-rolls $F^3$ and K′ are carried upon the shaft $f^4$, as in the construction illustrated in Fig. 5. Instead, however, of connecting the friction drive-rolls with the rocking lever, as hereinbefore described, I have shown a modified form of rocking lever $113^a$, to the upper end of which is connected a rod 200, the rear end of which engages a ring 201, attached to the forward extension of the hub of the friction drive-roll $F^3$. The rear side of the hub of this drive-roll $F^3$ is provided with a ring $t'$, that is engaged by the arm T′, that connects with the upper end of the lever 110, as in the construction shown in Fig. 5, the lower end of the lever 110 being pivotally connected to the arm $T^{10}$, that is united to a ring $t'$ on the hub of the drive-roll F′. It will thus be seen that when the rocking lever $113^a$ is shifted from the position shown in full lines to the position shown in dotted lines in Fig. 14 the friction drive-rolls F′ and $F^3$ will be correspondingly moved. The lower end of the rocking lever $113^a$ has pivotally connected thereto a rod $125^a$, the forward end of which connects with a ring $t^{10}$, that encircles the hub of the friction drive-roll K′ at its rear. By reference to the position shown by full lines and dotted lines in Fig. 14 it will be seen that when the rocking lever is shifted a corresponding shift will be given to both the rear drive-rolls F′ and $F^3$ and to the forward drive-roll K′, the extent of movement of the rear rolls being greater, however, than that of the forward roll. By reference to Fig. 15 it will be seen that the rocking lever $140^a$ there shown has its lower end connected by rod $141^a$ to a ring encircling the forwardly-projecting part of the hub of the drive-roll H′, while the rearwardly-projecting portion of this hub is connected by the arm $T^7$ with the rocking lever 142, and the upper arm of the lever 142 has connected thereto the arm $T^6$, that is united to the ring $t'$, that encircles the hub of the drive-roll H. The upper arm of the rocking lever $140^a$ is connected by a rod $150^a$ with a ring encircling the rearwardly-projecting portion of the hub of the drive-roll S. By reference to the position of the parts shown by full and dotted lines in Fig. 15 it will be seen that when the operating-lever $140^a$ is shifted from the position shown by full lines to the position shown by dotted lines a corresponding shift of the friction drive-rolls toward the centers of their respective disks will be effected. By reference to Figs. 14 and 15 of the drawings it will be seen that the rocking levers $113^a$ and $140^a$ have their ends slotted, and these slotted ends permit the connecting-rods to be adjustably united thereto, this adjustment permitting the throw of the drive-rolls on the shaft of the operating-levers to be varied in order that the relative movements of the parts may be accurately determined.

It will be understood that modifications and details of construction may be made within wide limits without departing from the spirit of my invention. So, also, while I have described my invention as an improvement in traction-engines it will be understood that it is applicable in part to other vehicles, and I do not wish the term "traction-engine" as herein employed to be understood as a term of limitation.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a traction-engine, the combination with the front axle of a trunnion-sleeve mounted thereon, a pedestal pivotally connected to said trunnion-sleeve and having an inclined annular track, a turn-table pivotally connected to said pedestal and also having an inclined annular track and conical rolls interposed between the turn-table and the pedestal, substantially as described.

2. In a traction-engine, the combination with a pair of steering-wheels, of variable individual gear mechanism for said wheels and whereby said wheels may be caused to rotate at different relative speeds, the individual gear mechanism for each of said wheels comprising a disk or wheel suitably connected with its corresponding steering-wheel and a pair of rolls or gears located upon opposite faces of said disk or wheel and suitable connections between said rolls or gears and the source of power, substantially as described.

3. In a traction-engine, the combination with a pair of steering-wheels, of variable individual gear mechanism for said wheels, the gear mechanism for each of said wheels comprising a friction disk or wheel connected with its corresponding drive-wheel and a pair of friction drive-rolls located upon opposite sides of said friction disk or wheel, and suitable connections between the pair of friction drive-rolls at each side of the machine, substantially as described.

4. In a traction-engine, the combination with a pair of steering-wheels, one located on each side of the engine and connected in a manner permitting their plane of rotation to be shifted with respect to the engine, of variable individual gear mechanism for said wheels and whereby said wheels may be caused to rotate at different relative speeds, said individual gear mechanism for each of the steering-wheels comprising a friction-disk suitably connected therewith, friction drive-rolls arranged upon opposite sides of said friction-disk, shafts whereon said friction drive-rolls are longitudinally adjustable and suitable lever mechanism for shifting said friction drive-rolls, and suitable connections between the shafts of said friction drive-rolls and the source of power, substantially as described.

5. In a traction-engine, the combination with the front and rear wheels, of differentially-operative driving mechanism and a common source of power whereby both said front and rear wheels are driven, said differentially-operative driving mechanism serving to impart different relative speeds to the pairs of front and rear wheels, whereby the pair of front wheels may be caused to travel faster than the corresponding rear wheels, substantially as described.

6. The combination with the front and rear wheels, of variable gear mechanism for each of said wheels and whereby the pair of front wheels may be caused to travel faster than the corresponding rear wheels and a common source of power with which said gear mechanism is suitably connected, substantially as described.

7. The combination with the front and rear traction-wheels, of variable gear mechanism for each of said wheels, and whereby the pair of front wheels may be caused to travel faster than the corresponding rear wheels, shifting mechanism whereby the speed of said gear mechanism is varied and a common source of power with which said gear mechanism is suitably connected, substantially as described.

8. The combination with the front and rear traction-wheels, of variable gear mechanism for each of said wheels, and whereby the pair of front wheels may be caused to travel faster than the corresponding rear wheels, shifting mechanism whereby the speed of the gear mechanism of the front and rear wheels may be differentially varied and a common source of power with which said gear mechanism is suitably connected, substantially as described.

9. The combination with front and rear traction-wheels, of variable gear mechanism for each of said wheels and whereby the pair of front wheels may be caused to travel faster than the corresponding rear wheels comprising wheels or disks and drive gears or rolls movable radially with respect to said wheels or disks and means for shifting said drive gears or rolls radially with respect to said wheels or disks, substantially as described.

10. The combination with the front and rear traction-wheels, of variable gear mechanism for each of said wheels comprising a friction-wheel, positively-driven rolls for imparting movement to each wheel and means for shifting said drive-rolls radially with respect to said friction-wheels, substantially as described.

11. The combination with the front and rear traction-wheels, of variable gear mechanism for each of said wheels, comprising wheels or disks and positively-driven gears or rolls for imparting movement thereto and shifting mechanism whereby the speed of the individual gear mechanism is varied, said shifting mechanism comprising suitable rods and levers and a common shaft whereby said rods and levers may be simultaneously operated, substantially as described.

12. The combination with the front and rear traction-wheels, of variable gear mechanism

for each of said wheels, and whereby the pair of front wheels may be caused to travel faster than the corresponding rear wheels, the gear mechanism of the front wheels of the machine being suitably geared together, substantially as described.

13. In a traction-engine, the combination with the front wheels, of a vertical shaft for each of said front wheels and suitably geared thereto, a suitable block through which each of said vertical shafts passes, a frame connected with said block and carrying gear-pinions, a common source of power and suitable gear mechanism connecting said pinions with the source of power, substantially as described.

14. In a traction-engine, the combination with the front traction-wheels, of individual vertical shafts for each of said wheels, gear mechanism connecting said shafts at their lower ends with the traction-wheels, suitable blocks through which said individual shafts pass, a shaft extending between said blocks, suitable frames pivoted to said blocks and through which frames the individual vertical shafts pass, suitable gear-pinions carried by said frame and gear mechanism connecting said pinions with the source of power, substantially as described.

15. In a traction-engine the combination with the front axle, of sleeves swiveled thereon adjacent the ends of the axle, individual yokes pivoted to said sleeves, said yokes provided with bearings, and shafts mounted in said bearings and connected by suitable gearing with the traction-wheels, said sleeves allowing for the front and rearward movement and said yokes allowing for the lateral movement of the parts.

STEPHEN B. GRAY.

Witnesses:
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ALBERTA ADAMICK.