W. R. DRAY.

DIFFERENTIAL GEAR.

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1,262,759.

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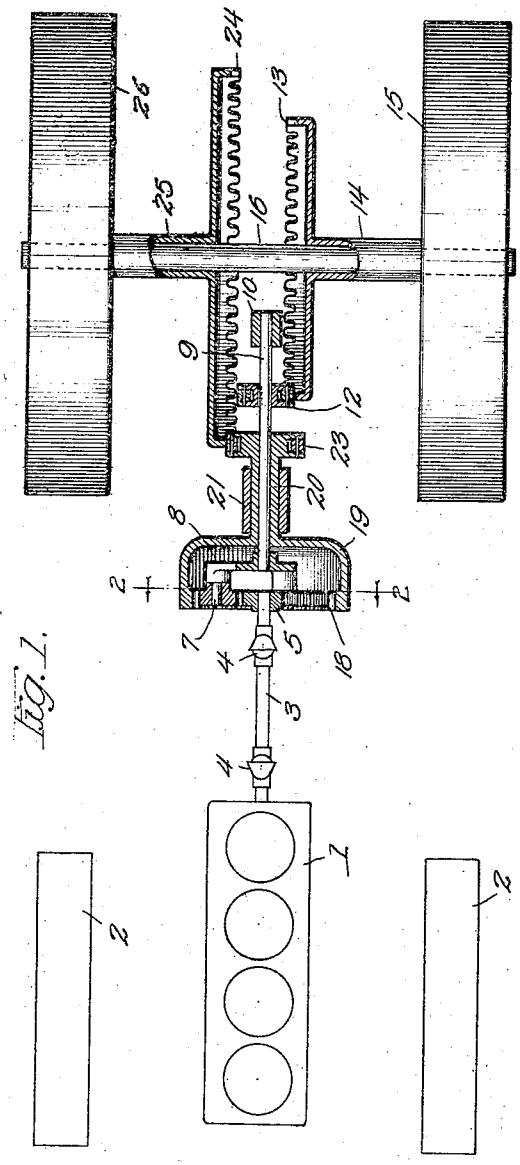

Fig. 1.

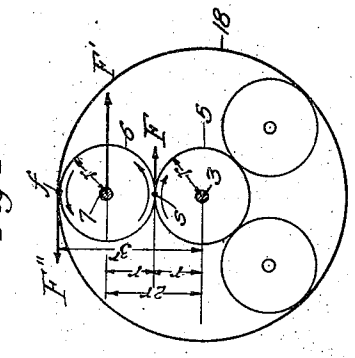

Fig. 4

Fig. 3

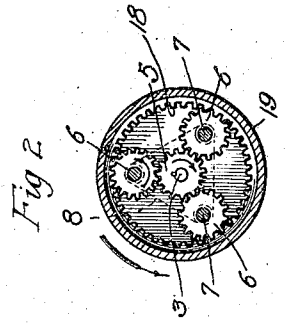

Fig. 2

Inventor
Walter R. Dray.
By Cheever & Cox Attys.

UNITED STATES PATENT OFFICE.

WALTER R. DRAY, OF MASON CITY, ILLINOIS.

DIFFERENTIAL GEAR.

1,262,759. Specification of Letters Patent. Patented Apr. 16, 1918.

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To all whom it may concern:

Be it known that I, WALTER R. DRAY, a citizen of the United States, residing at Mason City, in the county of Mason and State of Illinois, have invented a certain new and useful Improvement in Differential Gears, of which the following is a specification.

My invention relates to drives for self-propelled vehicles. In one of its aspects the invention is particularly useful in connection with tractors for plows or other implements where greater tractive effort is desirable on one side of the machine than the other, and in order to explain this feature I have elected to illustrate in a manner to bring out this characteristic. It will be understood by those familiar with tractive plows that in a case where one or two plowshares are employed, the plowshares are usually so located as to cause a greater drag on one side of the tractor than the other. This is ordinarily known as "side draft." In the form of mechanism illustrated, the mechanism accommodates itself to this situation and produces greater tractive effort or torque in one of the tractor wheels than in the other. Another object, and one which is not confined to the situation where greater torque is desirable in one of the tractor wheels than the other, is to provide a construction wherein all the reduction and differential gear elements occupy but small compass, and wherein the number and direction of the thrusts, stresses and strains are reduced to a minimum. Another object of the invention is to provide a construction such that the width of the individual tractor wheels may be greatly increased without increasing the distance from the outer edge of one of the wheels to the outer edge of the other. Contributory objects are concerned with certain mechanical expedients which will be hereinafter more fully described and claimed.

I accomplish my objects by the construction illustrated in the accompanying drawings, in which:

Figure 1 is a plan view, partly in section, of the chief operating parts of the mechanism, the motor and front wheels being indicated more or less diagrammatically.

Fig. 2 is a vertical section on the line 2—2, Fig. 1.

Fig. 3 is a detail showing a roller pinion coöperating with its crown gear, and

Fig. 4 is a diagrammatic view illustrating the principle of operation of the gearing.

Similar numerals refer to similar parts throughout the several views.

Referring to the drawings, power is furnished by the motor 1, which may assume the form of an internal combustion engine. The front wheels of the vehicle are indicated at 2, 2. The motor actuates the drive shaft 3 which preferably is provided with universal joints 4, 4.

Rigidly fastened to shaft 4 is a center pinion 5 which meshes with gear wheels 6. These latter are preferably three in number, as shown, and have some of the characteristics of planetary gears in that they travel around the center pinion. They are loosely mounted on studs or arbors 7 which project from the spider 8. Said spider is rigidly fastened to and rotates the inner driven shaft 9. The rear end of this shaft is here shown to be journaled in a bearing 10 fastened to some part of the chassis or framework of the machine. A pinion 12 is fastened to shaft 9 and meshes with a gear 13 which drives the hub 14 of one of the tractor wheels 15. Said hub rotates upon the main rear axle 16. In the present case the pinion 12 is shown in the form of a roller pinion and gear 13 in the form of a crown gear. This form of crown gear and roller pinion is preferable in certain instances because it confines the thrust to a single direction or plane whereas if beveled gears were used the thrusts would be divided into two components arranged at an angle to each other.

The intermediate gear 6 mesh with an internal gear 18 formed on a part 19 which is shown in the shape of a housing for the other gear wheels. Said housing has a hollow hub 20 which forms a bearing for shaft 9 and itself has a bearing in the journal 21 which is carried by some part of the chassis. A roller pinion 23 is fastened to hub 20 and meshes with a crown gear 24 which drives the hub 25 of the other tractor wheel 26.

In operation, when the driving shaft 3 is rotated, it causes the center pinion 5 to cause the spider 8 to rotate in one direction and the housing 19 to rotate in the

opposite direction. But as the pinions 12 and 23 are engaged on opposite sides, the tractor wheels both rotate in the same direction.

But the spider exerts greater torque upon its shaft 9 than housing 19 does upon its shaft 20, and the reason will be understood by referring to the diagram, Fig. 4.

Referring to the diagram, let the shaft 3 and stud 7 remain as before. Let the circles 5, 6 and 18 represent the pitch circles of the gear wheels 5, 6 and 18. Let it be assumed that the arrow at F represents the direction and strength of the force exerted by the wheel 5 upon wheel 6. Let it be assumed, also, that the wheels 5 and 6 are of equal size and of a radius equal to r. To determine the strength of the force F', let it be assumed that the wheel 18 is held against rotation. In such event, gear wheel 6 will be temporarily fulcrumed at the point of tangency f. The power arm through which the force F works will then be the distance from the point of tangency s to the point f, which equals $2r$. The work arm of the leverage will be the distance from the point f to the stud 7, which equals r. Hence

Force $F'=FX2r$, divided by r, or $2F$.

Consequently, F' equals 2F. The torque in shaft 9 will be equal to the force F' multiplied by the distance between the stud 7 and shaft 3. But the distance from stud 7 to shaft 3 equals $2r$, hence

$$\text{Torque}=F'X2r=4Fr$$

To determine the strength of the force of the arrow F'' let it be assumed that the stud 7 is held fast against rotation. In such event, gear wheel 6 will be temporarily fulcrumed on the stud 7 and the power arm will be the distance from s to 7, while the work arm will be the distance from stud 7 to point f. As these distances are equal, the strength of the force F'' will be equal to the strength of the force F. The torque exerted in hollow shaft 20 will be equal to the force F'' multiplied by the distance between the point f and shaft 3. This distance equals $3r$. Consequently,

$$\text{The torque in shaft } 20=F''X3r.$$

But F'' equals F, and making the substitution, we have

$$\text{Torque in shaft } 20=FX3r=3Fr$$

Hence the torque created in shaft 9 will be $4Fr$, while the torque created in the hollow shaft 20 will be $3Fr$, or a ratio of 4 to 3.

Thus, if the roller pinions 12 and 23 and the crown gears 13 and 24 are so proportioned that they will transmit power in proportion to the torques of their respective shafts, the torque or tractive force of the tractor wheel 15 will be four-thirds as great as of tractor wheel 26. This ratio, however, may be modified by changing the speed ratios of said roller pinions relative to said crown gears.

It will be noted that in this construction the crown gears 13 and 24 come very close together; and consequently each of the tractor wheels may be provided with very broad treads, there being plenty of space to extend the width inward. It will also be noted that the structure lends itself to assembly on the unit system, which tends to lower the cost of manufacture. For example, the gear wheels 5, 6 and 18, together with their shafts and roller pinions may be assembled as a single unit and introduced as a unit into the machine. Also, the tractor wheels with their hubs and crown gears form units, which may be similarly introduced. The housing 19 readily lends itself to form a casing for the inclosed gear wheels, and thus the parts are well protected in a simple and efficient manner.

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

1. In combination, a rotating driving element, a pair of rotatable driven elements each having its axis of rotation at an angle to the axis of rotation of the driving element, and means between the driven and driving elements actuated by the latter to rotate the driven elements with different torques.

2. A tractor drive comprising two tractor wheels, two coaxial rotatable driven shafts operatively connected to said wheels respectively, a driving shaft having its axis of rotation at an angle to the axis of rotation of the driven shafts, and means between the driven and driving shafts actuated by the latter to rotate the driven shafts with different torques.

3. A tractor drive comprising two tractor wheels, rotatable about a common axis, a tractor gear wheel for each of said tractor wheels, a pinion for each of said tractor gear wheels, said pinions being located between the planes of said tractor gear wheels, two coaxial driven shafts, one of which is secured to one of said pinions and the other to the other, a driving shaft, and means operated by said driving shaft for rotating the driven shafts in opposite directions with different torques.

4. A tractor drive comprising two concentric driven shafts, means for rotating said shafts in opposite directions, two tractor wheels, one on each side of said shafts, and two gear-connections for connecting the respective tractor wheels with the respective shafts, said gear-connections being on op-

posite sides of the shafts and on the same sides as their respective tractor wheels, whereby the tractor wheels are caused to revolve both in the same direction.

5. A tractor drive comprising two coaxial driven shafts, means for rotating said shafts, in opposite directions, a pinion fastened to each of said shafts, a tractor gear wheel on one side of said shafts, meshing with one of said pinions, a second tractor gear wheel on the other side of said shafts, meshing with the other of said pinions, whereby said tractor gear wheels revolve in the same direction, and tractor wheels connected to and driven by said tractor gear wheels.

6. A tractor having two tractor wheels rotatable about a common axis, a tractor gear wheel for each of said tractor wheels, a pinion for each of said tractor gear wheels, said pinions being located between the planes of said gear wheels, two coaxial driven shafts, one of which is secured to one of said pinions and the other to the other, the driven shafts being at right angles to the axis of the tractor wheels, and means for rotating said shafts.

In witness whereof, I have hereunto subscribed my name.

WALTER R. DRAY.