No. 725,223. PATENTED APR. 14, 1903.

M. CRAWFORD.

VARIABLE SPEED GEAR.

APPLICATION FILED DEC. 12, 1902.

NO MODEL. 3 SHEETS—SHEET 1.

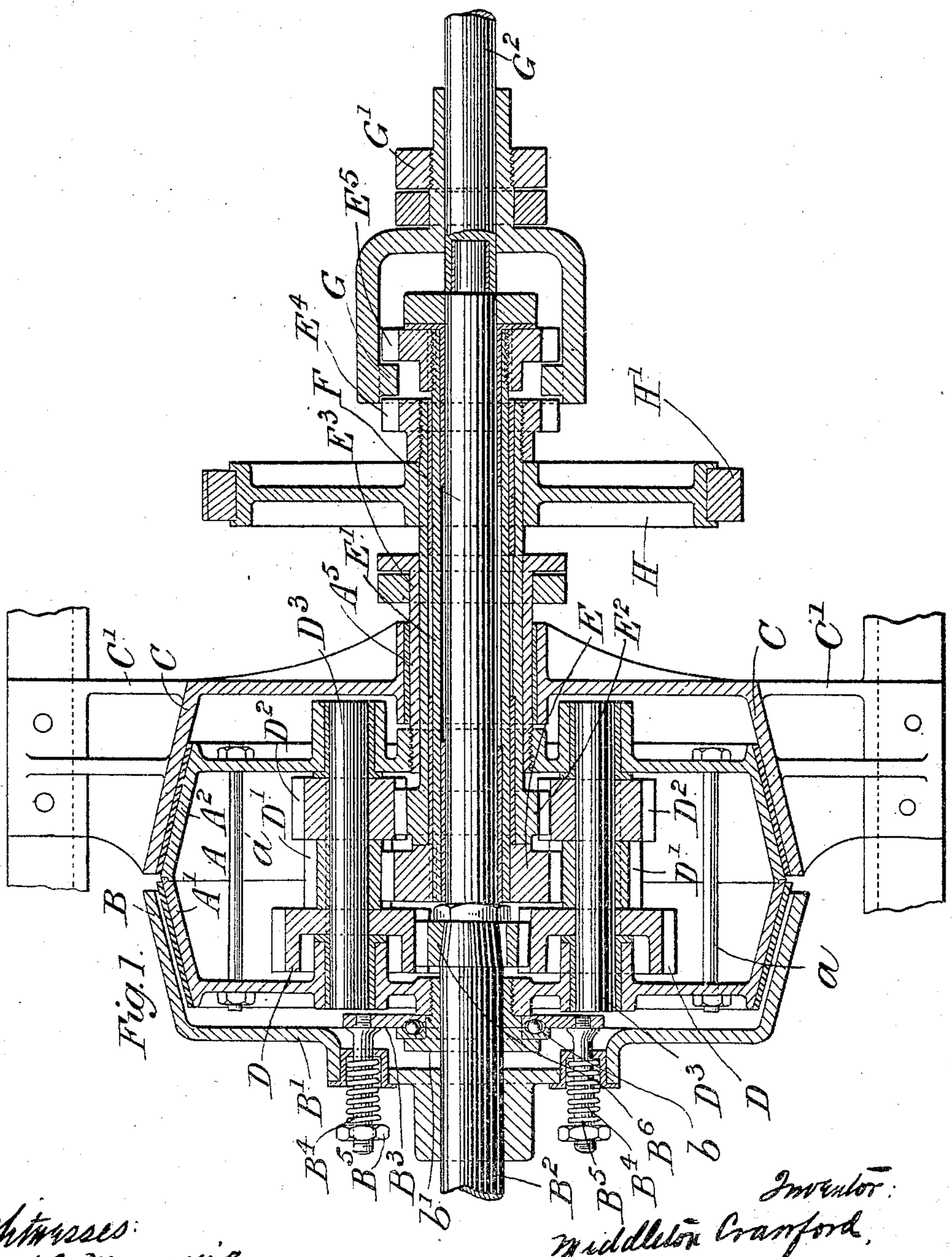


Fig. 1.

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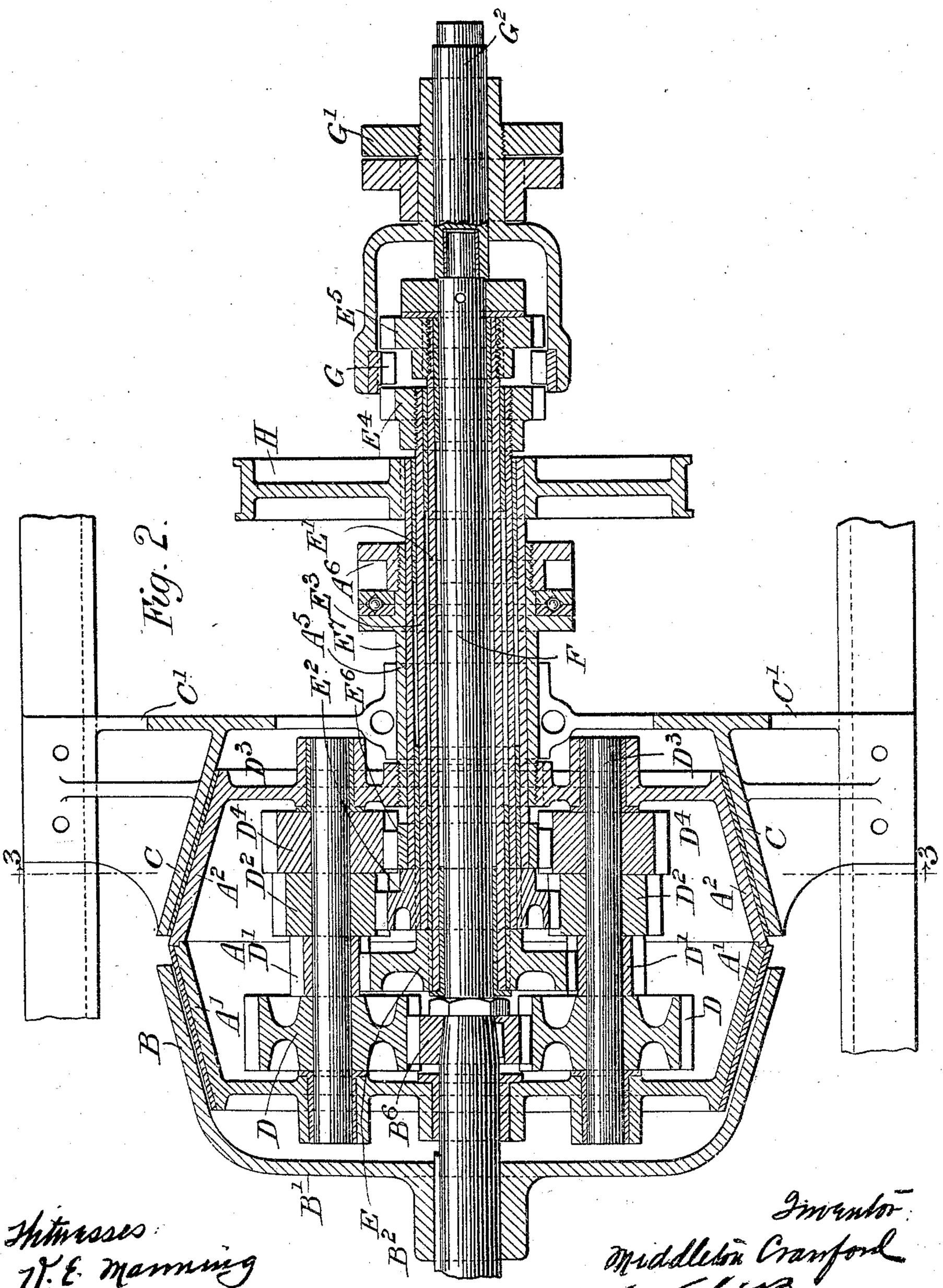
NO MODEL. 3 SHEETS—SHEET 2.

Fig. 2.

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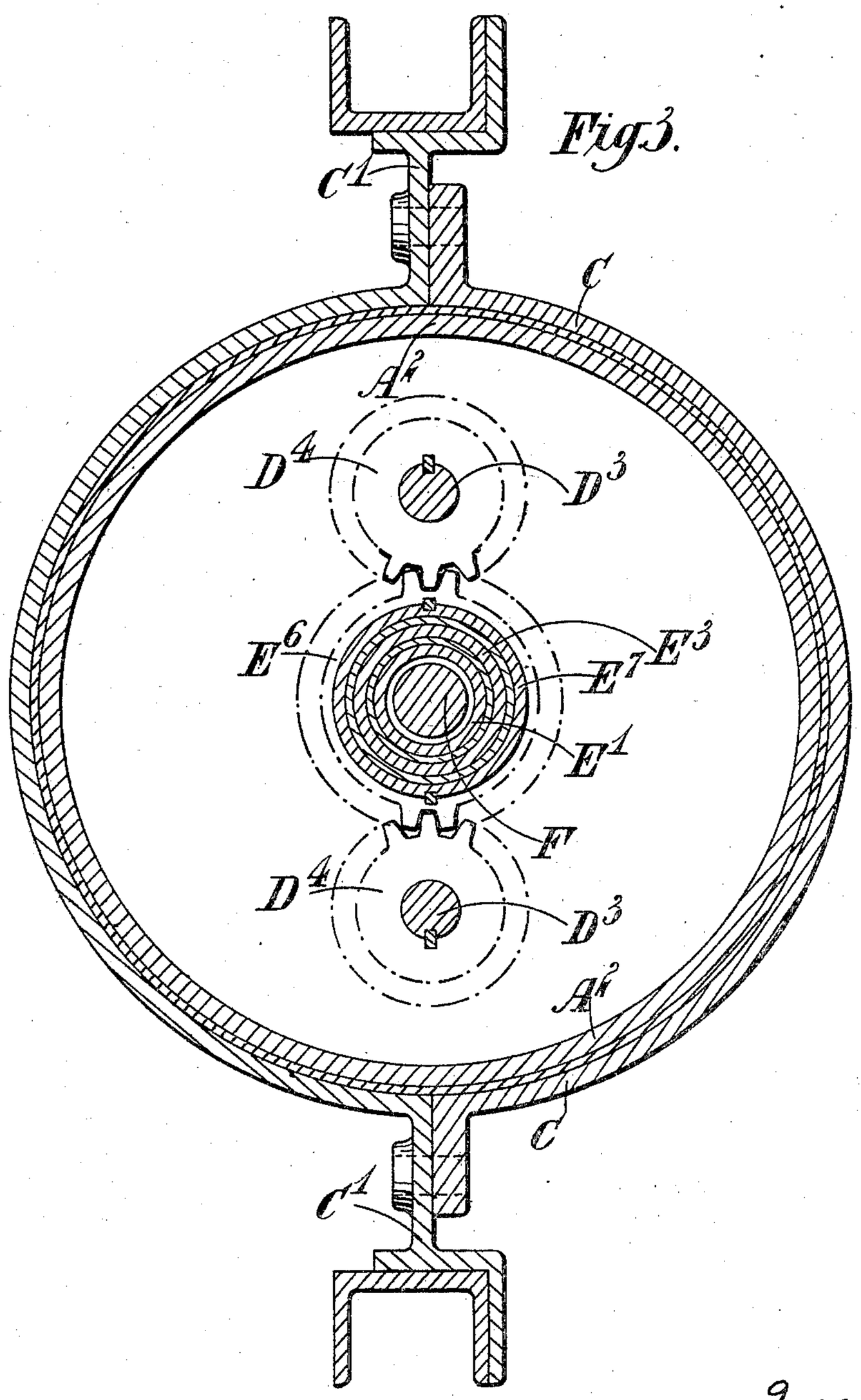
NO MODEL. 3 SHEETS—SHEET 3.

Fig 3.

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# UNITED STATES PATENT OFFICE.

MIDDLETON CRAWFORD, OF LONDON, ENGLAND.

## VARIABLE-SPEED GEAR.

SPECIFICATION forming part of Letters Patent No. 725,223, dated April 14, 1903.

Application filed December 12, 1902. Serial No. 134,964. (No model.)

*To all whom it may concern:*

Be it known that I, MIDDLETON CRAWFORD, a subject of the King of England, residing at London, England, have invented certain new and useful Improvements in or Relating to Variable-Speed Gear, of which the following is a specification.

This invention relates to variable-speed gear, and refers more particularly to gearing which can also be employed for reversing purposes.

According to this invention I provide a casing or drum having at each end an external conical friction-surface by means of which the casing can be locked to a corresponding friction-surface on the driving-shaft or to a stationary conical friction-surface. Within the drum I mount a convenient number of sets of gear-wheels or pinions, each set being arranged to rotate as a single compound pinion. One pinion of each set gears with a pinion on the driving-shaft and the others with pinions carried by concentric sleeves, some or all of which are adapted to be separately clutched to the driven shaft or member to rotate it, one or another of the sleeves being also adapted to be held stationary for reversing purposes.

In the accompanying drawings, Figure 1 is a longitudinal sectional view of a gearing constructed in accordance with this invention. Fig. 2 is a similar view of a modified construction of gear, and Fig. 3 is a cross-section on the line 3 3 of Fig. 2.

Like letters indicate like parts throughout the drawings.

A is the casing or drum, B the friction-surface connected to the driving-shaft, and C the stationary friction-surface.

Referring more particularly to Fig. 1, the casing A is for convenience of construction formed in two similar parts, which are secured together by bolts *a*, and the conical parts $A'$ $A^2$ at each end of the casing are covered with leather or other suitable material to form friction-surfaces. The casing is mounted to rotate loosely on the shaft, and the conical surface $A^2$ is adapted to engage with the conical surface C, carried by a stationary support $C'$, when the casing is moved axially to the right, and thereby prevents the casing from rotating, and the conical surface $A'$ when the casing is moved to the left engages with the friction-surface B, which is carried by a disk $B'$, mounted on the driving-shaft $B^2$, so that the casing is locked to the driving-shaft and rotates with it. The disk $B'$ is connected to the shaft by means of a groove-and-feather coupling, which allows it to move axially independent of the shaft, while causing it to rotate therewith.

$B^3$ is a collar mounted on a collar *b'*, fast on the driving-shaft and between which and the collar $B^3$ ball-bearings *b* are disposed. The collar $B^3$ is provided with studs $B^4$, which pass through the disk $B'$, between which and the nuts on the end of the studs are placed springs $B^5$, which provide a yielding connection and prevent sudden shock to the parts when the conical surfaces B and $A'$ come together. The springs also tend to draw the two conical surfaces together, but are prevented by the mechanism from moving the casing laterally in the opposite direction, which mechanism when released permits the spring to draw the conical surfaces together and is operated against the action of the springs to keep the surfaces apart.

Two or other convenient number of sets of compound pinions are mounted within the casing, each set consisting of three pinions D $D'$ $D^2$, carried by axles $D^3$, to which they are keyed, or the pinions of each set may be formed in one or otherwise connected together, so that each set operates as a single compound pinion. The driving-shaft $B^2$, which passes through one side of the casing, forms a bearing-surface for the casing on that side and is provided with a pinion $B^6$, which gears with a member D of each of the compound pinions. The pinions $D'$ of each set gears with a pinion E, carried by a sleeve $E'$, which is mounted on a central shaft or support F, which may be an extension of the driving-shaft, and the pinions $D^2$ gear with a pinion $E^2$, carried by a sleeve $E^3$, which is mounted concentrically on the sleeve $E'$. The outer sleeve $E^3$ forms a bearing for the other side of the casing, which has connected to it a sleeve $A^5$ and collar $A^6$, by which it can be moved axially in one direction, the springs $B^5$ serving to move the casing axially

in the opposite direction, or the springs $B^5$ may be dispensed with and the operating mechanism connected with the sleeve $A^5$ may be arranged to move the casing in both directions axially, as will be described with reference to Fig. 2.

The sleeves E' $E^3$ are provided, respectively, with clutch members $E^4$ $E^5$, between which is disposed a corresponding clutch member G, mounted on or connected to the driven shaft or member $G^2$, and this clutch can be moved by a collar G' to engage with either the clutch members $E^4$ or $E^5$.

A brake-drum H, mounted fast on the sleeve $E^3$, is provided with a brake strap or band H', by which its motion can be arrested to hold the sleeve stationary, as above described.

For high speed the casing A is moved to the left, so that the conical surfaces A' and B become locked together. The compound pinions are locked with the pinions on the driving-shaft and concentric sleeve, so that there is no relative movement between them, and provided that the clutch on the driven shaft is in engagement with the clutch on one or other of the concentric sleeves the driving and driven shaft will rotate together and at the same speed.

Intermediate and low forward speeds are obtained by locking the conical surfaces $A^2$ and C together, so as to hold the casing stationary and cause the compound pinions to be rotated on their own axes by the pinion $B^6$ on the driving-shaft. The intermediate speed is obtained when the sleeve $E^3$ is clutched to the driven shaft, so that the motion is transmitted through the pinions $B^6$, D, $D^2$, and $E^2$, and low speed is obtained by clutching the sleeve E' to the driven shaft, so that the motion is transmitted through the pinions $B^6$, D, D', and E.

If the driven-shaft clutch G is not in engagement with either of the sleeve-clutches, the gearing operates idly and no motion is transmitted to the driven shaft, and a similar effect is obtained by moving the casing so that neither of its conical surfaces is locked with the surfaces B or C.

To obtain rotation of the driven shaft or member in a reverse direction, the casing is moved into an intermediate position, so that it may rotate freely, neither of its surfaces A' $A^2$ being locked to the conical surfaces B and C. The sleeve $E^3$ with its pinion $E^2$ are held stationary by arresting the motion of the brake-drum H, so that the pinion $E^2$ becomes a stationary rack, around which the compound pinions rotate in an epicyclic manner in addition to their rotation upon their own axes, and the sleeve E' is clutched to the driven shaft, so that the motion is transmitted through the pinions $B^6$, D, D', and E—that is, through the pinions employed for low forward speed.

Referring now to Figs. 2 and 3, in which is illustrated a gearing constructed to give two reverse speeds, the disk B', carrying the conical surface B, is mounted fast on the driving-shaft $B^2$. The sleeves E' $E^3$ in addition to being employed for intermediate and low forward speeds are both available for reverse driving, and in order to permit of this an extra pinion or member $D^4$ is added to each set of compound pinions carried by the casing. The pinions $D^4$ gear with a corresponding pinion $E^6$, connected to a sleeve $E^7$, mounted on the sleeve $E^3$, and the brake-drum H is in this case connected to the sleeve $E^7$, which is not provided with a clutch member and is not employed for driving purposes proper, but rotates idly during the forward driving, which with this construction corresponds with the arrangement already described with reference to Fig. 1. For reverse speeds the sleeve $E^7$ is held stationary by the brake-drum, and its pinion becomes a stationary rack for the compound pinions to rotate around in an epicyclic manner in addition to their rotation on their axes. When the sleeve $E^7$ is held stationary and the casing allowed to rotate, one reverse speed is obtained by transmitting the motion through the low forward-speed gearing and the other reverse speed is obtained by transmitting the motion through the intermediate forward-speed gearing. The collar $A^6$ is arranged so that it can be engaged by a forked lever or other device to move the casing in both directions.

With both arrangements the casing is locked to the stationary cone C, so that the compound pinions rotate on their axes only for intermediate and low forward speeds, and reverse driving in both cases is obtained by permitting the casing to rotate and holding one or other of the concentric sleeves stationary, so that the compound pinions operate as epicyclic pinions in addition to their rotation on their own axes.

In place of constructing the modified form of gearing to give two reverse speeds it will be obvious that in place of one of them an additional or fourth forward speed can be obtained when the planet-pinions rotate epicyclically by forming the pinion E of smaller diameter, and therefore fewer teeth, than the pinion $E^6$ instead of having a larger diameter, the sizes of the pinions D' and $D^4$ being altered to correspond.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. In variable-speed gear the combination with a driving-shaft, a driven shaft and a rotatable casing having an external conical surface at each end of means for locking the casing by one of its conical surfaces to the driving-shaft, means engaging with the other conical surface for holding the casing stationary, a compound pinion carried within the casing, a pinion on the driving-shaft gearing with one part of the compound pinion, pinions gearing with the other parts of the compound pinion, means for locking a desired number of these pinions to the driven

shaft and means for holding one of the pinions stationary substantially as and for the purpose described.

2. In variable-speed gear the combination with a driving-shaft, a driven shaft and a rotatable casing having an external conical surface at each end of means for locking the casing by one of its conical surfaces to the driving-shaft, means engaging with the other conical surface for holding the casing stationary, means for moving the casing axially, a compound pinion carried within the casing, a pinion on the driving-shaft gearing with one part of the compound pinion, pinions gearing with the other parts of the compound pinion, means for locking a desired number of these pinions to the driven shaft and means for holding one of the pinions stationary substantially as and for the purpose described.

3. In variable-speed gear the combination with a rotatable casing having an external conical surface at each end of a stationary support having a conical surface, a driving-shaft having a conical surface, means for moving the casing axially to engage successively with the stationary and the driving-shaft conical surfaces, an axle within the casing, a compound pinion mounted on said axle, a pinion on the driving-shaft gearing with one part of the compound pinion, pinions gearing with the other parts of the compound pinion, means for locking a desired number of these pinions to the driven shaft and means for holding one of the pinions stationary substantially as described.

4. In variable-speed gear the combination with a rotatable casing having an external conical surface at each end of a stationary support having a conical surface, a driving-shaft having a conical surface, means for moving the casing axially to engage successively with the stationary and the driving shaft conical surfaces, an axle within the casing, a compound pinion mounted on said axle, a pinion on the driving-shaft gearing with one part of the compound pinion, pinions gearing with the other parts of the compound pinion, sleeves connected to these pinions, clutch members on the sleeves employed for forward driving, a corresponding clutch member on the driven shaft and means for holding one of the pinions stationary for reverse driving substantially as described.

5. In variable-speed gear the combination with a rotatable casing having an external conical surface at each end of a stationary support having a conical surface, a driving-shaft having a conical surface, means for moving the casing axially to engage with the conical surface of the stationary support, a spring disposed between the casing and the conical surface on the driving-shaft tending to move the casing to engage and keep the surfaces in contact, an axle within the casing, a compound pinion mounted on said axle a pinion on the driving-shaft gearing with one part of the compound pinion, pinions gearing with the other parts of the compound pinion, means for locking a desired number of these pinions to the driven shaft and means for holding one of the pinions stationary substantially as described.

6. In variable-speed gear the combination with a rotatable casing having an external conical surface at each end of a stationary support having a conical surface, a driving-shaft having a conical surface, means for moving the casing axially to engage successively with the stationary and the driving-shaft conical surfaces, an axle within the casing, a compound pinion mounted on said axle, a pinion on the driving-shaft gearing with one part of the compound pinion, pinions gearing with the other parts of the compound pinion, sleeves connected to these pinions, clutch members on the sleeves employed for forward driving, a corresponding clutch member on the driven shaft, a brake-drum on one sleeve for holding one of the pinions stationary for reverse and forward driving and braking means to coöperate with the drum substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

MIDDLETON CRAWFORD.

Witnesses:
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WM. J. DOW.