

H. C. GRAY.
 VALVE GEAR FOR RECIPROCATING STEAM ENGINES.
 APPLICATION FILED AUG. 21, 1916.

1,261,925.

Patented Apr. 9, 1918.
 4 SHEETS—SHEET 2.

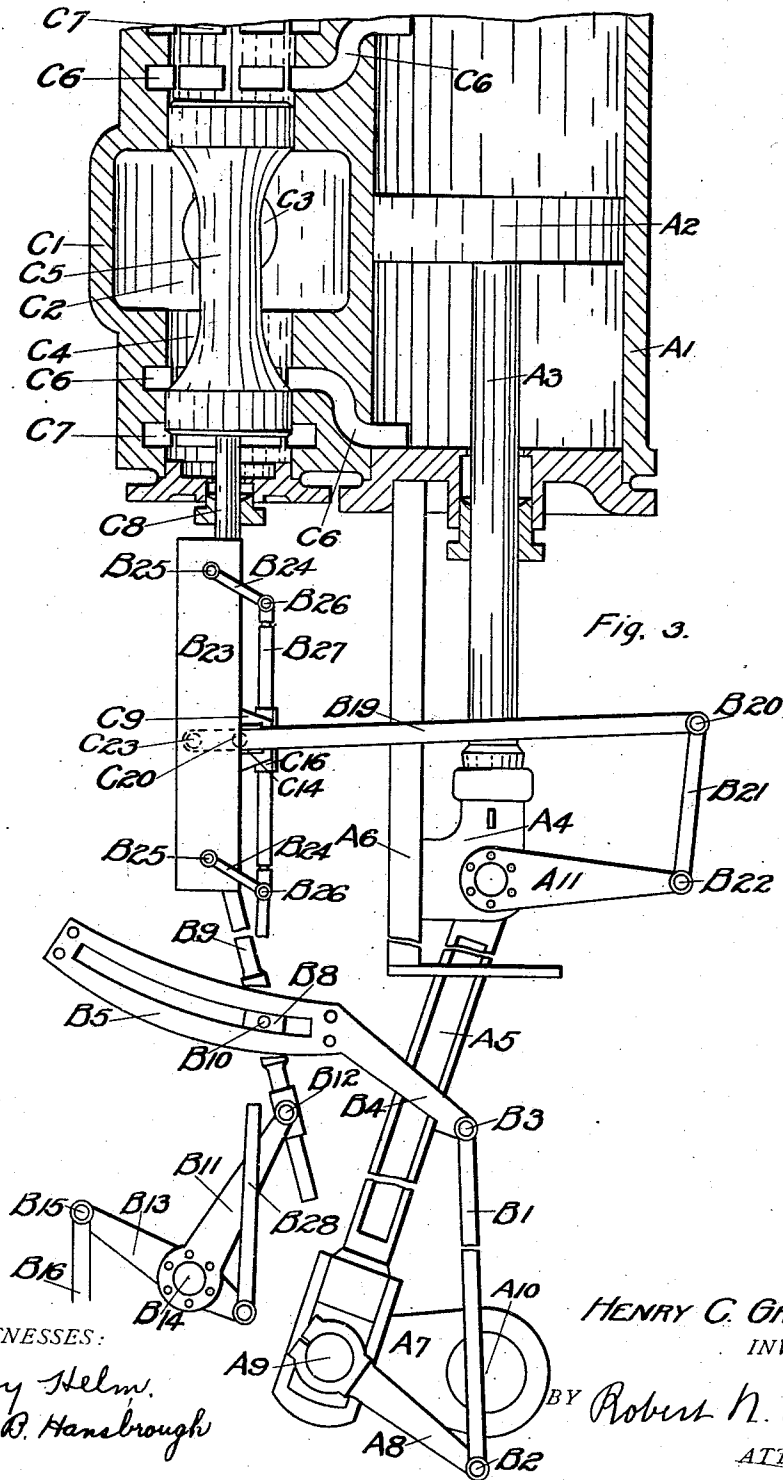


Fig. 3.

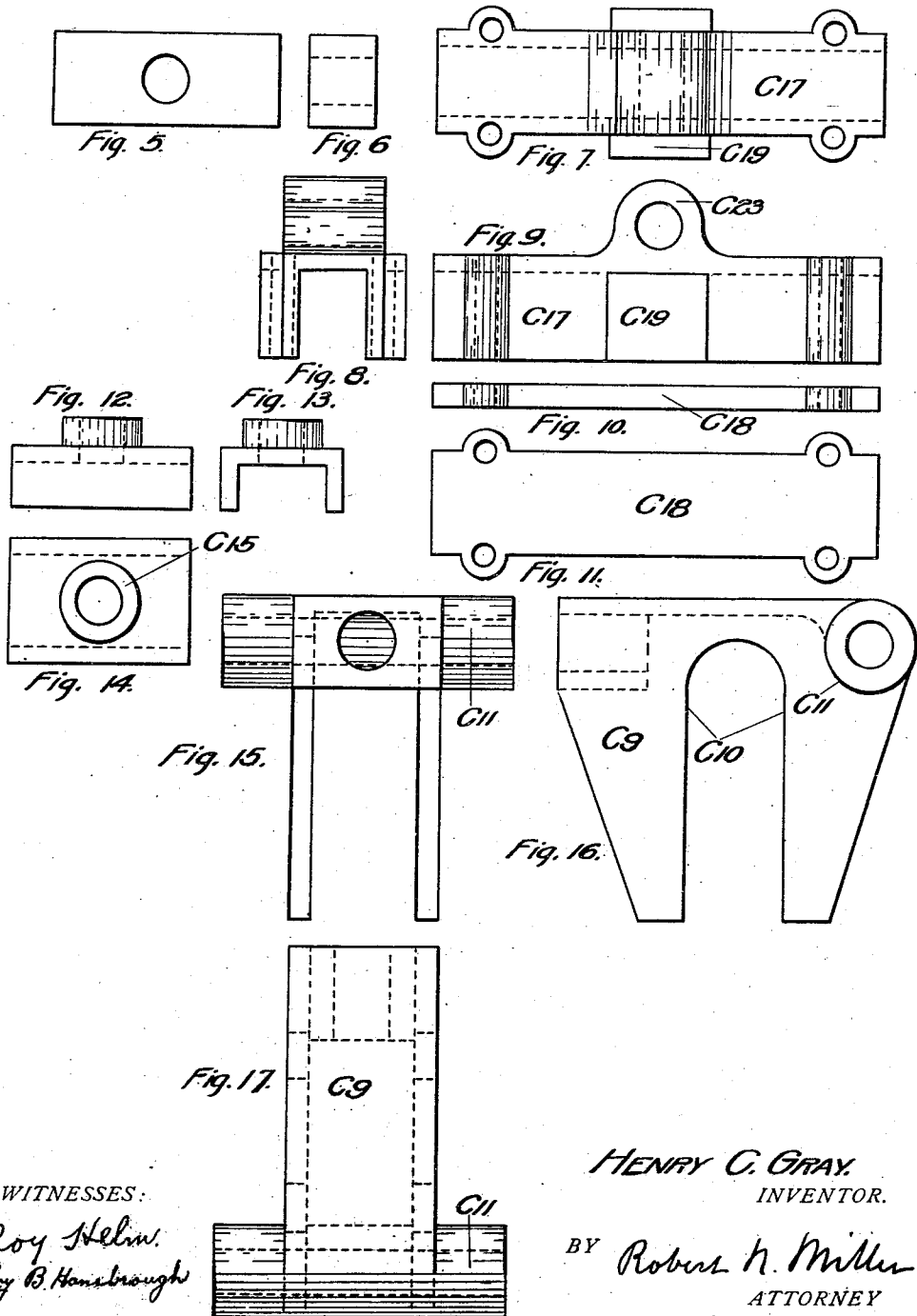
WITNESSES:
 Roy Helm,
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 INVENTOR.
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UNITED STATES PATENT OFFICE.

HENRY C. GRAY, OF LOUISVILLE, KENTUCKY.

VALVE-GEAR FOR RECIPROCATING STEAM-ENGINES.

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Specification of Letters Patent.

Patented Apr. 9, 1918.

Application filed August 21, 1916. Serial No. 116,023.

To all whom it may concern:

Be is known that I, HENRY C. GRAY, of Louisville, Jefferson county, Kentucky, have invented new and useful Improvements in Valve-Gears for Reciprocating Steam-Engines.

My invention relates to improvements in that type of valve gear known as the Walschaert valve gear, wherein the movement of the valve is effected both from the driving wheel and from the piston-rod. In the Walschaert type of valve gear, the motion of the piston-rod, through intermediate means, modifies the motion derived from the driving shaft, so as to produce what is known as "lead." The meaning of this term will appear later. The "lead" produced by the Walschaert valve gear remains constant, whether steam is being admitted for the full stroke of the piston, or a fractional part thereof. This want of variation is a disadvantage, and one of the objects of the present invention is so to modify the Walschaert valve gear, that the "lead" will vary, the variation being dependent upon the point at which cut-off is effected; that is, so that a different "lead" will be secured when steam is being admitted during the full length of the stroke than is secured when it is being cut off, and so that the amount of "lead" will be variable according to the part of the stroke at which cut-off is effected.

The commonest application of this type of valve gear is to steam locomotives of the ordinary type, having cylinders in which pistons reciprocate, piston rods attached to the pistons, and driving wheels revolving on shafts or axles, valves by which steam is admitted to the cylinders, and by which it is cut-off, valve stems, and other features in common use on locomotives.

I attain the objects of my invention by the mechanism illustrated in the accompanying drawings in which—

Figure 1 is a side view of the mechanism showing the cylinder and the valve chest in cross-section.

Fig. 2 is an end view of the hanger at X X, showing the guides and valve stem in cross-section.

Fig. 3 is a side view of the apparatus, which, like Fig. 1, shows the cylinder and steam chest in section. Unlike Fig. 1 it shows the steam chest and cylinder broken off at the front end, and shows the link, later described, with the link bracket piece removed. Fig. 3 also differs from Fig. 1 in that it represents the piston at half stroke, instead of showing the crank on dead center, and also shows the link block.

Both in Fig. 1 and Fig. 3, for simplicity and compactness, certain parts are shown as broken.

Fig. 4 is an enlarged view of the detail adjacent to the point where the combination lever and the radius rod (later referred to) are connected, with the guide pieces partially cut away so as to show certain parts they would hide.

Fig. 5 is a side view of the guide blocks later referred to, and Fig. 6 an end view thereof.

Fig. 7 is a top view of the valve-stem-cross-head-driving-block, Fig. 8 an end view of the top portion of the same, Fig. 9 a side view of the top portion of same, Fig. 10 a side view of the bottom portion of same, and Fig. 11 a plan of the bottom portion of same.

Fig. 12 is an end view of one of the slides, Fig. 13 a top view thereof, and Fig. 14 a side view thereof.

Fig. 15 is an end view of the valve-stem-cross-head, Fig. 16 a side view thereof and Fig. 17 a top view.

Similar figures refer to similar parts throughout all of the views.

A¹ is the cylinder, A² the piston adapted to reciprocate therein, A³ the piston rod, A⁴, the cross-head, A⁵ the connecting rod, A⁶, the cross-head guide, A⁷ the crank, A⁸ the eccentric crank, A⁹ the crank pin, A¹⁰ the driving shaft, in this case the axle of the driving wheel of the locomotive.

B¹ is the eccentric rod, pivoted at B² to the eccentric crank A⁸ and at B³, to the foot, B⁴, of the link B⁵, which is pivoted at the trunnion B⁶; B⁷ is the link bracket piece, which does not appear in Fig. 3, this part of the link structure having been removed so as to show the block B⁸, which is adapt-

ed to move back and forth inside the slot in the link B⁵. B⁹ is the radius rod, connected with the block B⁸ so as to be actuated thereby at the pivot B¹⁰. B¹¹ is the lifting arm, and is pivotally connected at one end at B¹², with a sleeve in which the radius rod B⁹ is adapted to slide and at the other end is fixed to the reversing arm B¹³, which turns on the reversing shaft B¹⁴, and is pivoted at B¹⁵ to the reach rod B¹⁶.

The radius rod B⁹ terminates, in the form shown, in a transverse cylindrical extremity, B¹⁷, designed to fit in between the forks B¹⁸ (see Fig. 4) which constitute the upper portion of the combination lever B¹⁹. The pin C²² passes through appropriate borings in the said extremity B¹⁷ of the radius rod B⁹, the combination lever and the blocks C²¹, forming the pivot by means of which the radius rod and combination lever are connected. Said combination lever B¹⁹ is pivoted at B²⁰ to the cross-head link B²¹ which in turn is pivoted at B²² to the cross-head arm A¹¹, fastened rigidly to the cross head A⁴.

The steam chest C¹ has a steam chamber C² in its interior, with a steam inlet-opening C³ and a valve cylinder C⁴ in which the valve piston C⁵ is adapted to reciprocate. Steam inlet ports C⁶, and steam exhaust ports C⁷, are provided in the wall of the steam chest C¹. To the valve piston C⁵ is attached the valve stem C⁸, which is rigidly connected to the valve-stem-cross-head C⁹ (see Fig. 4). This valve-stem-cross-head, as shown in Fig. 4 and also in Figs. 15, 16 and 17, has two deep wings or flanges having an inner clearance so that the valve-stem-cross-head-driving-block C¹⁰ fits in between. The said valve-stem-cross-head C⁹ also has slits in the sides thereof as shown at C¹⁰, and a projection C¹¹ which is bored for the reception of a pin, C¹², which passes through said projection C¹¹ of said cross-head C⁹, and also through the guide blocks C¹³. The slides C¹⁴, appearing in Fig. 4 and Figs. 12, 13 and 14, are adapted to slide on forks, B¹⁸, forming the upper end of the combination lever B¹⁹. Said slides are provided with cylindrical projections C¹⁵, and are bored so as to accommodate the pin C²⁰, which, with the projections C¹⁵, connects the two slides C¹⁴. The cross-head C⁹, and the slot C¹⁰, therein, are of such dimensions that the connections between the two slides, C¹⁴, easily slide in said slots.

The valve-stem-cross-head-driving-block C¹⁰, as shown in Figs. 1, 3, 4, 7, 8, 9, 10 and 11, is composed of an upper portion C¹⁷ and lower portion C¹⁸, and incloses a rectangular opening such that the suspended controlling bar, later referred to, can slide therein. The upper portion C¹⁷ has a lug or projection C¹⁹ thereon, of such dimensions that it slides in the slot C¹⁰ in the valve-stem-cross-head

C⁹. The valve-stem-cross-head-driving-block C¹⁰ also has a projection C²³ at the top, which is suitably bored so that the pin C²⁰ may pass through said boring.

The guide pieces B²³ are provided with grooves adapted for the blocks C¹³ and C²¹ to slide therein, the purpose of these guide pieces being to support the weight of the various parts nearby. To the guide pieces B²³, are attached the hangers B²⁴, at pivots B²⁵, and at B²⁶; the said hangers, B²⁴, are pivoted to the suspended controlling bar B²⁷. Said suspended controlling bar B²⁷ is connected by the shifting rod B²⁸, with a point on the reversing arm B¹³.

The operation of the device is as follows:

The piston being in position shown in Fig. 1, and the steam chamber C² being full of steam it will be seen that by reason of the "lead" shown at C²², some steam will be entering the cylinder behind the piston before the stroke begins. This amount by which the steam port is opened when the piston is at the end of its stroke is called "lead". It will be seen that any motion of the piston, through the piston-rod, cross-head, the connecting rod, crank, shaft and eccentric crank will produce a movement in the foot B⁴ of the link. It will also be seen that the position of the block in the link is capable of being shifted by moving the reversing arm with the reach rod, and that the position of the block in the link will determine the extent to which the rocking motion imparted to the link by the eccentric rod will cause motion in the radius rod; when the point of attachment between the block and the radius rod is in line with the axis of the attachment on which the link rocks, or is pivoted, then the rocking of the link will impart no motion to the radius rod. However, if the block is shifted off this point, the rocking motion of the link will impart motion to the radius rod, the extent of said motion varying with the position of the block. The reciprocating motion imparted to the radius rod will be communicated to its other extremity.

Any motion of the piston rod, as will be seen by reference to the drawings, results not only in motion tending to drive the shaft A¹⁰, but by reason of cross-head arm A¹¹ and the cross-head link B²¹, produces motion in the combination lever B¹⁹, which is, as before stated, pivoted to the radius rod B⁹. It will, therefore, be seen, that any point on the combination lever except the point where it is pivoted to the radius rod, will have motion similar to the motion which is being imparted through the radius rod, except that such motion is modified by the varying position of the combination lever B¹⁹.

Since the valve stem is driven from the combination lever, it receives from some

point in the combination lever a displacement which is equal to the displacement of that point in the combination lever, measured with reference to the axis of the valve stem; that is, the movement of the valve stem will be equal to that component of the motion of said point in the combination lever, which is parallel to the axis of the valve-stem. If the valve stem had been attached to the end of the radius rod, and the block occupied the position which it occupies in Fig. 1, it is evident that the "lead" shown at C⁹ would be different or would not exist at all, the said "lead" being due, as an examination of the drawing will show, to the inclination of the combination lever; that is, in the Walschaert type of valve gear, dependence for the necessary "lead" is placed on the combination lever to which the valve stem is attached. In the ordinary type of Walschaert valve gear, the motion of the valve piston and valve stem is governed by some one point of the combination lever to which it is attached, and the resulting "lead," after the apparatus is once adjusted, does not vary at all. No matter what the position of the block B⁸ is; no matter whether steam is admitted during the full length of the stroke or cut off at some intermediate point, the "lead" will be the same. The amount of the "lead" will, of course, vary with the ratio which exists between two distances, to wit, the distance from the center of the pivot B²⁰, where the combination lever is connected with the link B²¹ and the center of the pivotal connection between the combination lever B¹⁹ and radius rod B⁹ on the one hand, and on the other hand the distance measured along the combination lever from the center of said pivot C²³ between radius rod and combination lever and the point in the combination lever which controls the motion of the valve stem C⁸. In the ordinary Walschaert type of valve gear, these two distances are fixed and invariable after the machine is put together. In the applicant's device, this ratio is made variable, as will be seen, through the slide structure, which is adapted to slide along the combination lever and move with same so that a change occurring in the position of this slide structure brings it about that the motion of the valve stem corresponds to a new point in the combination lever, and produces a change in the ratio of the two distances before described.

In applicant's device, further, the shifting (along the combination lever) of the slide structure from which the valve stem is actuated, is produced by the rising or falling of the suspended controlling bar B²⁷, the rising or falling of which is brought about through the operation of the reversing lever B¹³, which is also the agency by which the cut-off of steam is regulated. Therefore applicant's device furnishes a means by which one

motion of the reach rod will at the same time produce a change as to the admission of steam into the cylinder, and a change in the amount of "lead" which is provided for.

With reference to the manner in which the raising or lowering of the suspended controlling bar B²⁷ actuates the sliding structure which controls the motion of the valve stem and the point in the combination lever whose motion controls the motion of the valve stem, reference to Fig. 4 will show that a raising of the suspended controlling bar B²⁷, which slides in the valve stem-cross-head-driving-block C¹⁶, raises the pin C²⁰ and slides C¹⁴, which will move in the slot C¹⁰ in the side wings of the cross-head C⁹ so that the motion of the combination lever, being communicated to the slide C¹⁴, will operate against the sides of the slot C¹⁰ at a higher point than before and therefore at a point which is closer to the pivot point between the radius rod and combination lever.

In the form of apparatus shown, the adjustment is such that when the block B⁸ is at either extremity of the slot the motion of the radius rod has a maximum travel, and steam will be admitted to the cylinder through the entire stroke; when the block is in either of these positions, the suspended controlling bar is at its highest. This being true, the point in the combination lever whose motion determines the motion of the valve stem is closer to the pivot pin C²³ than it will ever get otherwise. Therefore, when the block is in either of these extreme positions the "lead" will be least. As the block is moved toward the pivot of the link, the limits of travel of the valve piston C⁹ diminish, and the steam is cut off before the stroke is finished. It is evident that as the block is moved toward the pivot of the link, the controlling bar B²⁷ will descend, until the lead will be maximum at mid position.

The principal utility of "lead" in steam engines consists first in the fact that it provides a cushioning effect against battering by reciprocating parts at extreme positions, the steam admitted in advance serving to soften the thrust of the piston; and secondly, in securing a large steam opening during the period when the piston requires more steam; that is, at the early portion of its stroke, thus giving steam in the cylinder at a higher pressure than would be the case if there had been no "lead." The need for the cushioning effect is greatest when the engine is running at high speed, and as the block, when the engine is running at high speed, would not be placed or kept at the extreme position at the bottom or top of the link, but at a point nearer the trunnion than the end of the slot, the applicant's device provides the greater "lead" in that position of the block in which greater "lead" is desirable. Experience has proved that to maintain a

constant "lead" of the same extent as is necessary and useful at high speed, is not satisfactory or economical; therefore applicant's device by which the "lead" can be varied according to the part of the stroke at which the steam is cut off is valuable and adds to the effectiveness and economy of the engines to which it is applied.

I am aware that structures have been devised wherein the ratio between the two parts of the combination lever referred to above has been variable, but I am not aware of any device similar to mine. It is to be especially noted that in my device as illustrated the combination lever and radius rod are pivoted so that the pivoting occurs always at the same point of the combination lever and the same point at the radius rod, and that the means for varying the ratio referred to above consists of a connecting structure interposed between the valve stem structure (that is, the valve stem and the cross-head attached thereto, and the combination lever) and that the means which are employed to vary the position of this connecting structure or slide structure with reference to the combination lever, are independent of the combination lever, operating by direct contact with the said connecting structure.

In applicant's device, the relative position of the said connecting means and the combination lever does not depend upon the combination lever, but upon separate means, independent of the position of the combination lever. It provides an adjustable connection between the movable part of the valve and the combination lever, involving the slide structure mentioned above, this slide structure being raised and lowered according to the position of the suspended controlling bar, which engages it. Applicant's device is more useful, more durable, and more easily operated and repaired than any device wherein the adjustment depends upon a raising or lowering of the combination lever, because such attachment to the combination lever for the purpose of raising or lowering, interferes with the free movement of the combination lever, and renders the device more complicated. Applicant's device is also superior to any device wherein the connection between the combination lever and radius rod requires the use of a slot, instead of a simple pivot. It is evident that the use of said slot at the pivot makes it impossible for the ends of the radius rod to be at all times equally distant from the ends of the reversing link, and this inequality will result in having a different lead when the piston is at the front end of the cylinder from that which occurs when the piston is at the other end of the cylinder. An examination will disclose that in applicant's device the parts which are neces-

sarily made heavy are simple in construction and free from complication, the necessary complication occurring, in applicant's device, with reference to the smaller and lighter parts.

In the forms hitherto known in which the combination lever is lifted in effecting the change of ratio above referred to, a change was necessarily involved in the relative position of the combination lever and the two members to which it is pivoted, and both of said members are necessarily caused to move when a change of adjustment is made. All of these parts sustain heavy stresses and are necessarily very heavy, requiring great force to lift or move them. It is found that in applicant's device, the power required for shifting is only a very small fraction of the power required in the other case, because, as explained, the parts to be moved are small and light, and it is also found that the operation of applicant's shifting device does not change the position of the combination lever as regards the cross-head link B²¹ or radius rod B². The use of the older form has never been general because of the existence therein of the defects which applicant's device avoids.

I claim as new and desire to protect by Letters Patent the following:

1. In a valve gear for reciprocating steam engines having a piston, principal shaft, and a valve having stationary and movable parts, the combination of a radius rod, a combination lever pivotally connected therewith, means for driving said radius rod and regulating the limits of travel of said radius rod, means for communicating motion and force from the piston to the combination lever, a valve-stem-cross-head connected with the movable parts of the valve, a slide structure slidable on the combination lever, and adapted to actuate said valve stem cross-head, in combination with means adapted to engage said slide structure and thereby change the position of said slide structure.

2. In a valve gear for reciprocating steam engines having a piston, principal shaft, and a valve having stationary and movable parts, the combination of a radius rod, a combination lever pivotally connected therewith, means for driving said radius rod and regulating the limits of travel of said radius rod, means for communicating motion and force from the piston to the combination lever, a slide structure adapted to move with the combination lever and slide thereon, a valve stem fixed to the movable part of the valve, a valve stem cross head fixed to the valve stem, said cross head having a slot of such position and dimensions that as the slide structure slides along the combination lever, a portion of the slide structure will slide in said slot, and so that any movement of the slide structure which has a component in the

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direction of the axis of the valve stem, will cause a motion of said cross-head equal to said component.

3. In a valve gear for reciprocating steam engines having a piston, principal shaft, and a valve having stationary and movable parts, the combination of a radius rod, a combination lever pivotally connected therewith, means for driving said radius rod and regulating the limits of travel of said radius rod, means for communicating motion and force from the piston to the combination lever, said combination lever being forked near the point at which it is pivoted to the radius rod, slides, a rod connecting the same, a valve stem fixed to the movable part of the valve, a valve stem cross head fixed to said valve stem and having slots in which the connections of said slides are adapted to move.

4. In a valve gear for reciprocating steam engines having a piston, principal shaft, and a valve having stationary and movable parts, the combination of a radius rod, a combination lever, pivotally connected therewith, means for driving said radius rod and regulating the limits of travel of said radius rod, means for communicating motion and force from the piston to the combination lever, a valve-stem-cross-head, movable parts, slidable on the combination lever and adapted to actuate the valve stem cross-head, a controlling bar so formed and placed as to engage said slidable movable part, and determine the position thereof, said shifting rod being connected with the means of driving and regulating the radius rod.

5. In a valve gear for reciprocating steam engines having a piston, principal shaft, and a valve having stationary and movable parts, the combination of a radius rod, a combination lever pivotally connected therewith, means for driving said radius rod and regulating the limits of travel of said radius rod, means for communicating motion and force from the piston to the combination lever, a slide structure adapted to move with the combination lever and slide thereon, a valve stem fixed to the movable part of the valve, a valve stem cross head fixed to the valve stem, said cross head having a slot of such position and dimensions that as the slide structure slides along the combination lever, a portion of the slide structure will slide in said slot, and so that any movement of the slide structure which has a component in the direction of the axis of the valve stem, will cause a motion of said cross head equal to said component and means for so actuating said slide structure that any change in the limits of travel in the radius rod will produce a change in the position of said slide structure with reference to the combination lever.

6. In a valve gear for reciprocating steam

engines having a piston, principal shaft, and a valve having stationary and movable parts, the combination of a radius rod, a combination lever pivotally connected therewith, means for driving said radius rod and regulating the limits of travel of said radius rod, means for communicating motion and force from the piston to the combination lever, said combination lever being forked near the point at which it is pivoted to the radius rod, slides, a rod connecting the same, a valve stem fixed to the movable part of the valve, a valve stem cross head fixed to said valve stem, and having slots in which the connections of said slides are adapted to move and means for so actuating said slide structure that any change in the limits of travel in the radius rod will produce a change in the position of said slide structure with reference to the combination lever.

7. In valve gear for reciprocating engines having pistons, principal shafts, valves and valve stems, an eccentric crank, a pivoted link, means for rocking said link as the eccentric crank revolves, a block slidable in said link, a radius rod pivotally connected with said block, a lifting arm, means for connecting said rod and lifting arm, a reversing arm, a controlling bar shifting rod, said reversing arm being fixed to said lifting arm, and pivotally connected at one point with the reach rod, and at another with the controlling bar shifting rod, a suspended controlling bar pivotally connected with the shifting rod aforesaid, hangers supporting said suspended controlling bar, a combination lever, pivotally connected to the radius rod, means for actuating said combination lever from the motion of the piston rod, a structure slidable along the combination lever, means for connecting said structure with the valve stem so that any motion of same along the axis of the valve stem will be communicated to said valve stem, and means for causing said slidable structure to move along the combination lever according as the suspended controlling bar rises or falls.

8. In a valve gear for reciprocating steam engines, having pistons and principal shafts, a radius rod, means for actuating same from the principal shaft, a pivoted link, a block movable therein, means for shifting the position of said block, means for connecting said block with the radius rod, means for moving the suspended controlling bar so as to vary its distance, within limits, from the radius rod, said means being connected and actuated so that the position of the controlling bar changes when the position of the block changes, a combination lever pivoted to the radius-rod, means for actuating said combination lever from the piston, means for actuating the valve stem so that its motion equals the displacement of some point in the combination lever so far as said dis-

placement is in the direction of the axis of the valve stem, and means for so connecting the suspended controlling bar and the valve-stem-actuating-means that when the suspended controlling bar moves so as to vary its distance from the radius-rod, such movement will cause a movement of the

valve-stem actuating means along the combination lever.

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Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."