May 11, 1948. J. KIRCHHOF ET AL 2,441,199

ROTARY CAM MECHANISM FOR ACTUATING THE VALVES OF LOCOMOTIVES

Filed March 6, 1944 4 Sheets-Sheet 1

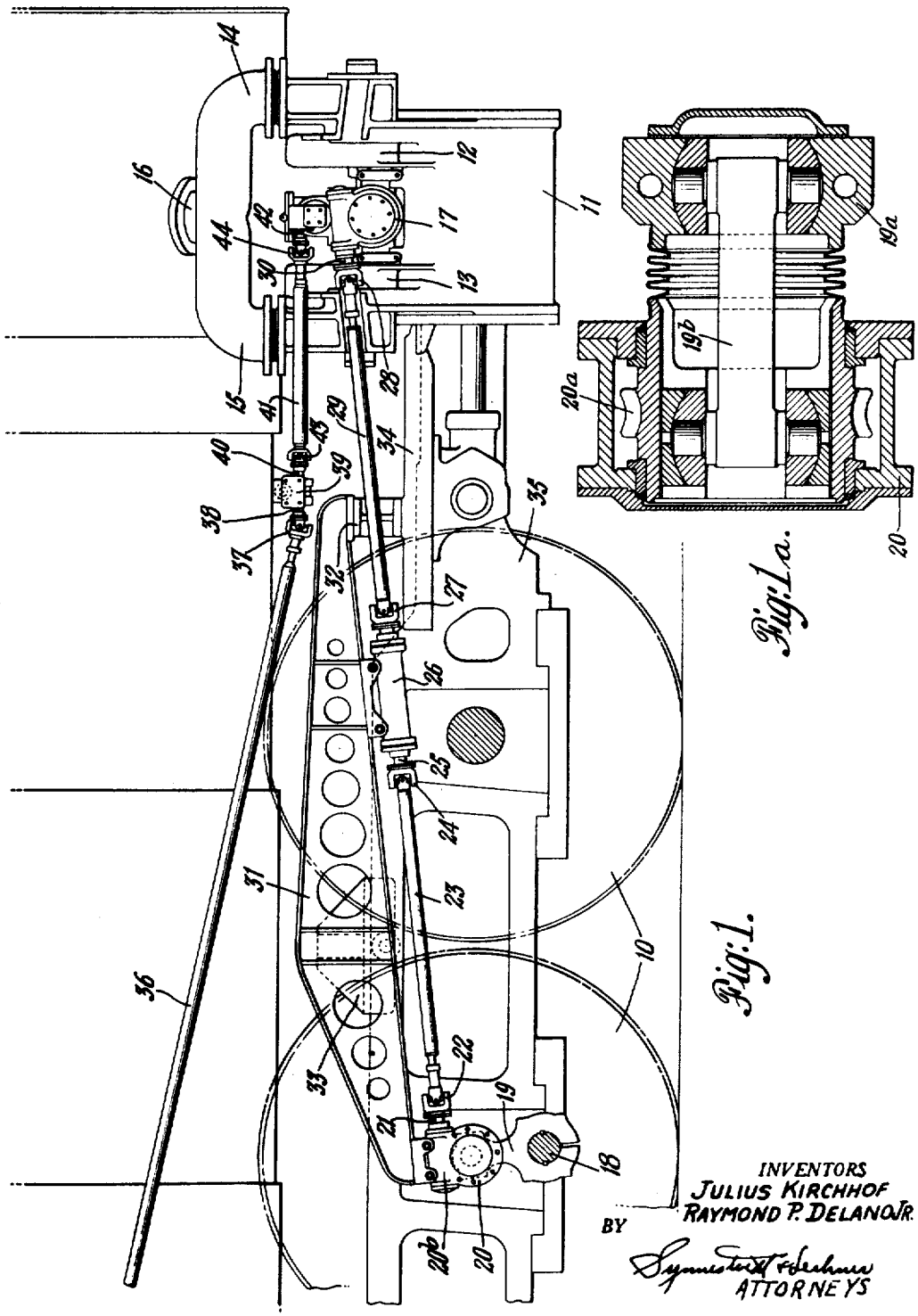

Fig. 1a.

Fig. 1.

INVENTORS
JULIUS KIRCHHOF
RAYMOND P. DELANO JR.
BY
Symmes Stern & Eberhardt
ATTORNEYS

May 11, 1948. J. KIRCHHOF ET AL 2,441,199

ROTARY CAM MECHANISM FOR ACTUATING THE VALVES OF LOCOMOTIVES

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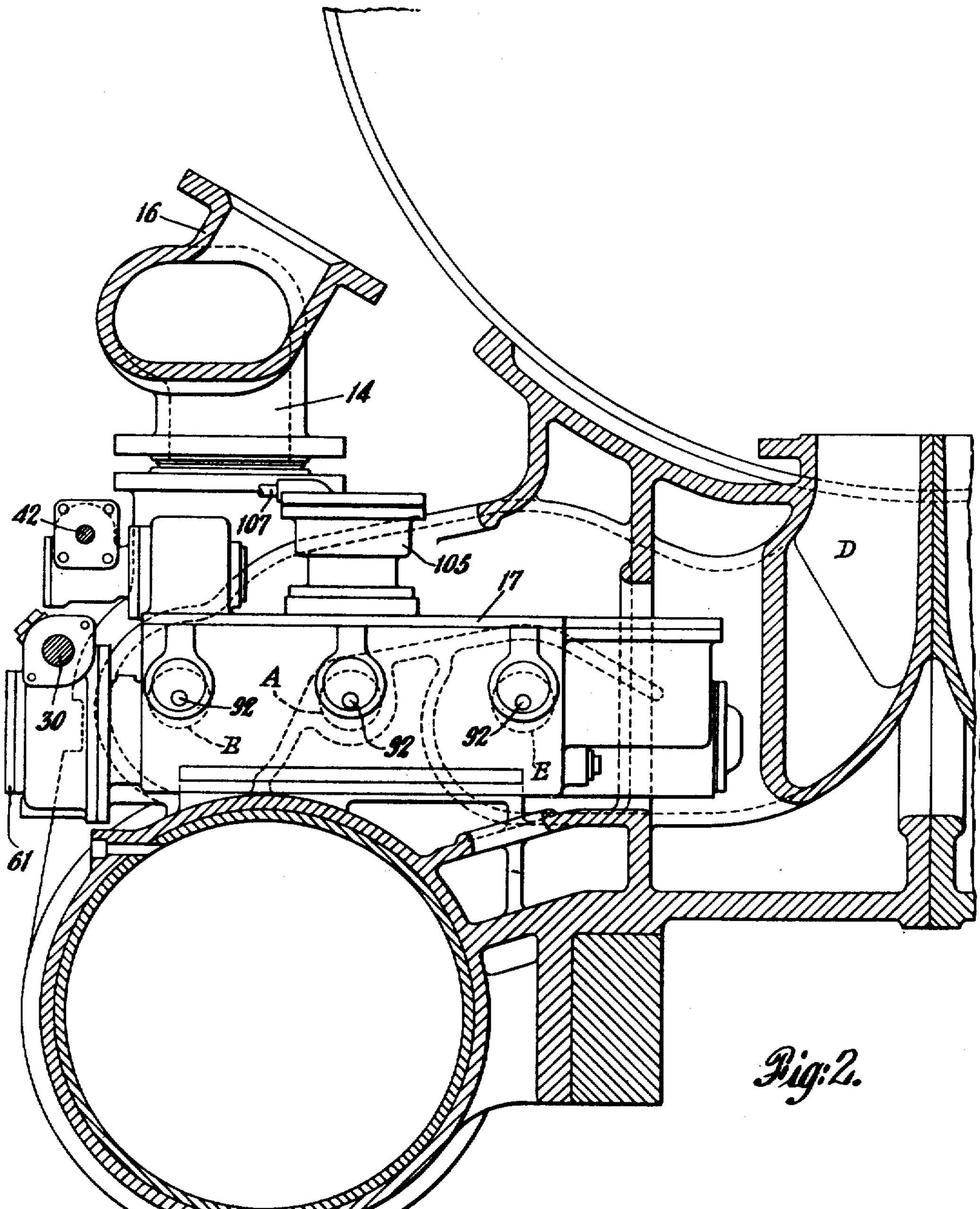

Fig. 2.

INVENTORS
JULIUS KIRCHHOF
RAYMOND P. DELANO JR.
BY Symmes, Kirk & Lechner
ATTORNEYS

May 11, 1948. J. KIRCHHOF ET AL 2,441,199

ROTARY CAM MECHANISM FOR ACTUATING THE VALVES OF LOCOMOTIVES

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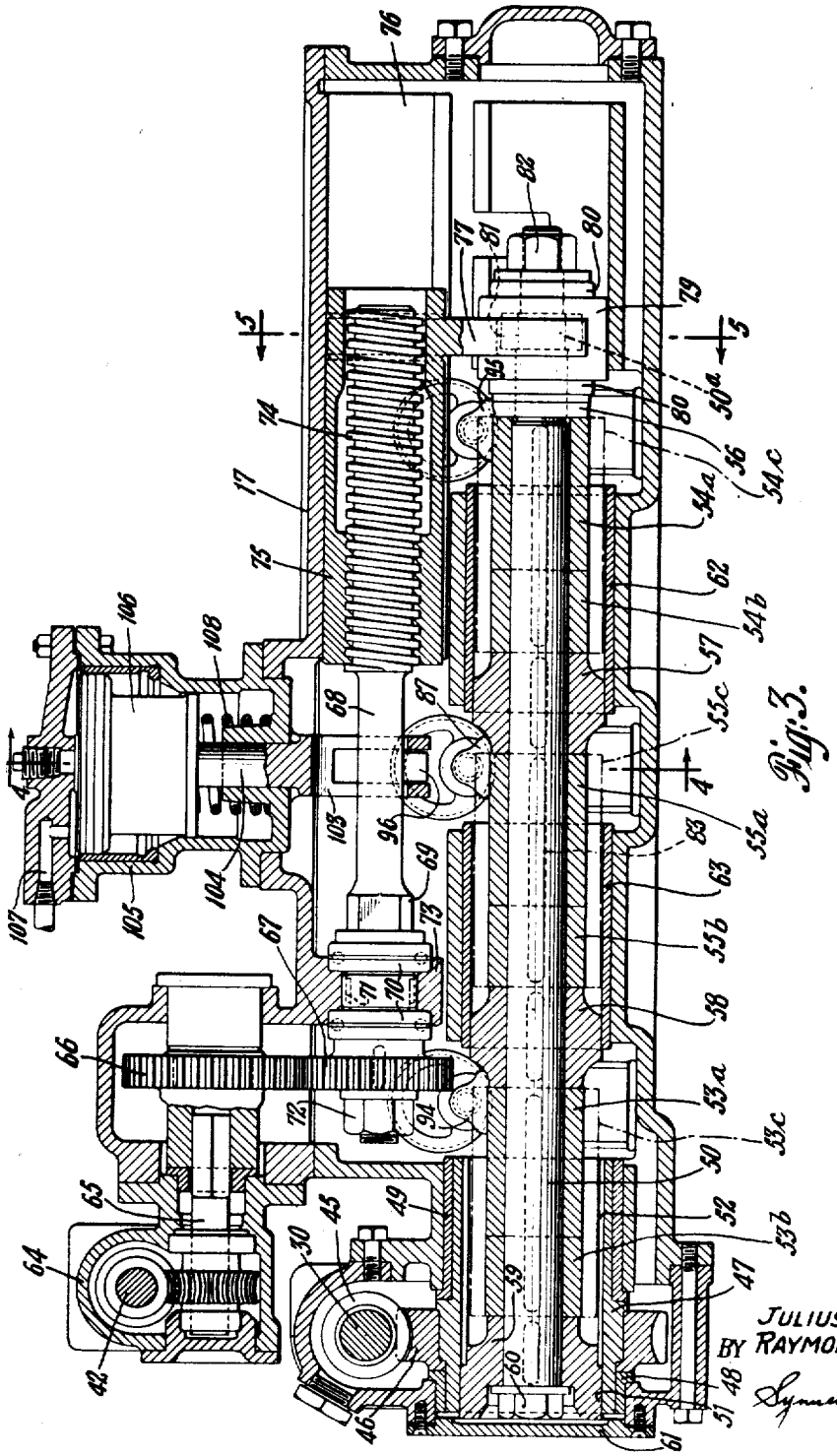

Fig. 3.

INVENTORS
JULIUS KIRCHHOF
BY RAYMOND P. DELANO JR.
Synnestvedt & Lechner
ATTORNEYS

May 11, 1948. J. KIRCHHOF ET AL 2,441,199

ROTARY CAM MECHANISM FOR ACTUATING THE VALVES OF LOCOMOTIVES

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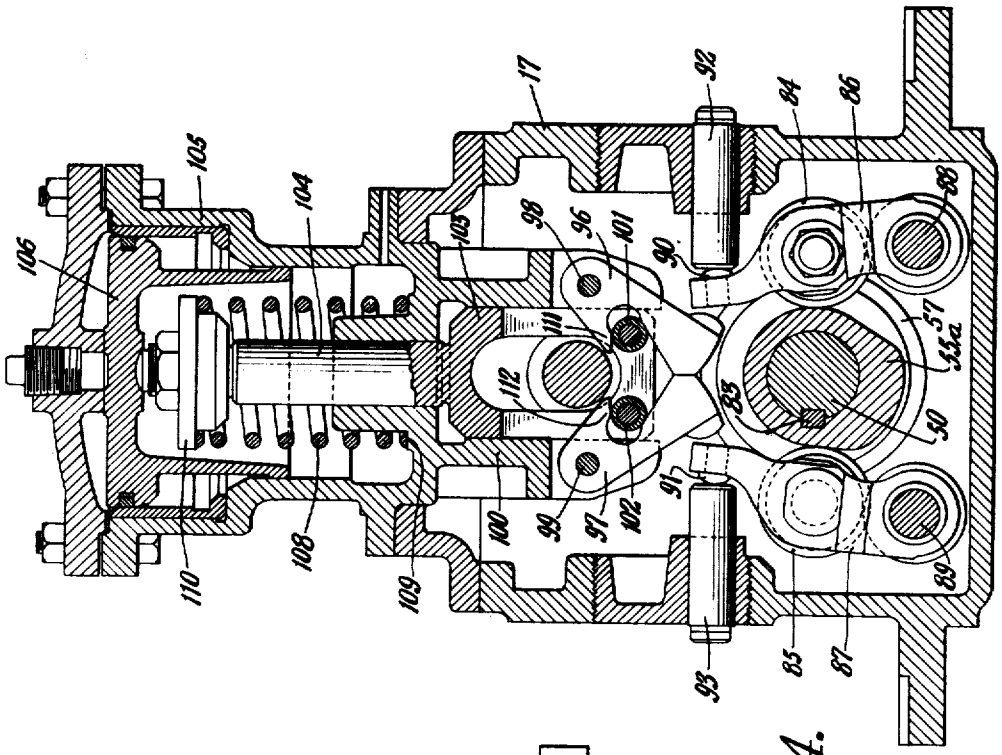

Fig. 4.

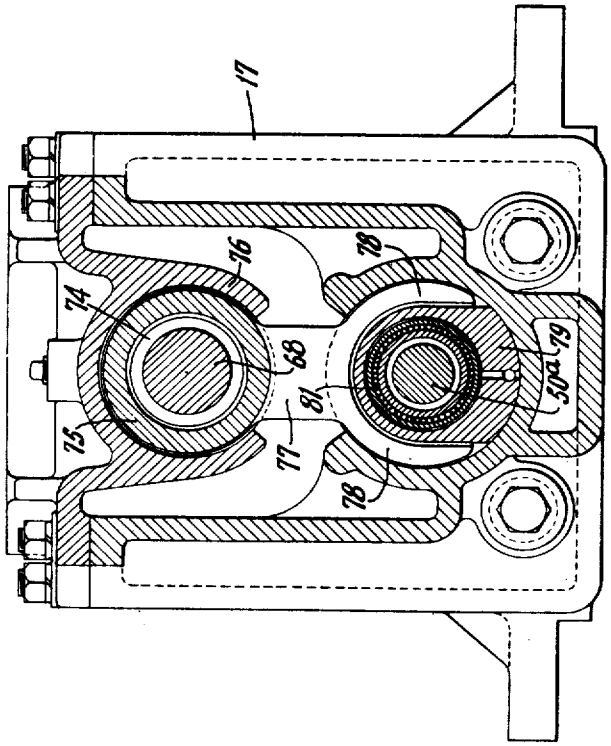

Fig. 5.

INVENTORS
JULIUS KIRCHHOF
RAYMOND P. DELANO JR.

BY Szymanski & Liebman
ATTORNEYS

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UNITED STATES PATENT OFFICE

2,441,199

ROTARY CAM MECHANISM FOR ACTUATING THE VALVES OF LOCOMOTIVES

Julius Kirchhof, Ruxton, and Raymond P. Delano, Jr., Baltimore, Md., assignors, by mesne assignments, to Franklin Railway Supply Company, New York, N. Y., a corporation of Delaware

Application March 6, 1944, Serial No. 525,180

13 Claims. (Cl. 121—167)

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This invention relates to locomotives and is particularly concerned with cam actuating mechanism for poppet-type steam distributing valves of locomotive engines.

The structure with which the invention is principally concerned is a cam mechanism including a cam box incorporating valve actuating cams and also various driving and controlling devices associated therewith, many of the individual parts having features of novelty and improvement, and the box with its associated parts being arranged for unitary mounting on and removal from a locomotive cylinder.

The cam actuating mechanism according to the present invention is particularly adapted for cooperation with an arrangement of steam passages and valves of the type disclosed in copending application of Julius Kirchhof, Serial No. 525,182, filed concurrently herewith, in which three poppet valves are located toward each end of each cylinder, the center valve of each group of three being an intake valve and the other two being exhaust valves. A cam actuating mechanism according to the invention, including the cam box thereof, is adapted to be mounted on each cylinder between the groups of valves which are disposed toward opposite ends of the cylinder, the cam mechanism including actuating parts adapted to cooperate with the valves at both ends of that cylinder.

According to one aspect of the invention, rotative cams are employed, these cams being mounted on a cam shaft extended transversely of the cylinder and which is not only rotatable but which is axially shiftable for controlling the cut-off and other valve events and for reversing the operation of the engine. The invention provides driving mechanism for rotating the cam shaft which driving mechanism is associated with the cam shaft at the outer end thereof beyond the cams thereon.

In addition, controllable means are provided for shifting the cam shaft axially, this controllable means having its ultimate connection with the cam shaft at the inner end of the latter. Connection of the means for axially shifting the cam shaft at the inner end of the cam shaft has a number of advantages including the fact that an improved bearing arrangement for the cam shaft is thereby facilitated. Moreover, if desired, somewhat longer cams may be employed in this arrangement, than where the connection for shifting the cam shaft is coupled with the cam shaft between cams thereon.

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According to another feature, an actuating connection for the controllable means just mentioned is carried through the cam box from the inner end of the cam shaft to the outer end of the cam box and, at that point, is provided with readily separable coupling means to which an operating connection extended rearwardly to the cab of the locomotive may be attached. With this arrangement, and also with the driving means for rotating the cam shaft located at the outer end of the cam shaft, as is contemplated, all of the driving and operating connections are made readily accessible from the side of the locomotive without the necessity of gaining access to the necessarily cramped quarters between the boiler and the cylinder with its steam passages.

With further reference to the means for axially shifting the cam shaft, it is noted that the invention contemplates provision of a novel type of controllable means incorporating mechanism for taking end thrusts thereon. Thus, in the preferred construction, the actuating connection which extends from the outer end of the cam box to the inner end thereof, and is there coupled with the cam shaft, includes an irreversible rotative screw having associated therewith thrust bearings adapted to transfer thrust loads from the cam shaft to a fixed part of the cam box.

The invention still further contemplates employment of a locomotive drifting mechanism, i. e., a mechanism for holding intake valves open to prevent the development of substantial differences in pressure (and particularly to avoid vacuum conditions) in the opposite ends of the cylinders when coasting or "drifting," which drifting mechanism is associated with the cam box and located intermediate the inner and outer ends thereof.

Still further the invention provides novel lubrication features, in which connection it may be mentioned that certain of the actuating parts, including the intermediate levers which are associated with the cams are pivotally mounted close to the bottom wall of the cam box, thereby bringing these as well as other parts well downwardly

into the lubricant reservoir which is provided in the lower portion of the cam box.

An advantageous form of cam shaft drving means is also provided, as will further appear.

With the foregoing objects and advantages in mind, attention is now directed to the following description referring to the accompanying drawings, which illustrate a preferred embodiment.

In the drawings:

Figure 1 is a fragmentary side elevational view of the forward portion of a locomotive, the view showing in outline the right-hand cylinder of a 2-cylinder engine, and various parts of the cam actuating mechanism including the driving means and the operating shaft for the timing control;

Figure 1*a* is a sectional view through a portion of the driving means for the cam shaft;

Figure 2 is a transverse vertical sectional view through the left-hand cylinder and saddle casting, looking forwardly, and illustrating the cam box in elevation;

Figure 3 is a vertical sectional view through the cam box taken in a plane containing the axis of the cam shaft therein;

Figure 4 is a sectional view taken through the cam box as indicated by the line 4—4 on Figure 3; and

Figure 5 is a sectional view taken as indicated by the section line 5—5 on Figure 3.

As seen in Figure 1, the driving wheels of the locomotive are indicated in dot-and-dash lines at 10, one of the cylinders being shown at 11. The front and rear valve chests 12 and 13 are arranged above the cylinder, steam being delivered thereto through the branches 14 and 15 of the steam pipe 16.

As above mentioned, the cam box 17 is mounted above the cylinder 11 intermediate the front and rear valve chests 12 and 13 (see also Figure 2). The cam drive originates at the driving wheel with which the main crank pin 18 is associated, this crank pin being provided with a return crank arm 19, located laterally outside of the plane of the main rod and having an apertured and portion or eye 19*a* (see Figure 1*a*) which is centered on the driving wheel axis. A short shaft 19*b* serves to transmit the rotative motion from the return crank to a gear 20*a* which is journalled in the transmission box 20. The ends of shaft 19*b* are flexibly connected with the return crank eye 19*a* and with the gear 20*a* to provide freedom for universal angular movement, and in addition the end of the shaft 19*b* which is associated with the gear 20*a* (left end in Figure 1*a*) is also arranged to permit relative sliding movement axially of the gear. The transmission box 20 is fixedly mounted on the supporting bracket 31 and the flexible joints associated with drive shaft 19*b* serve to accommodate motion of the driving wheel and the return crank 19 which takes place relative to the fixed transmission box 20, for instance, when the driving wheel axle moves vertically in the pedestal jaws of the frame.

The gear 20*a* is adapted to mesh with a driven gear mounted in the casing part 20*b* of the transmission box (see Figure 1), this driven gear being connected with a shaft 21 projecting forwardly for connection with a universal joint 22 from which drive shaft 23 extends forwardly to another universal joint 24. This shafting is continued with shaft 25 which is journalled in a fixed bearing housed at 26. An additional pair of universals 27 and 28 at the ends of shaft 29 serve

to couple the shaft 25 with shaft 30 which projects into the cam box to drive the cams therein, in the manner more fully set out herebelow.

With regard to the transmission shafting, it is to be noted that it is of advantage, especially from the standpoint of smoothness of operation at high speeds, that this shafting is divided into sections with a fixed supporting bearing intermediate the ends (housed at 26). The transmission box 20—20*a* and the bearing housing 26 are advantageously carried by a common bracket support 31 which is supported as at 32 and 33 by members which are carried in turn by the main frame member 35.

It is also pointed out with reference to Figure 1 that the timing adjustments and the reversal of operation of the engine may be accomplished by the employment of a reverse gear, for example of the type disclosed in copending application of Raymond P. Delano, Jr., Serial No. 508,338, filed October 30, 1943. The forwardly extending connection from such a reverse gear is indicated in Figure 1 at 36. The forward end of shaft 36 is coupled through a universal 37 with a shaft 38 which projects rearwardly from a 3-way transmission box 39. Shaft end 40 projects forwardly from this box for coupling with the cam box at the right-hand side, and in addition a transverse shaft extends from transmission box 39 toward the left-hand side of the engine, at which side additional gearing is employed to carry a connection forwardly to the left-hand cam box, this latter connection being of the same type illustrated in Figure 1 for the right-hand side. Shaft 41 interconnects shaft end 40 with another shaft 42 projecting from the cam box, universals 43 and 44 being included in the connection.

The location of the cam box 17 just above the left cylinder is plainly shown in Figure 2. This figure also shows, in dotted outline, the location of the three valves provided at the forward end of the left cylinder, a pair of exhaust valves being indicated at E—E and an intermediate admission or intake valve at A. The exhaust steam passages extend inwardly toward the center line of the locomotive for discharge through a passage D which may deliver to an exhaust nozzle or the like in the smokebox, as is understood in this art.

The details of the arrangement of the intake and exhaust valves and steam passages need not be considered herein since the present invention does not reside in them per se. For a fuller disclosure of these parts reference may be made to the copending application of Julius Kirchhof, Serial No. 525,182, filed concurrently herewith, wherein said valve and steam passage arrangement is claimed.

Turning now to the structure of the cam box as shown in Figure 3, attention is first called to the cam drive shaft 30 at the left end of the figure. This shaft carries a worm 45 meshing with a worm wheel 46 which is fixed on a sleeve 47, the sleeve being journalled in liners 48 and 49. The cam shaft 50 extends lengthwise through the cam box and is adapted to be driven from the sleeve 47 by inter-fitting spline elements 51 and 52 which are provided in order to permit the cam shaft and the cams and other parts carried thereby to move axially in the cam box, without interrupting the rotation effected by the drive.

The several cams and other parts which are mounted on the cam shaft are arranged to be serially placed thereon in end to end relation. Since, as above noted, the mechanism herein il-

lustrated is adapted to cooperate with groups of valves each incorporating two exhaust valves and one intake valve at each end of each cylinder, the cam shaft carries three cams or groups of cams, which serve to actuate the exhaust and intake valves at opposite ends of the cylinders in pairs. Preferably, the cam shaft carries three groups of cams, each group including a forward cam and a reverse cam. The group of forward and reverse cams for one of the exhaust valves is indicated at 53*a* and 53*b*, respectively, at the left end of the shaft, the other exhaust valve group being shown at 54*a* and 54*b* at the right-hand end. The group for the intake valves shown at 55*a* and 55*b*, is located intermediate the exhaust cam groups 53*a*—53*b* and 54*a*—54*b*. Dot-and-dash lines 53*c*, 54*c* and 55*c* have been applied to indicate the maximum radius of the cam lobes in any position thereof about the axis of the cam shaft. Between the cam groups 54*a*—54*b* and 55*a*—55*b* is an annular bearing part 57, a similar bearing part 58 being positioned between cam groups 55*a*—55*b* and 53*a*—53*b*.

At the right end of the cams, the cam shaft carries a spacer sleeve 56 and at the left end a part 59 is arranged, the latter being that on which the spline elements 51 are formed. The assemblage of cams and intermediate bearings is adapted to be clamped in position between the nut 60 threaded onto the end of the cam shaft and another nut at the opposite end described hereinafter. Nut 60 is arranged just inside a removable cover 61 which provides for ready access to and for convenient withdrawal and insertion of, the cam shaft assembly.

The bearing parts 57 and 58 which alternate in position with the cam groups lengthwise of the cam shaft are adapted to provide support for the cam shaft intermediate its ends, these bearing parts having external bearing surfaces complementary to the internal surfaces of bearing sleeves 62 and 63. The radius of the bearing surfaces between the bearing parts 57—62 and 58—63 is slightly larger than the highest cam peak, in view of which the cams may telescope within the bearing sleeves 62 and 63 upon movement of the cam shaft. This arrangement of parts not only provides effective bearing support for the cam shaft intermediate its ends and even intermediate the cams, but accomplishes this without the necessity for greatly extending the length of the cam shaft. Still another advantage of the arrangement just described is the fact that a point of bearing support for the cam shaft is provided relatively close to each point at which a cam follower cooperates with any particular cam. The intermediate levers are also shown in Figure 3 but are described more fully below in connection with Figure 4.

Attention is now directed to the mechanism employed for adjusting the cut-off and other valve events and reversing the operation of the engine, i. e., the mechanism providing for longitudinally shifting the position of the cam shaft. Toward the left end and at the top of Figure 3 the rotative connection 42 from the reverse gear is indicated as being mounted in a gear-box 64. Gearing arranged within this box is adapted to couple shaft 42 with shaft 65 which carries spur gear 66 meshing with another spur gear 67 which is fixed to the threaded shaft 68. Shaft 68 has an abutment shoulder 69 adapted to position thrust bearings 70—70 and a radial bearing 71, these parts, together with gear 67, being clamped against shoulder 69 by means of a nut 72. End

thrust of shaft 68, therefore, is transmitted through one or the other of bearings 70—70 to the fixed bearing support 73.

Shaft 68 has a threaded end portion 74 cooperating with a complementarily threaded slidable member 75 which is arranged to move axially of the screw thread 74 in a slotted sleeve 76 (see Figure 5). The lower portion of sleeve 76 is cut out as clearly appears in Figure 5 so as to accommodate the downwardly projecting fork member 77. The prongs 78—78 of this fork are received in a complementarily formed groove in a block 79 which is centrally apertured to pass an extension 50*a* of the cam shaft 50. This block cooperates with thrust bearings 80—80 and also with a radial bearing 81, the bearing parts being secured on the cam shaft by means of a nut 82 threaded onto the extremity of the shaft extension. The two nuts 60 and 82, at opposite ends of the cam shaft, cooperate in securing all of the intermediate parts on the cam shaft.

The mechanism described above serves to shift the cam shaft axially and it may be noted in this connection that the threading between parts 74 and 75 is preferably of such pitch as to be irreversible, in view of which any axial loads arising in the operation of the cam shaft are transmitted to the forked member 77 and from there through the threaded parts 74 and 75 to the shaft 68, such loads then being delivered through one or the other of thrust bearings 70 to the fixed cam box casing. In this way all thrust loads are effectively taken through thrust ball bearings and in addition no such loads can be transmitted back beyond the bearings 70—70 to the actuating connections which are extended therefrom rearwardly to the reverse gear in the locomotive.

Returning again to the cam groups 53*a*—53*b*, 54*a*—54*b* and 55*a*—55*b*, it is to be understood that these cams may be of any one of several different shapes or types, for instance the stepped type shown in copending Delano application Serial No. 508,338, above mentioned, or cams of continuously varying contour. The cams preferably employed herein are of the continuous type and it may be mentioned that an adjustment mechanism incorporating an irreversible screw and thrust bearings as above described, is especially useful when employing continuous cams, since this type of cam sets up certain end thrusts which are not encountered when employing other types.

In addition to being clamped together endwise of the cam shaft, the cams are also keyed to the cam shaft, such a key being indicated at 83 in Figure 4, this figure being taken through the intake cam 55*a*.

Pairs of cam rollers 84 and 85 are arranged to cooperate with the cam group 55*a*—55*b*, as is shown in Figure 4. These rollers are of appropriate shape, such as spherical or cylindrical, depending upon the nature and shape of the cams employed. The cam rollers are carried by intermediate levers 86 and 87 pivotally mounted at 88 and 89, the upper end of the levers carrying abutments 90 and 91 adapted to engage the tappets 92 and 93 which in turn transmit the motion to the valve stems in order to open the valves according to the setting of the reverse gear.

Similar pairs of intermediate levers and cam rollers are arranged to cooperate with the groups of exhaust cams 53*a*—53*b* and 54*a*—54*b*, one of each of these pairs of intermediate levers being indicated at 94 and 95 in Figure 4.

With respect to the intermediate levers, note that they are all mounted by pivots located closely adjacent the bottom of the cam box, which is of importance since it permits location of the poppet valves themselves close to the cylinder, and at the same time provides for effective lubrication, the bottom portion af the cam box being utilized as a lubricant reservoir.

As is seen in Figure 1, the cam box is disposed between the front and rear valve chests 12 and 13, and in view of this disposition of the box, the several sets of tappets, such as those indicated at 92 and 93 in Figures 2 and 4 project forwardly and rearwardly to cooperate respectively with the valve stems in the front and rear valve chests.

For the purpose of holding the intake valves open, and thereby providing for drifting operation of the engine, a mechanism of the type shown in Figure 4 is employed, including a pair of arms 96—97 which are pivotally mounted at 98 and 99 on a fixed structure 100. These arms are adapted to be urged outwardly thereby engaging behind the upper ends of the intermediate levers 86 and 87 so as to separate the cam rollers from the cam and push the tappets 92 and 93 outwardly to open the intake valves. This outward movement of arms 96 and 97 is accomplished by means of pins 101 and 102 which are carried and adapted to be moved vertically by a yoke 103 depending from the lower end of a rod 104 projecting upwardly into cylinder 105 for piston 106. Admission of pressure to the cylinder 105 through port 107 (see Figure 3) urges the piston 106 downwardly, thereby moving the shaft 104 and yoke 103 downwardly. Return movement of the piston and shaft 104 takes place, upon exhaust of fluid pressure through port 107, by means of a return spring 108 expansively reacting between a fixed abutment 109 and an abutment ring 110 which is secured to the shaft 104 at the upper end thereof.

The arms 96 and 97 are provided with projections 111 and 112 with which the pins 101 and 102 cooperate upon upward movement thereof in a manner to hold the swinging arms out of contact with the intermediate levers when the drifting mechanism is not in operation, thereby insuring against contact of these arms with the intermediate levers during normal operation of the valves.

The drifting mechanism just described is disclosed and claimed in copending application of Raymond P. Delano, Serial No. 525,181, filed concurrently herewith, which issued as Patent No. 2,383,534 on August 28, 1945.

Turning now to the general arrangement of the cam box and the cams therein, and to the relation of these parts to the valve chests and valves, one important point to note is that as above mentioned many features of the cam arrangement herein disclosed are particularly adapted to an engine having two exhaust valves and one intake valve at each end of each cylinder. Moreover, the cam mechanism above described effectively cooperates with a valve arrangement in which the intake valve at each end of each cylinder is located between two exhaust valves. It is especially noted that the arrangement of the invention avoids the use of multiple upper and lower cam shafts and/or upper and lower sets of tappets, cam rollers, intermediate levers and the like, all of these parts, as fully described above, being arranged in a single set located close to the bottom of the cam box in which, moreover, the oil level may readily be kept high enough to effectively lubricate all of the parts, either by actual submersion in the oil or by splashing incident to rotation of the cam shaft. This results in elimination of the necessity for a special lubricating pump, as has been employed in various prior cam box arrangements, the rotating cam shaft and the cams carried thereby adequately serving to circulate and splash the lubricant even up to the cut-off adjustment shaft 68 and the working parts associated therewith, such as the screw 74, bearings 70 and 71, and gear 67.

With further reference to the arrangement of the valves (employment of two exhaust valves and one intake valve at each end of each cylinder) it is also pointed out that the disposition of the intake valve between the two exhaust valves not only has a number of advantages pointed out in said copending application of Julius Kirchhof filed concurrently herewith, but has additional advantages in the relationship of these valves with parts in the cam box. In this connection it is to be observed that the drifting mechanism is most effectively located intermediate the ends of the cam box in an arrangement of the type shown in Figure 3 wherein the cam drive and cut-off control connections are coupled with the cam shaft toward the ends thereof. Location of the drifting mechanism (which, of course, must be associated with the intake valves) intermediate the two ends of the cam box thus avoids unnecessary complication of parts as would result were the drifting mechanism disposed in the vicinity of the cam shaft drive or the screw and connected parts for shifting the cam shaft axially.

The above described arrangement of various parts of the cam mechanism, including the connection of the drive means at one end of the cam shaft and the connection of the cut-off control at the other end of the cam shaft is of advantage since it makes possible keeping the several cams relatively close together along the cam shaft, and may even permit lengthening the cams, which in turn permits use of less steep angles on the cam surfaces.

We claim:

1. In a locomotive engine having poppet-type steam distributing valves including a group of such valves located adjacent an end of a cylinder in side-by-side relation transversely of the locomotive, cam mechanism for actuating the valves including a cam box, a cam shaft extended transversely of the locomotive with its inner end extended inwardly beyond a vertical plane containing the cylinder axis, the cam shaft being positioned adjacent the valves and mounted in the box for movement about its axis and for movement along its axis transversely of the cylinder, a plurality of cams carried by the cam shaft for actuating the several valves, and mechanism for controllably shifting the cam shaft axially including control connections coupled with the cam shaft at a point inboard of the vertical plane containing the cylinder axis adjacent the inner end of the cam shaft, said control connections being extended from said point outwardly through the cam box beyond the vertical plane containing the cylinder axis to a point adjacent the outer end of the cam shaft and thence through a wall of the cam box, and operating means for said connections separably coupled therewith adjacent the outer end of the cam box.

2. In a locomotive engine having poppet-type

steam distributing valves including at one end of a cylinder at least three valves at least one of which is an intake valve and is located between vertical planes passing through the other valves, cam mechanism for actuating the valves including a cam shaft extended transversely of the cylinder axis and mounted for movement about its own axis and for axial movement, a plurality of cams arranged along the cam shaft and movable therewith, driving means for moving the shaft about its axis, the driving means being connected with the cam shaft toward one end thereof beyond the cams, controllable means for axially moving the cam shaft, said controllable means being connected with the cam shaft toward the other end thereof beyond the cams, the points of connection of said driving means and said controllable means with the cam shaft being spaced appreciably toward opposite sides of a vertical plane containing the cylinder axis, intake valve actuating means associated with a cam on the cam shaft intermediate the ends of the shaft, and a controllable drifting mechanism located intermediate said points of connection of the driving means and the controllable means with the cam shaft, the drifting mechanism including means adapted to cooperate with the intake valve actuating means to hold an intake valve in open position.

3. In a locomotive engine having poppet-type steam distributing valves for a cylinder spaced different distances from the vertical mid-plane of the locomotive, cam mechanism for actuating the valves including a cam box, a cam shaft extended in a direction transversely of the locomotive with its inner end extended inwardly beyond a vertical plane containing the cylinder axis and mounted in the cam box for rotative and axial movement, a plurality of cams arranged along the cam shaft and rotative therewith and adapted to cooperate with the respective valves, driving means for rotating the cam shaft connected therewith at a point outboard of the vertical plane containing the cylinder axis toward the outer end of the shaft beyond the cams, controllable means for axially moving the shaft, connected with the shaft inboard of the vertical plane containing the cylinder axis adjacent the inner end of the cam shaft beyond the cams, an actuating connection for said controllable means extended outwardly from the inner end of the cam shaft beyond the vertical plane containing the cylinder axis to a point adjacent the outer end of the cam shaft, the said actuating connection being mounted in association with the cam box, and operating means for said actuating connection separably coupled therewith adjacent the outer end of the cam box.

4. A construction in accordance with claim 3 and further including a mechanism providing for drifting operation of the locomotive, which mechanism is associated with the valve actuating mechanism in a plane intermediate the inner and outer ends of the cam shaft.

5. In a locomotive engine having poppet-type steam distributing valves, cam mechanism for actuating the valves including a cam box, a cam shaft mounted in the cam box for rotation and axial movement, a plurality of cams arranged along the cam shaft and rotative therewith, driving means for rotating the cam shaft connected therewith toward one end of the shaft beyond the cams, the driving means incorporating a slidable connection accommodating axial movement of the shaft, controllable means for axially moving the shaft, said last means being connected with

the shaft toward the other end thereof beyond the cams and including a thrust bearing accommodating rotation of the cam shaft, and means for transferring thrust loads from the cam shaft through said controllable means to the cam box.

6. In a locomotive engine having a cylinder with its axis extended fore-and-aft of the locomotive, poppet valve mechanism for the cylinder including cam actuating means for the valves comprising a cam shaft extended transverse the axis of the cylinder and mounted for movement about its own axis and also for axial movement and carrying valve actuating cams therealong, and means for adjusting the axial position of the cam shaft including a rotatable screw in spaced parallel relation to the cam shaft and extended at least in large part along the cams carried thereby without extensive projection beyond the cams in any position of axial adjustment of the cam shaft, a non-rotative travelling block in threaded engagement with the screw, and an operating interconnection between the block and the cam shaft adjacent one end of the latter including means accommodating movement of the cam shaft about its axis and further including thrust bearing means adapted to take thrust loads axially of the cam shaft.

7. In a locomotive engine having a cylinder with its axis extended fore-and-aft of the locomotive, poppet valve mechanism for the cylinder including cam actuating means for the valves comprising a cam box, a cam shaft extended transverse the axis of the cylinder and mounted in the cam box for movement about its own axis and also for axial movement and carrying valve actuating cams therealong, and means for adjusting the axial position of the cam shaft including cooperating screw and nut members mounted in the cam box with the axis of the screw offset from the cam shaft and extended at least in large part along the cams carried thereby without extensive projection beyond the cams in any position of axial adjustment of the cam shaft, said members having complementary irreversible threads, an operating connection between one of said members and the cam shaft adjacent one end of the latter including means accommodating movement of the cam shaft about its axis and further including thrust bearing means adapted to take thrust loads axially of the cam shaft, and thrust bearing means between the other of said members and the cam box, whereby axial loads on the cam shaft are transmitted through the irreversible threads of said members to the cam box.

8. A construction in accordance with claim 7 in which the threaded nut member is restrained as against rotation and is mounted for translational movement and in which the nut member is connected with the cam shaft.

9. A construction in accordance with claim 7 in which the screw member is rotative and is arranged parallel to the cam shaft, the nut member being restrained as against rotation and mounted for translational movement in a path paralleling the cam shaft, and the nut member further being connected with the cam shaft.

10. For a steam locomotive having a cylinder with at least two exhaust poppet valves and at least one intermediate intake poppet valve adjacent one end of the cylinder, cam actuating mechanism for the valves including a cam shaft serially carrying cams for cooperation with the respective valves, and, for each valve, a separate cam follower and actuating connection extended therefrom to the respective valve.

11. A construction according to claim 10, wherein said valves are all arranged substantially in a common plane, and wherein the several cams are of varying contour axially of the cam shaft and the cam shaft is axially shiftable to provide for adjustment of the valve events, an intermediate cam on said shaft being an intake cam in position to cooperate with the cam follower for said intake valve, and cams toward the two ends of said cam shaft being duplicate exhaust cams for cooperation with the followers for said two exhaust valves.

12. A construction according to claim 10 and further including a pivoted intermediate lever carrying the cam follower, the several levers all being pivotally mounted toward one side of the cam shaft.

13. A construction according to claim 12, wherein a box or casing encloses the cams and provides a lubricant reservoir in the lower portion of the casing, and said levers are all pivotally mounted in said reservoir.

JULIUS KIRCHHOF.
RAYMOND P. DELANO, JR.

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FOREIGN PATENTS

Number	Country	Date
386,187	Great Britain	Jan. 22, 1933

Certificate of Correction

Patent No. 2,441,199. May 11, 1948.

JULIUS KIRCHHOF ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 1, line 9, for the word "the" before "individual" read *these*; column 3, line 46, for "and portion" read *end portion*; column 6, line 75, for "Figure 4" read *Figure 3*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of July, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

11. A construction according to claim 10, wherein said valves are all arranged substantially in a common plane, and wherein the several cams are of varying contour axially of the cam shaft and the cam shaft is axially shiftable to provide for adjustment of the valve events, an intermediate cam on said shaft being an intake cam in position to cooperate with the cam follower for said intake valve, and cams toward the two ends of said cam shaft being duplicate exhaust cams for cooperation with the followers for said two exhaust valves.

12. A construction according to claim 10 and further including a pivoted intermediate lever carrying the cam follower, the several levers all being pivotally mounted toward one side of the cam shaft.

13. A construction according to claim 12, wherein a box or casing encloses the cams and provides a lubricant reservoir in the lower portion of the casing, and said levers are all pivotally mounted in said reservoir.

JULIUS KIRCHHOF.
RAYMOND P. DELANO, JR.

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