Chapter XXXVIII.—THE LOCOMOTIVE.

IN Fig. 3326 is shown a modern freight locomotive, the construction being as follows:

For generating the steam we have the boiler, which at the front end is firmly bolted to the engine cylinders, which are in turn bolted to the frames, while at the back end the boiler is suspended by the links B (one at each end of the fire box on each side of the engine).

The starting bar is shown in position to start the engine, and it is seen that the rod *a* and bell crank *b* are in such a position as to open the valve T, and thus admit steam from the dome to the pipe *e*, whence it passes through pipes *f*, *g* and *r* into the steam chest *i*, the slide valve V distributing the steam to the cylinder. The exhaust occurs through the exhaust port *d*, whence it passes up the exhaust pipe and out at the smoke stack.

The boiler is fed with water as follows:

The *feed pipe from the tender* supplies water to the injector,

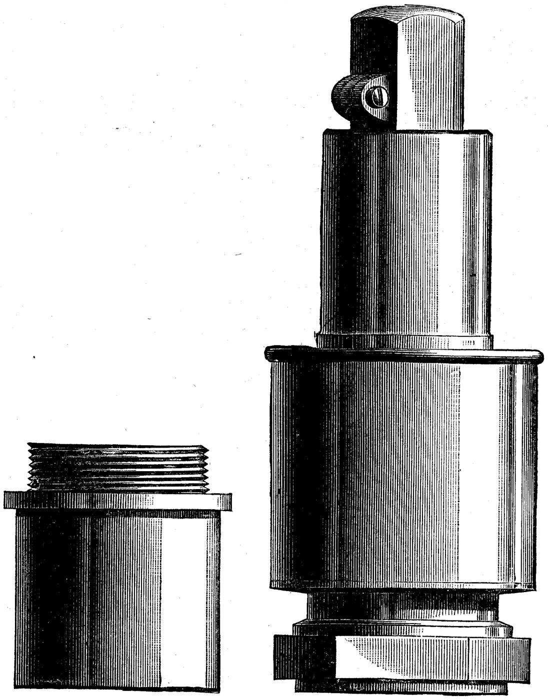


Fig. 3326*a*.

which is forced by the injector through the *feed pipe to boiler* and into the latter.

In the figure the parts are shown in position for the engine to go ahead, hence the reversing gear is in the extreme forward notch of the sector, and the valve gear is in full gear for the forward motion.

The lever *m* is for opening and closing the cylinder cocks, which are necessary to let the water of condensation out of the cylinder when the engine is first started and the cold cylinder condenses the steam.

To supply steam to the injectors (of which there are two, one on each side of the engine) and to the steam cylinder of the pump, there is a steam pipe leading from the dome to the steam drum, the pipe K supplying steam to the injector, and pipe J supplying steam to the steam cylinder of the air pump. The pipe for supplying oil to the slide valve and cylinder is furnished with a sight feed oil cup, the oil being carried by steam from the steam drum. This pipe passes beneath the lagging until it reaches the smoke box, which is done to keep it warm and prevent the oil from freezing, while the steam pressure enables the oil to feed against the steam pressure in the steam chest.

The slide valve is balanced by means of strips let into its back, and bearing against a plate fixed to the steam chest cover.

The frame on the side of the engine shown in the engraving is shown broken away from the yoke A to the fire box, so as to expose the link motion to full view, the shaded portion of the frame being that on the other side of the engine.

The yoke or brace A carries one end of the guide bars. The safety valve S may be raised to see that it is in working order, or to regulate the steam pressure, by the lever O, which has a ratchet tongue engaging with the notches at *l*.

In addition to the safety valve with spring balance, however, a pop safety valve is employed on the part of the dome that is shown broken away, the construction of this pop valve being shown in the outside view, Fig. 3326*a*, and a sectional view, Fig. 3326*b*, the casing being removed from the latter. In the valve seat B is a recess *a*, and upon the circumference of the valve is a threaded ring C′. When the valve lifts, the steam is somewhat confined in the annular recess of the valve, and the extra valve area thus receiving pressure causes the valve to lift promptly and the steam to escape freely. The degree of this action is governed as follows:

The sleeve C′ is threaded upon the upper part of the valve, so that by screwing it up or down upon the valve the amount of opening between the annular recess *a a*, and the lower edge of the sleeve C′ C′, is increased or diminished at will; the less this

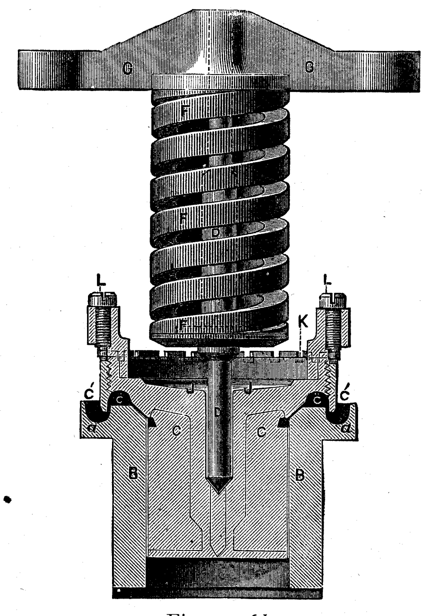


Fig. 3326*b*.

opening, the more promptly the valve will rise after lifting from its seat.

To secure the sleeve or ring in its adjusted position, the ends of the screws L, L seat in notches cut in the upper edge of the sleeve. In many engines pop valves alone are used, and in some cases levers are provided by means of which the pop valve can be raised from its seat to test if it is in working order.

Referring again to Fig. 3326, H is the handle for operating the injector, and *w* a rod for opening the injector overflow.

We now come to the automatic air brake; steam for the steam cylinder of which, is received from the steam drum through the pipe J, passing through the pump governor, or regulator G. The exhaust pipe for the steam cylinder of the air pump passes into the smoke box. The air cylinder receives its supply of air through the small holes at *k*, *k*, and delivers it through the pipe C into the air reservoir or tank, from which it passes through the tank pipe up to the threeway cock or engineer's brake valve, whose handle is shown at M. The brakes are kept free from the wheels and out of action so long as there is air pressure in the air reservoir and in the train pipe, hence the normal position of the handle M is such as to let the air pass from the air reservoir up the pipe *x* and into the train pipe. When the brakes are to be applied, handle M is moved so that there is an open connection made between the train pipe and the *pipe to open* air, which releases the air pressure and then puts on the brakes not only on each car, but also on the engine, because the engine brake cylinders receive their air pressure from the pipe shown leading to the train pipe. From the tank pipe *x* a pipe *h* leads to the top of the pump governor G, whose action is to shut off the steam from the steam cylinder of the air pump whenever the pressure in the air reservoir or tank exceeds

3326 for a freight locomotive, the eccentric rods in this case being straight, as there is no wheel axle in the way.

The injector for feeding the boiler is the same as that shown on the freight locomotive.

The ash pan is provided with two dampers, one at each end, and the front one is operated by the bell crank *a c*.

The sand boxes are here fastened to the frame, both sand valves being operated by the lever *m*, which at its lower end connects to a rod, *u*, which at its back end connects to an arm, *p*, on a shaft that extends across the fire box and connects to a rod corresponding to rod *u*, but situated on the other side of the engine and connecting with the other sand valve.

The steam pump for the automatic air brake is on the other side of the engine, and the air reservoirs, of which there are two, are horizontal and situated beneath the front end of the boiler. The air pipe to the triple valve here connects to the front pipe of the three beneath the triple valve, the middle pipe being that which is open to the atmosphere, which is the usual construction. The engine brake receives its air from a pipe on the other side of the engine which feeds the pipes G, V, for the brake cylinder shown in the figure. When the engine is running backwards, the train brakes are operated through the medium of the "pipe to air brake and to front end of engine" which is shown broken off.

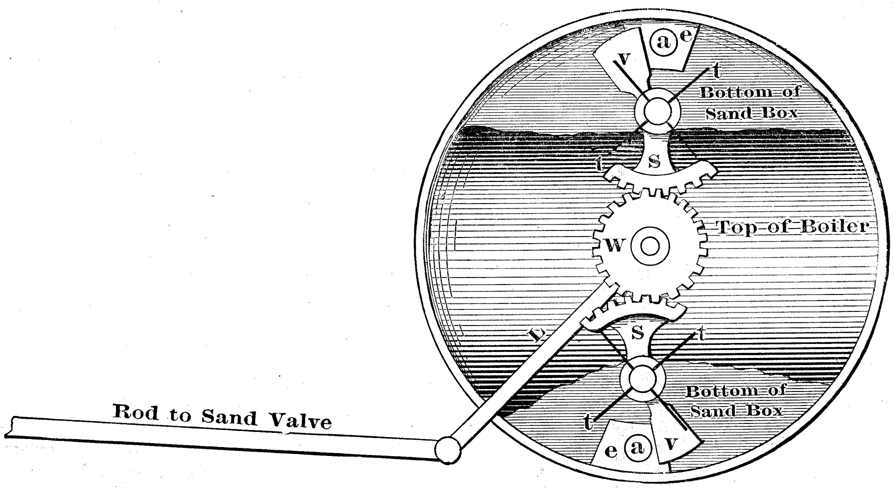


Fig. 3327.

70 lbs. per square inch. A small pipe leads up from pipe *h* to the air pressure gauge.

For regulating the draught of the fire there is a damper door at each end of the ash pan, and to increase the draught, a pipe leads from the steam drum into the smoke box, where it passes up alongside of the exhaust pipe, its end being shown at Z. This is called the *blower*, and its pipe is on the other side of the engine. The plate shown at P, P in the smoke box checks the draught in the upper tubes, and therefore distributes it more through the lower ones.

There are two sand valves, both of which are operated by one rod, the construction being shown in Fig. 3327, which is a plan showing the bottom of the sand box broken away to expose the gear for moving the valves. The two valves *v*, *v* for the sand pipes are on raised seats *e*, *e*, and are fast on the same shafts as the segments *s*, *s*, but the valves are obviously above, while the segments are beneath the bottom of the sand box. The gear wheel W is pivoted to the under side of the bottom of the sand box, and the arm L is fixed to the wheel. At *t* are pieces of wire, which, being fast in the spindle, revolve with it and stir up the sand when the valves are moved. As shown in the figure, the two sand pipes *a*, *a* are open, but suppose the rod is moved endways and L will revolve W, which will move *s*, *s* and the valves *v*, *v*, causing the latter to move over and cover the pipes *a*, *a*, and shut off the sand from the pipes.

Fig. 3328 represents an American passenger locomotive with a steam reversing gear, or in other words, a reversing gear that is operated by steam.

The link motion is substantially the same as that shown in Fig.

The construction of the steam reversing gear is shown in Fig. 3328*a*. A is a steam cylinder and B a cylinder filled with oil or other liquid. Each of these cylinders has a piston, the two being connected together by their piston-rods C C'. These rods are also connected to a lever D E F, which works on a fulcrum E. The lower end of the lever is connected to the reverse rod F G, the front end of which is attached to the vertical arm of the lifting or reverse shaft. It will readily be seen that if the piston in B is free to move and steam is then admitted to either end of the steam cylinder A, the two pistons will be moved in a corresponding direction, and with them the lever D E F, and the other parts of the reversing gear. A valve, H, is provided, by which communication is opened between the cylinder A and the steam inlet pipe. Another valve, I, is placed between H and the cylinder A, by which the steam may be admitted either into the front or back end of the cylinder. It will be apparent, though, that if the piston in A is thus moved, and the reverse gear placed in any required position, some provision must be made to hold it there securely. This is accomplished by the oil cylinder and piston B. To it a valve, J, is provided, by which communication between the front and back ends of the cylinder may be opened or closed. It is evident that if the piston B is in any given position, and both ends of the cylinder are filled with liquid, the former will be held securely in that position if the liquid in one end cannot flow into the other. If, however, communication is opened between the two ends, then, if a pressure is exerted on the piston B, it will cause the liquid to flow from one end of the cylinder to the other, and thus permit B to move in whichever direction the pressure is exerted.

R is the reverse lever, made in the form of a bell crank, the

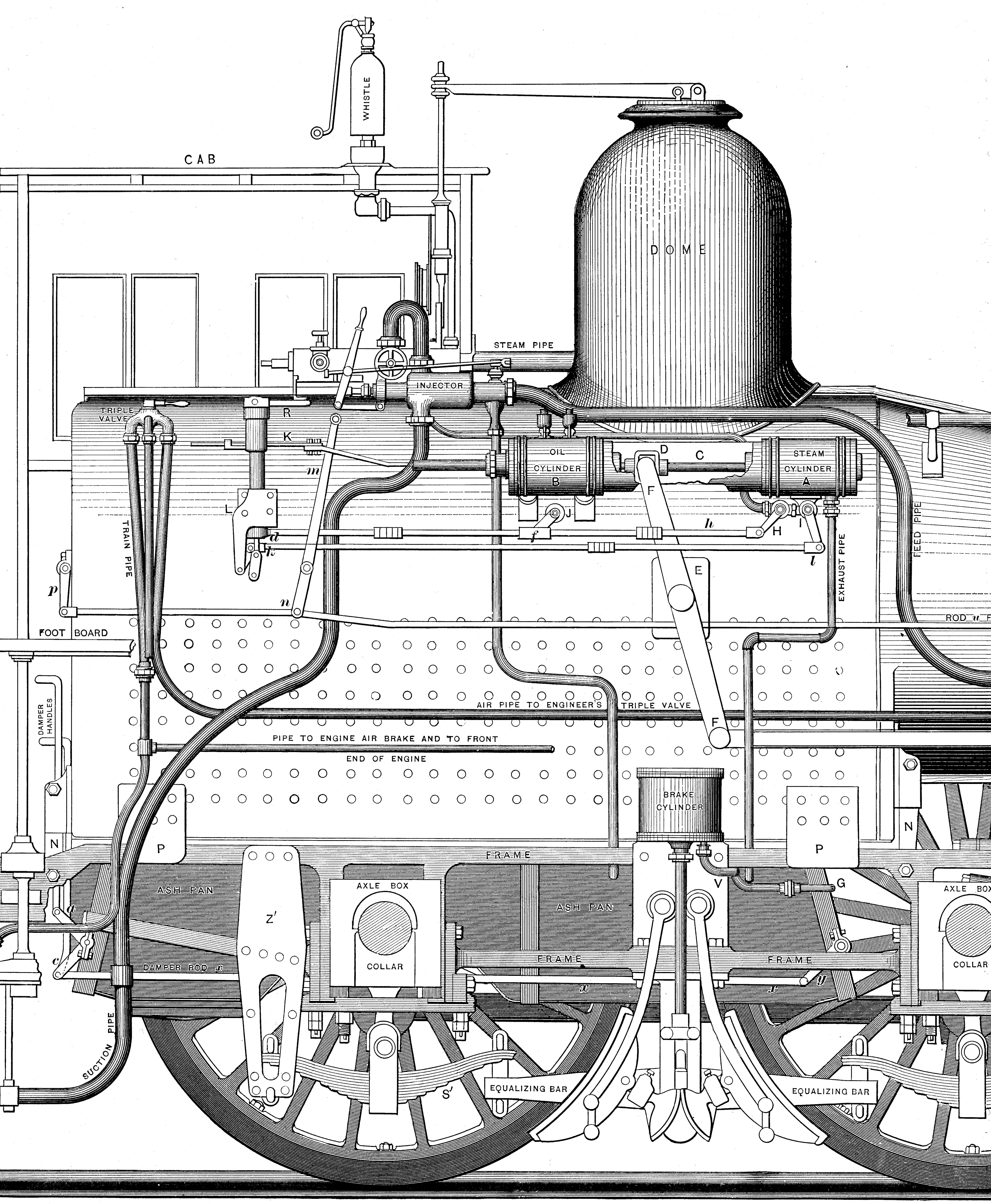
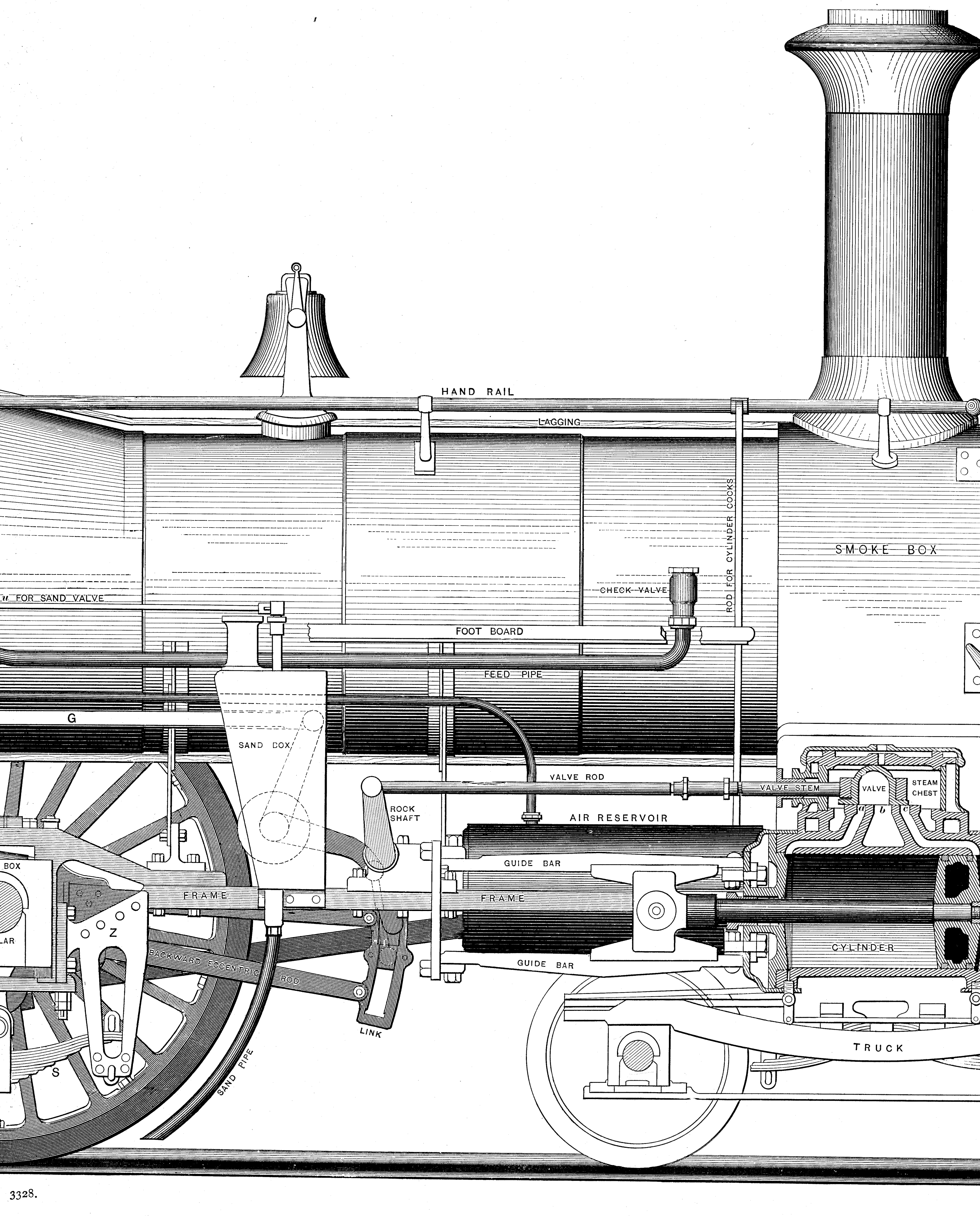

WHISTLE
CAB
DOME
STEAM PIPE
INJECTOR
TRIPLE VALVE
R
K
m
L
OIL CYLINDER
B
D
C
STEAM CYLINDER
A
F
J
h
H
I
d
k
f
l
E
EXHAUST PIPE
FEED PIPE
TRAIN PIPE
p
n
ROD n
FOOT BOARD
DAMPER HANDLES
AIR PIPE TO ENGINEER'S TRIPLE VALVE
PIPE TO ENGINE AIR BRAKE AND TO FRONT END OF ENGINE
BRAKE CYLINDER
N
P
FRAME
ASH PAN
AXLE BOX
COLLAR
Z'
V
G
DAMPER ROD x
x
y
SUCTION PIPE
S'
EQUALIZING BAR

Fig. 3


HAND RAIL
LAGGING
ROD FOR CYLINDER COCKS
SMOKE BOX
FOR SAND VALVE
CHECK VALVE
FOOT BOARD
FEED PIPE
G
SAND BOX
VALVE ROD
VALVE STEM
VALVE
STEAM CHEST
ROCK SHAFT
AIR RESERVOIR
a
b
c
BOX
GUIDE BAR
FRAME
FRAME
Z
LAR
BACKWARD ECCENTRIC ROD
CYLINDER
GUIDE BAR
LINK
TRUCK
S
SAND PIPE

3328.

short end of which works in a slot *c*, in the upper end of a shaft or spindle *d*. This shaft is inclosed by a tubular shaft S, to which the fulcrum of R is fastened. The tubular shaft has an arm *b*. The reverse lever has two movements, the one to raise the end up, and the other to turn on the axis of the tubular shaft. The arm *b* on the latter is connected by a rod, *f*, with the valves J and H. The lower end of the shaft *d* is connected with a bell crank, *f'* which, in turn, is connected by a rod, *k l*, with the valve I. Therefore, by turning the lever R so as to partly revolve the shaft S, the valves J and H may be opened or closed, and by moving the lever R up or down, the valve I is moved to admit steam to the front or back end of A. To reverse the engine, therefore, the lever R is turned so as to open the valves J and H. This opens communication between the opposite ends of B, and H admits steam to I. Now, by reversing the end of the reverse lever R, the valve I is moved so as to admit steam to either end of A, the pressure in which will move the reverse gear to the desired position. When this is done, the valves J and H are closed. This prevents the fluid in B from flowing from one end of the cylinder to the other, and thus securely locks the piston B in the position it may happen to be in, and at the same time the valve H shuts off steam from the cylinder A.

The bar K is graduated, as shown in the plan of R, K, to indicate to the locomotive runner the position of the reversing gear.

This apparatus enables the reversing gear to be handled with the utmost facility, and with almost no exertion on the part of the engineer. The engine can be reversed almost instantly, and it can be graduated with the most minute precision.

THE LINK MOTION AND REVERSING GEAR.

The link motion of an American locomotive is shown in Figs. 3329 and 3330. In Fig. 3329 it is shown in full gear for the forward gear, or in other words, so as to place the engine in full power for going ahead.

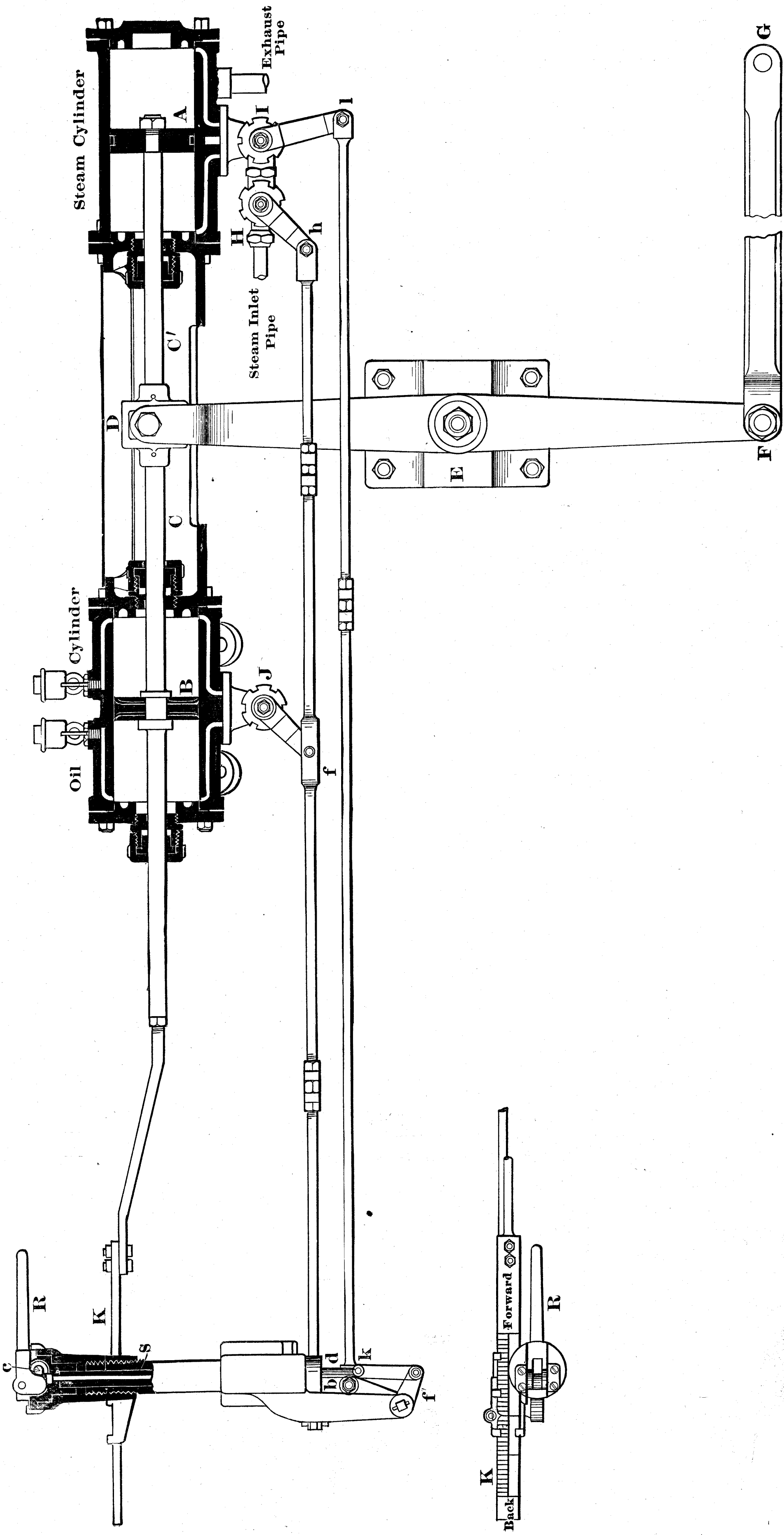


Fig. 3328*a*.

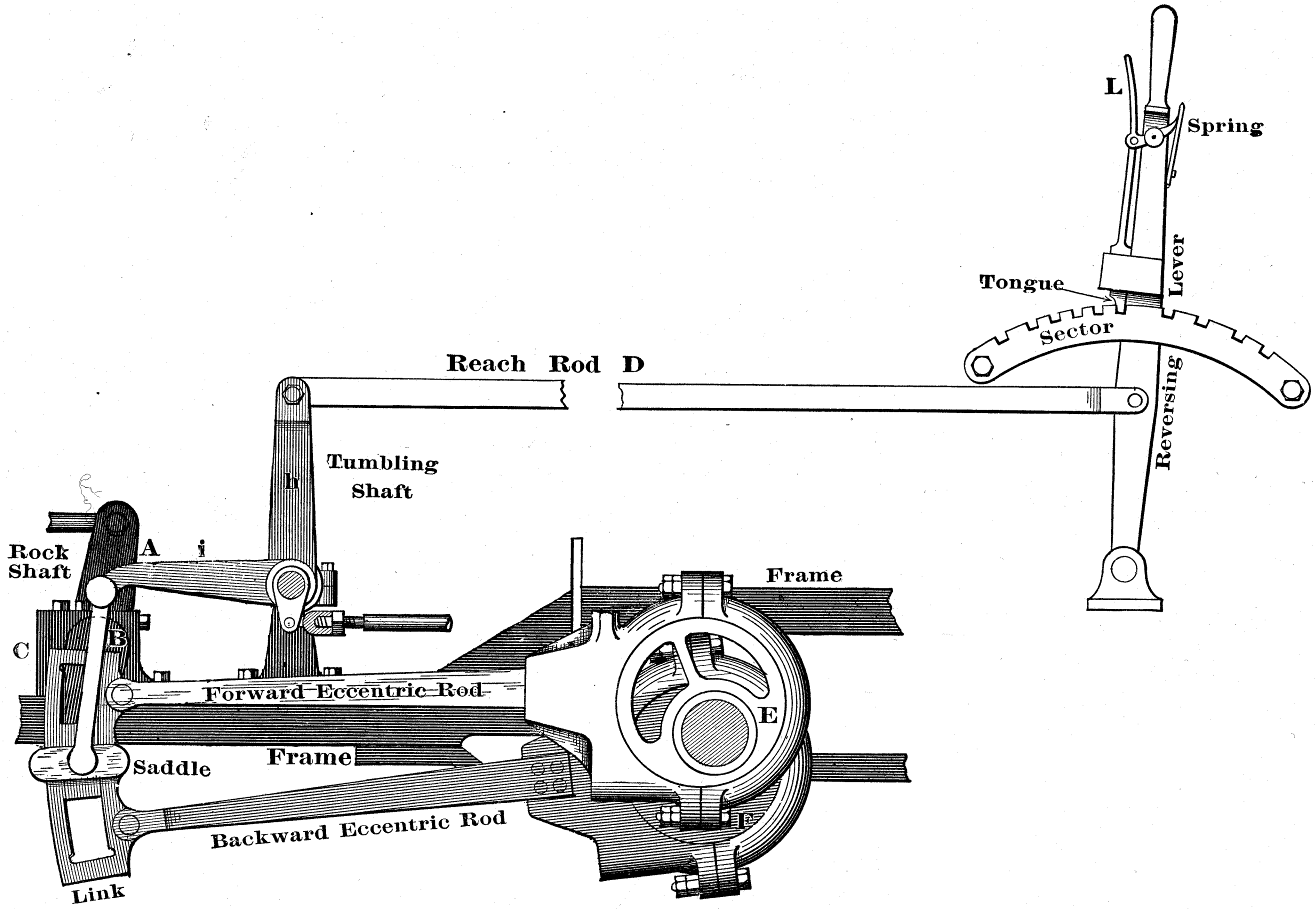


Fig. 3331.

The meaning of the term full power is that, with the link motion in full gear, the steam follows the piston throughout very nearly the full stroke.

In Fig. 3331 the link motion is shown in mid gear, in which position the engine is at its least power, the cut off occurring at its earliest point, and in Fig. 3332 it is shown in full gear for the backward motion.

Referring to Fig. 3329 for the full gear forward, the reversing

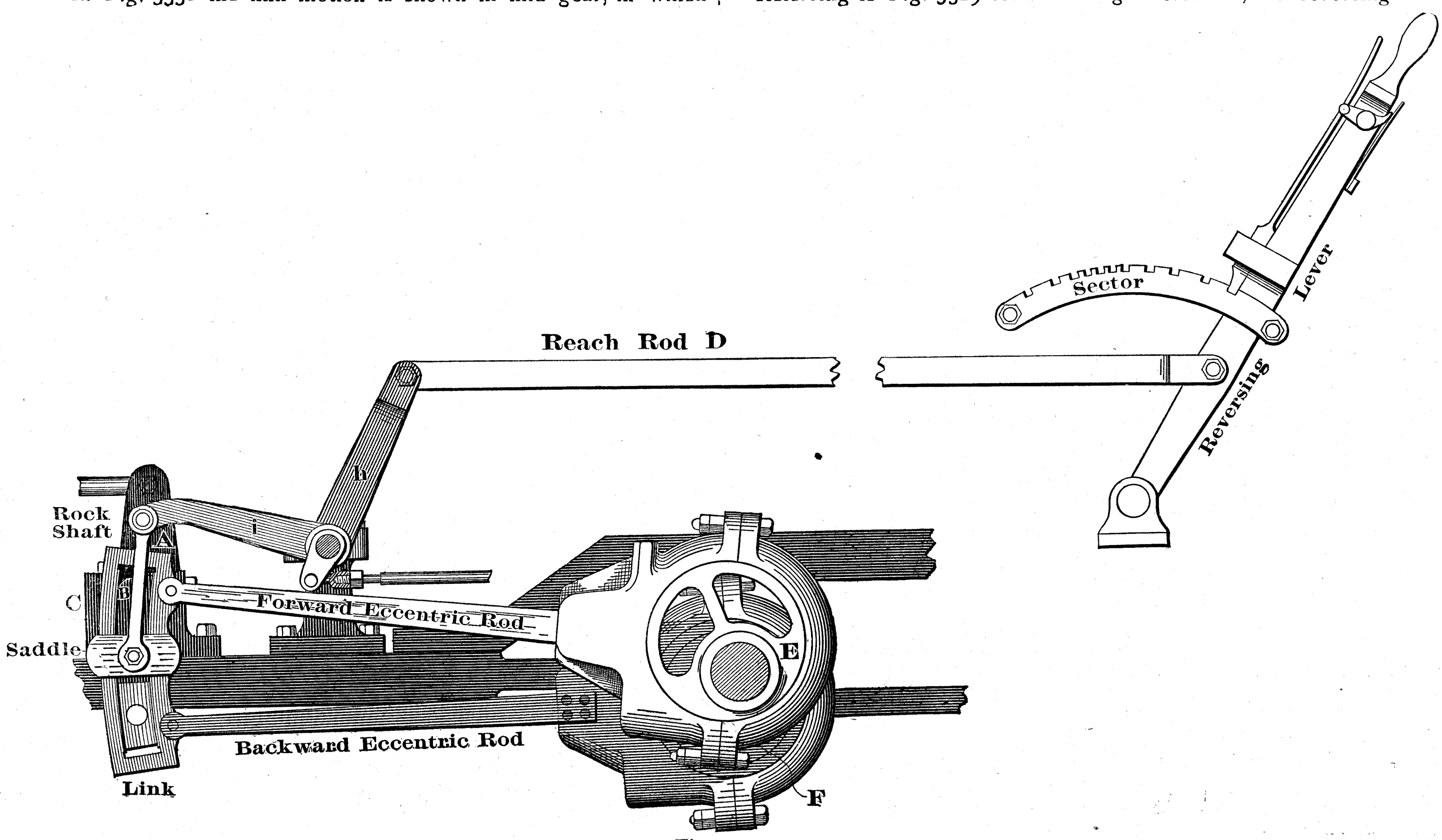


Fig. 3332.

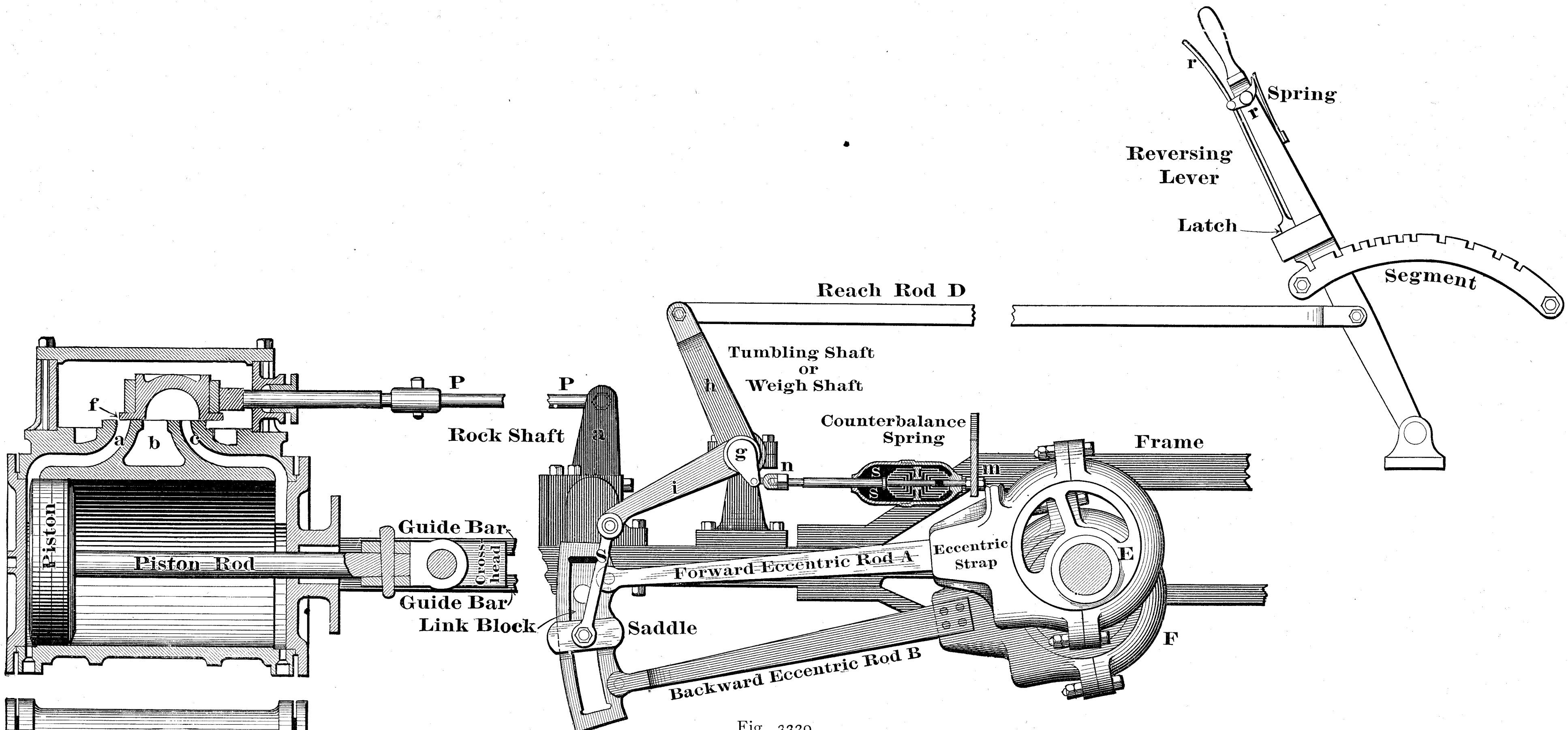


Fig. 3329.

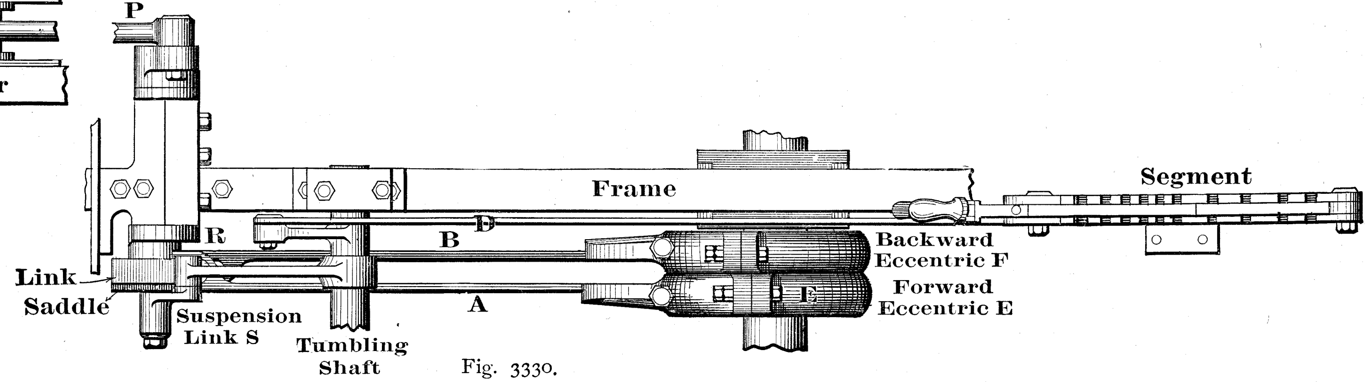


Fig. 3330.

gear proper consists of the reversing lever, the segment, the reach rod, the tumbling shaft, and its counterbalance rod and spring; while the link motion proper consists of the eccentrics and their rods, the link, the link block or die, the suspension link S, the rock shaft and the rod P P. These, however, are terms applied for shop purposes, so as to distribute the work in sections to different men, it being obvious that a *complete* link motion includes the reversing gear, the eccentrics, the link and its block, the rock shaft, the rod P P, and the valve and its spindle or stem. This mechanism, as a whole, may also be called, and is sometimes called, the valve gear, because it is the mechanism or gear that operates the slide valve.

The link motion may be moved from full gear forward to full gear backward or to any intermediate position, whether the engine is running or at rest, but is, when the engine is running, harder to move from full gear forward toward back gear, and easier to move from full gear backward toward mid and forward gears, which occurs because of the friction of the eccentrics in the straps, and it follows that this will be the case to a greater extent in proportion as the revolutions of the eccentrics are increased.

If in a properly constructed link motion we move the link from the tumbling shaft. To regulate the proper amount of counterbalancing, the nuts at *m* are provided, these nuts regulating the amount of tension on the spring *s s*.

The forward eccentric E is that which operates the valve when the link motion is in full gear forward, as in Fig. 3329, and the backward eccentric is that which moves the valve when the link motion is in back gear, as in Fig. 3332.

This occurs because it is the eccentric rod that is in line or nearest in line with the link block that has the most effect in moving the valve. When the link is in full gear, the motion of the valve is almost the same as though there was no link motion and the eccentric rod was attached direct to the rod P P, the difference being so slight as to have no practical importance. This will be seen by supposing that we were to loosen the backward eccentric F upon the shaft and revolve it around the shaft by hand, in which case it would swing the lower end of the link backward and forward with the centre of the link block as a pivot or centre of motion, the forward eccentric rod rising and falling a trifle only, and therefore moving the rock shaft to a very slight amount.

Let it now be noted that the suspension link not only sustains the weight of the link and eccentric rods, but also compels the

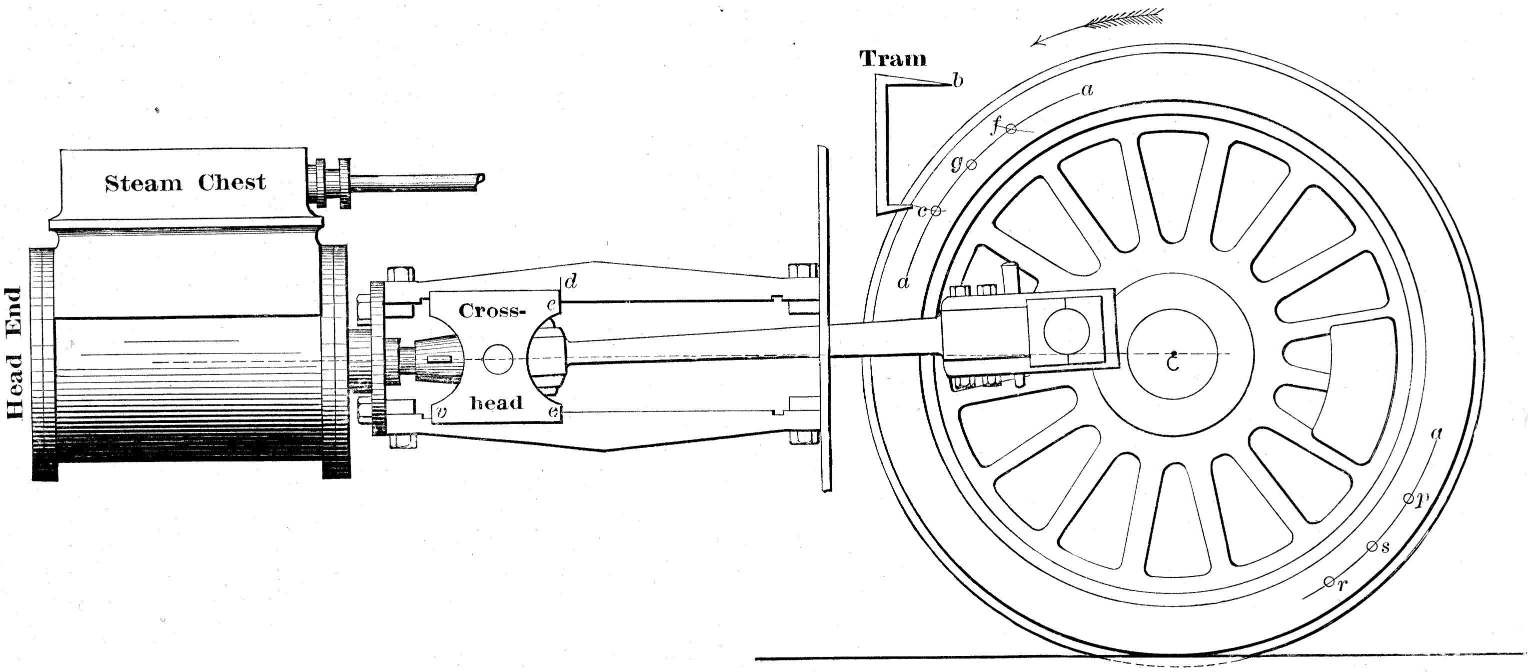


Fig. 3333.

full gear forward to mid gear when the engine is standing still, and watch the valve, we shall find that the lead or opening at *f* gradually increases; and if we then move it from mid gear to full gear backward, the lead will gradually decrease and finally become the same as it was in full gear forward. The construction of the parts is as follows:

Referring to Fig. 3329 (full gear forward), the segment is fixed in position and the reversing lever is pivoted at its lower end. *r r* is a bell crank, which is pivoted to the reversing lever and to which the latch rod is pivoted at its upper end. The spring acts on the end of *r r*, and thus forces the tongue of the latch into the notches on the sector as soon as the tongue comes fair with the notch and *r r* is released from the hand pressure. As the reversing lever is moved over from full gear forward, the reach rod moves the tumbling shaft, whose lower arm *i* (through the medium of the suspension link S) lifts the link and brings the centre of the saddle pin nearer to the centre of the pin in the link block, which reduces the amount of motion given to the lower arm (B, Fig. 3331) of the rock shaft, and therefore reduces the amount of valve travel, thus causing the point of cut-off to occur earlier in the piston stroke.

The weight of the eccentric rods, the link, suspension link S, and the tumbling shaft arm *i*, is counterbalanced by the counterbalance spring in the box *s s*, whose rod attaches to the lug *g* on centre of the saddle pin to swing (as the link is moved by the eccentrics) in an arc of a circle of which the centre is the upper end of the suspension link. Suppose, therefore, that the backward eccentric rod was to break, or was taken off and the engine could still run forward, but no motion would be given to the valve, if the link was placed in mid gear, because in that case the forward eccentric rod would simply swing the link on the centre of the link block as a pivot. Now, suppose the forward eccentric rod was to break or be taken off, and the engine may be made to go ahead by setting the backward eccentric fair with the forward eccentric and connecting its rod to the upper end of the link.

Similarly, if the engine was running with the smoke stack toward the train and the link motion in backward gear, and the backward eccentric rod was to break, we may take it off, shift the forward eccentric so that it comes fair or stands in line with the backward eccentric and connect its rod to the lower end of the eccentric and with the link motion in backward gear, the engine would still haul the train.

If the reach rod was to break, the tumbling shaft could be held in position by loosening the cap bolts of the tumbling shaft journal and putting between the cap and the tumbling shaft journal a piece of metal, which, on bolting up the cap screws again, would firmly grip the shaft and prevent it from moving.

SETTING THE SLIDE VALVES OF A LOCOMOTIVE.—The principles of designing, and the action of D valves, such as are used upon locomotives, have been so thoroughly explained with reference to stationary engines, that there is no need to repeat them in connection with the locomotive, and we may proceed to explain how to set the valves of a locomotive. In doing this, there are two distinct operations, one of which is to place the crank alternately exactly on its respective dead centres, and the other is to set the position of the eccentrics, and get the eccentric rod of the proper length. These two operations comprise all that require to be done to set the valves, under ordinary and workmanlike conditions; hence we may proceed at once to explain the operation.

The first thing to be done is to put the crank pin on a dead centre, and it does not matter which one.

In Fig. 3333 it is supposed that the piston is to be at the head end of the cylinder when the crank is on its corresponding dead centre.

The first thing to do is to put the reversing gear in full gear forward, so as to set the forward eccentric, and see if its rod is of proper length.

The next thing to do is to move the wheel so that the crank pin is nearly on the dead centre, and then take a tram (such as shown in the figure), pointed at each end, and mark on the splash plate, or any other convenient place, a centre punch dot in which the point *b* of the tram can rest. Next, from the centre of the axle as a centre, mark arcs or portions of circles *a*, *a*. This being done, point *b* of the tram is rested in the centre punch dot before referred to, and with the other end a line *c* is marked, a straight edge is then rested against the ends *e e* of the cross head, and a line *d* is marked on the guide bar, this line being exactly even or fair with the end *e e* of the cross head.

We then move the wheel in the direction of the arrow, and as soon as we begin to do so, the cross head will move to the left and away from the line *d* on the guide bar. But as soon as the crank pin has passed its dead centre, the cross head will begin to move to the right, and as soon as the end *e e* comes again exactly in line with the line *d* marked on the guide bar, we must stop moving the wheel, and again resting the point *b* of the tram in the centre punch mark before mentioned, we move its other end so as to mark a second line, which will be the line or arc *f*.

The next thing to do is to mark a fine centre punch dot, where *c* and *f* cross the arc or line *a*, and then find the point *g* midway between *f* and *c*, and mark a fine centre punch mark there. This being done, we must move the wheel back into the position it occupies in the figure, and then slowly move it in the direction of the arrow, until with the end *b* of the tram resting in the centre punch dot, the other end of the tram will fall dead into the centre punch dot at *g*, at which time the crank pin will be exactly on the dead centre.

During this part of the process we have nothing to do with anything except getting the crank pin on the dead centre, but there is one point that requires further explanation, as follows:

In this operation we have first put the crank on one side of the dead centre and then put it to the same amount on the other side of the dead centre, both being improper positions; but by finding the mean or mid position between the two, we have found the proper position. In doing so, however, we have moved the wheel, the wheel has moved the connecting rod, and the connecting rod has moved the piston. But in the actual running of the engine, this order of things will be reversed; for the steam will move the piston, the piston will move the connecting rod, and the connecting rod will move the crank and therefore the wheel.

The difference between the two operations is this: Suppose there is lost motion or play between the connecting rod brasses and the crank pin, or between the connecting rod brasses and the cross head pin, and then if we move the wheel in the direction denoted by the arrow, we take up this lost motion, so that if the tram was fair with the centre punch at *g* and steam was admitted to the piston, then there would be no lost motion to take up, and as soon as the piston moved the crank pin would move. But if we moved the wheel in the opposite direction to that denoted by the arrow, then we are placing any lost motion there may be in the opposite direction, and if steam were turned on, the piston and connecting rod might move before the crank and wheel moved.

In which direction the wheel should be moved while placing the crank on the dead centre depends upon the condition of the engine, as will be explained presently, the assumption being at present that the engine is in thorough good order, in which case the wheel should (while placing the crank on the dead centre) be moved in the direction of the arrow in the figure.

The object is under all conditions to bring the working surfaces to bear (while setting the valve) in the same way as they will bear when the engine is actually at work.

Having placed the crank on the dead centre, and thus completed the first operation in valve setting, we may turn our attention to the second, viz., correcting the lengths of the eccentric rods and setting the valve lead. Almost all writers who have dealt with this part of the subject have fallen into a very serious error, inasmuch as they began the operation by what they call *squaring* the valve. This means so adjusting the length of the eccentric rod that the valve will travel an equal distance each way from its mid position, so that if the engine wheel is revolved and the extreme positions of the valve marked by a line, these lines will measure equally from the edges of the steam ports, or, what is the same thing, from the centre of the cylinder exhaust port. This procedure is entirely erroneous, because, on account of the angularity* of the eccentric rod, the valve cannot, if equal lead is to be given to the valve, travel equally beyond the two steam ports, and if the eccentric rods are so adjusted for length as to *square the valve*, they are made wrong.

The valve lead, and the lead only, it is that determines the length of the eccentric rods. Suppose that, as is generally the case, the lead is to be equal, or, in other words, that there is to be as much valve lead when the piston is at one end of the cylinder as there is when it is at the other, and if we make the eccentric rods of such a length that the valve travels equally on each side of the steam port, there will be less lead at the head end port than there is at the crank end port. The proper method, therefore, is (as soon as the crank is on the dead centre and the link in full gear, as in Fig. 3334) to set the eccentric so as to give the desired amount of lead, and then give the wheel a half revolution, the lower end of the tram falling into the centre punch dot at *s*, when the crank pin will be on its other dead centre and ready for the lead to be measured again. If the lead is equal at each end, one eccentric rod is of the right length, and all we have to do is to set the eccentric so that the right amount of lead is given.

We now turn our attention to the backward eccentric and its rod, putting the reversing lever in full gear for the backward motion, and putting the crank on the respective dead centres, and testing the lead for both ports as before, and when the required amount of valve lead is given the valve setting is complete.

In some practice the wheel is blocked up on the pedestal guides while setting the valves, but a more correct method is to let the engine rest on the rails and push it back and forth with a crowbar to revolve the wheels when putting the crank pin on the dead centre. The best thing to measure the lead with is a wooden or leaden wedge having but a slight degree of taper, as say $\frac{3}{16}$ or $\frac{1}{4}$ inch in a length of four inches. We have in this example of valve setting supposed the parts to be of the proper dimensions, as they would be in a new engine or in an engine that had been running and merely had a new valve or a new eccentric put in.

But suppose the notches were not cut in the sector, and we have then to mark them off while setting the valves. All the difference that this makes to the operation is that we must clamp the reversing lever to the sector while setting the valve, taking care to so clamp it that there is the same space between the top end of the link block and the end of the link slot in the full forward gear as there is between the bottom end of the link block and the end of the link slot when the engine is in full backward gear. In this connection it is, however, to be remarked that when the link is in full gear, either forward or backward, and the crank is on the dead centre, the link block is not at the end of its motion toward the end of the link slot; hence it is a good plan to move the wheels around and to so regulate the length of the reach rod and the position of the reversing lever on the sector, that when the link block is at the highest point in the link slot for the forward gear and at the

* See page 376, Vol. II., for the meaning of angularity.

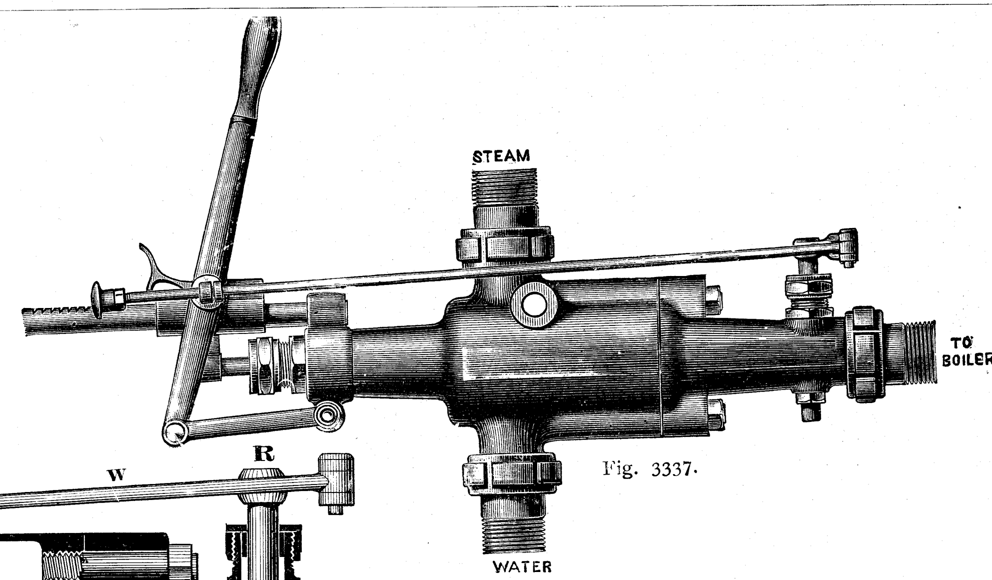
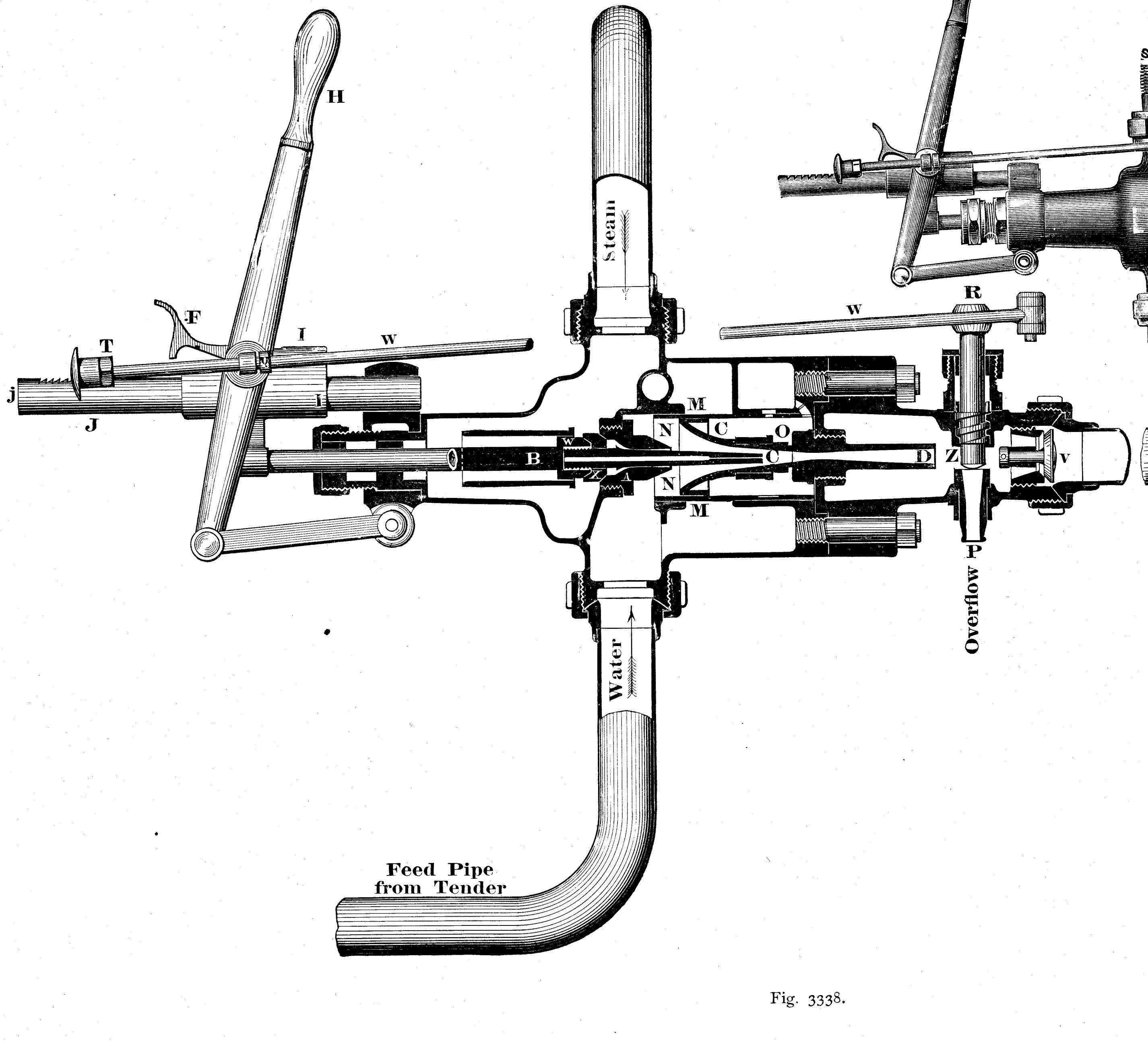


Fig. 3337.



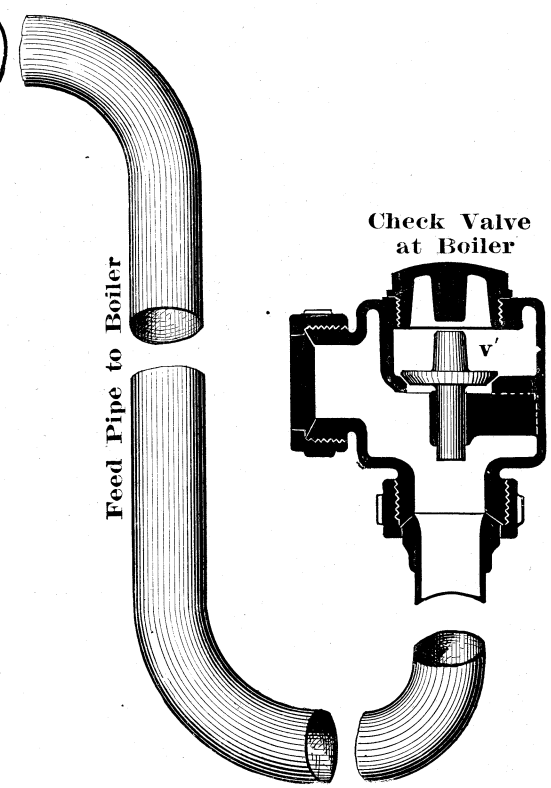


Fig. 3338.

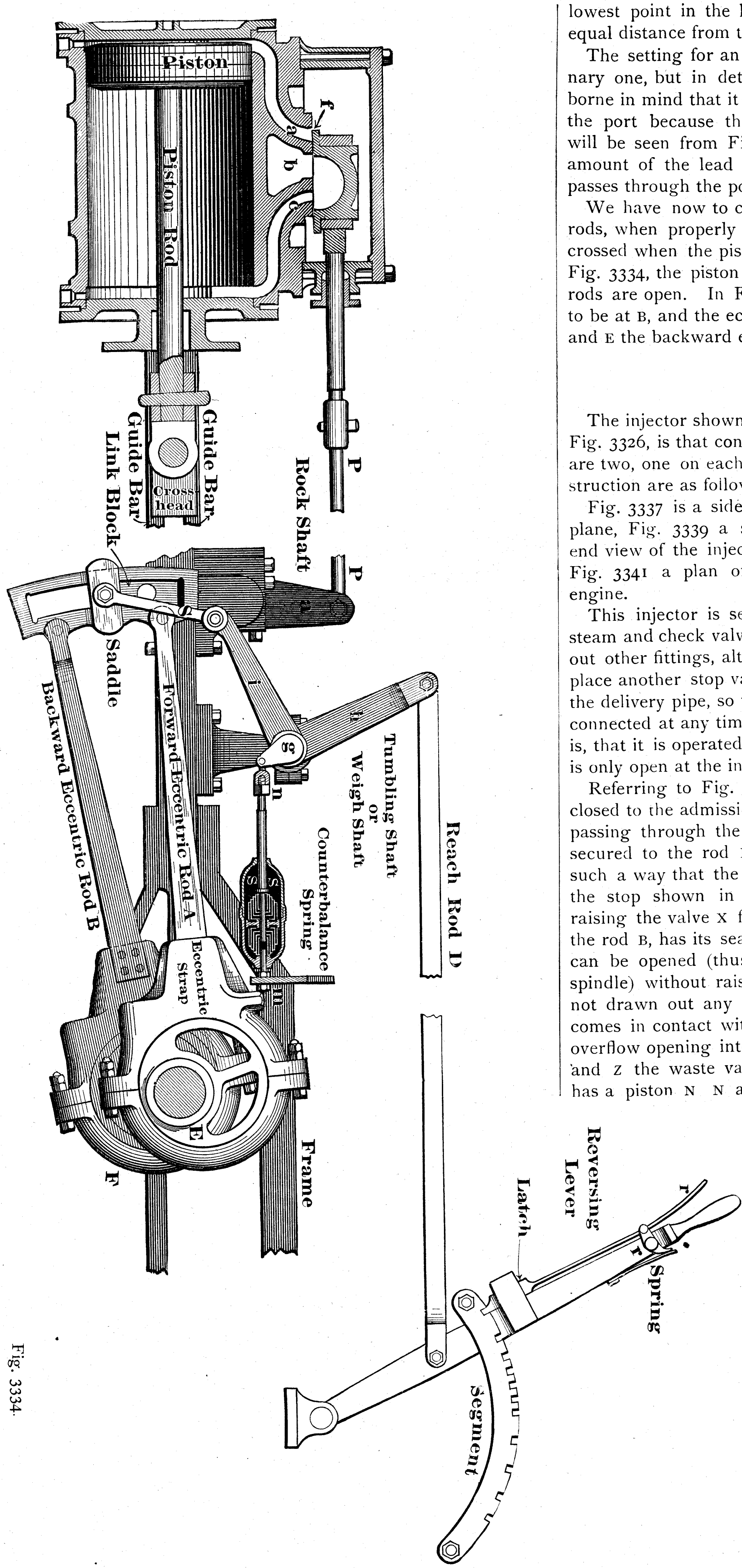


Fig. 3334.

lowest point in the link slot for the backward gear, it comes an equal distance from the end of the link slot.

The setting for an Allen valve is the same as that for an ordinary one, but in determining the amount of the lead it is to be borne in mind that it is virtually twice as much as it measures at the port because there are two openings for the steam. This will be seen from Fig. 3335, in which the valve is open to the amount of the lead at *f*. But the steam also enters at *e*, and passes through the port in the valve and into steam port *a*.

We have now to call attention to the fact, that the eccentric rods, when properly connected, are, in an American locomotive, crossed when the piston is at the crank end of the cylinder. In Fig. 3334, the piston is at the head end of the cylinder, and the rods are open. In Fig. 3336, however, the crank pin is supposed to be at B, and the eccentric rods are crossed, F being the forward and E the backward eccentric.

THE INJECTOR.

The injector shown in the general view of a freight locomotive, Fig. 3326, is that constructed by William Sellers & Co., and there are two, one on each side of the engine. The details of its construction are as follows:

Fig. 3337 is a side elevation, Fig. 3338 a section on a vertical plane, Fig. 3339 a section on a horizontal plane, Fig. 3340 an end view of the injector at the right-hand side of the engine, and Fig. 3341 a plan of the injector on the left-hand side of the engine.

This injector is self-contained, or in other words, it has both steam and check valves, so that it can be connected directly without other fittings, although, of course, it is generally desirable to place another stop valve in the steam pipe, and a check valve in the delivery pipe, so that the injector can be taken to pieces or disconnected at any time. Another important feature of this injector is, that it is operated by a single handle, and that the waste valve is only open at the instant of starting.

Referring to Fig. 3338, A is the receiving tube, which can be closed to the admission of steam by the valve X. A hollow spindle passing through the receiving tube into the combining tube is secured to the rod B, and the valve X is fitted to this spindle in such a way that the latter can be moved a slight distance (until the stop shown in the figure engages with valve X) without raising the valve X from its seat. A second valve W, secured to the rod B, has its seat in the upper side of the valve X, so that it can be opened (thus admitting the steam to the centre of the spindle) without raising the valve X from its seat, if the rod B is not drawn out any farther, after the stop on the hollow spindle comes in contact with the valve X. D is the delivery tube, O an overflow opening into space C, V the check valve in delivery pipe, and Z the waste valve. The upper end of the combining tube has a piston N N attached to it, capable of moving freely in a cylindrical portion of the shell M, M, and the lower end of the combining tube slides in a cylindrical guide formed in the upper end of the delivery tube.

The rod B is connected to a cross head which is fitted over the guide rod J, and a lever H is secured to the cross head. A rod W, attached to a lever on the top end of the screw waste valve, passes through an eye that is secured to the lever H; and stops T, Q control the motion of this rod, so that the waste valve is closed when the lever H has its extreme outward throw, and is opened when the lever is thrown in so as to close the steam valve X, while the lever can be moved between the positions of the stops T, Q without affecting the waste valve. A latch F is thrown into action with teeth cut in the upper side of the guide rod J, when the lever H is drawn out to its full extent and then moved back; and this click is raised out of action as soon as it has been moved in far enough

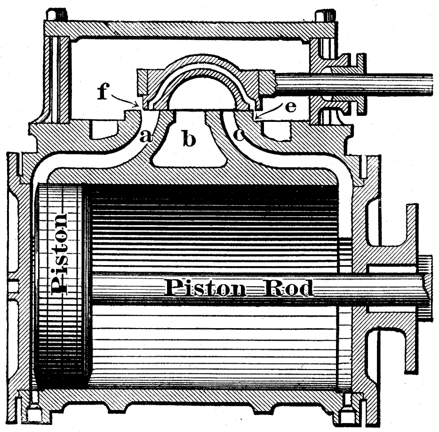


Fig. 3335.

to pass the last tooth on the rod J. An air vessel is arranged in the body of the instrument, as shown in the figure, for the purpose of securing a continuous jet when the injector and its connection are exposed to shocks, especially such as occur in the use of the instrument on locomotives.

The manipulation required to start the injector is exceedingly simple—much more so in practice, indeed, than it can be rendered in description. Moving the lever H until contact takes place between valve X and stop on hollow spindle, which can be felt by the hand upon the lever, steam is admitted to the centre of the spindle, and, expanding as it passes into the delivery tube D and waste orifice P, lifts the water through the supply pipe into the combining tube around the hollow spindle, acting after the manner of an ejector or steam siphon. As soon as solid water issues through the waste orifice P, the handle H may be drawn out to its full extent, opening the steam valve X and closing the waste valve, when the action of the injector will be continuous as long as steam and water are supplied to it.

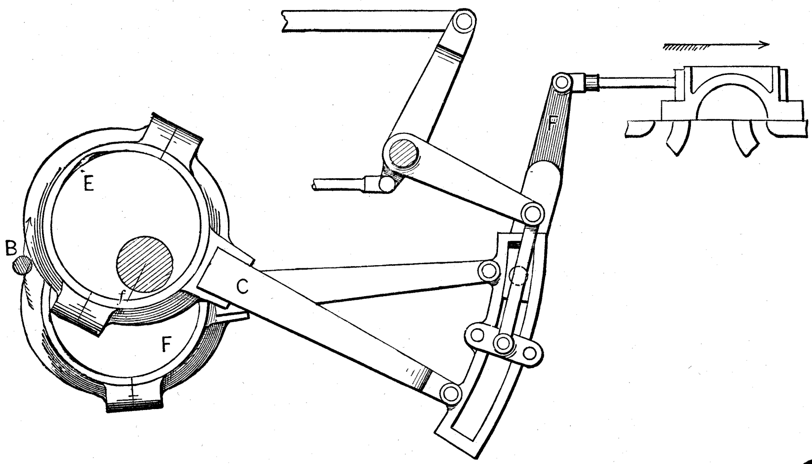
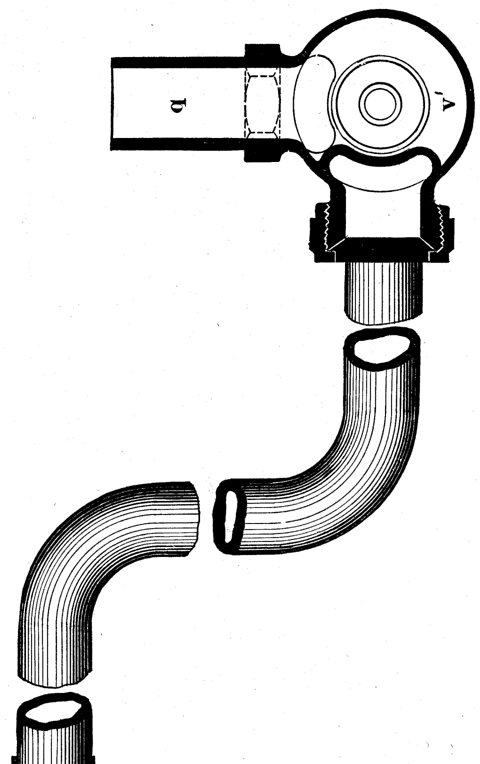
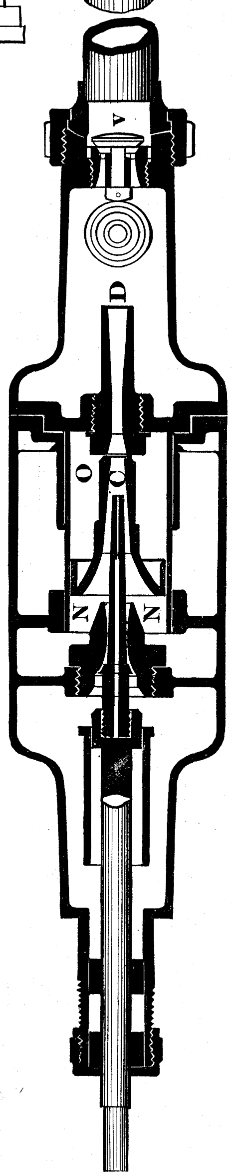


Fig. 3336.





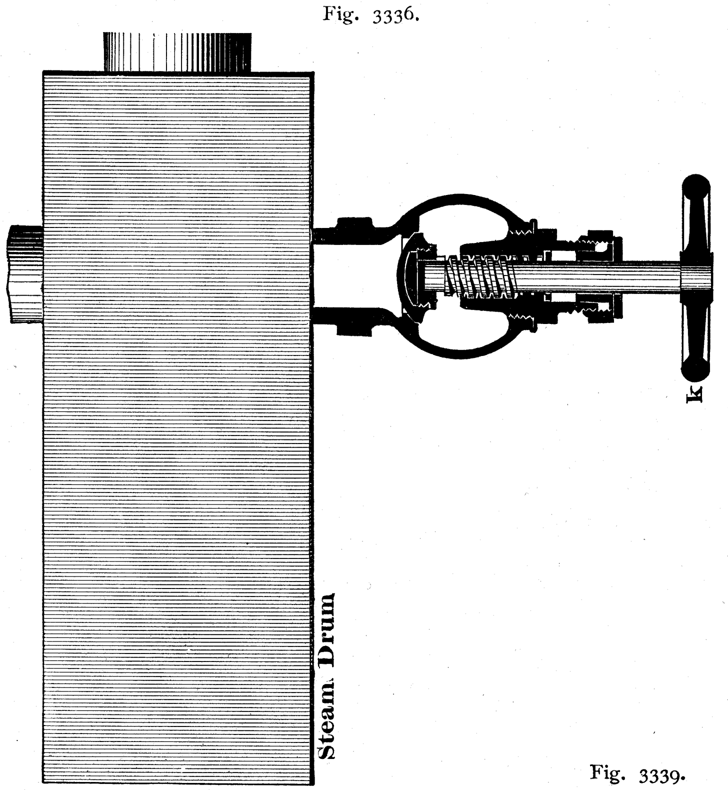


Fig. 3339.

To regulate the amount of water delivered, it is necessary only to move in the lever H until the click engages any of the teeth on the rod J, thus diminishing the steam supply, as the water supply is self-regulating. If too much water is delivered, some of it will escape through O into C, and, pressing on the piston N N, will move the combining tube away from the delivery tube, thus throttling the water supply; and, if sufficient water is not admitted, a partial vacuum will be formed in C, and the unbalanced pressure on the upper side of the piston N N will move the combining tube toward the delivery tube, thus enlarging the orifice for the admission of water. From this it is evident that the injector, once started, will continue to work without any further adjustment, delivering all its water to the boiler, the waste valve being kept shut. By placing the hand on the starting lever, it is easy to tell whether or not the injector is working; and, if desired, the waste valve can be opened momentarily by pushing the rod W, a knob on the end being provided for the purpose.

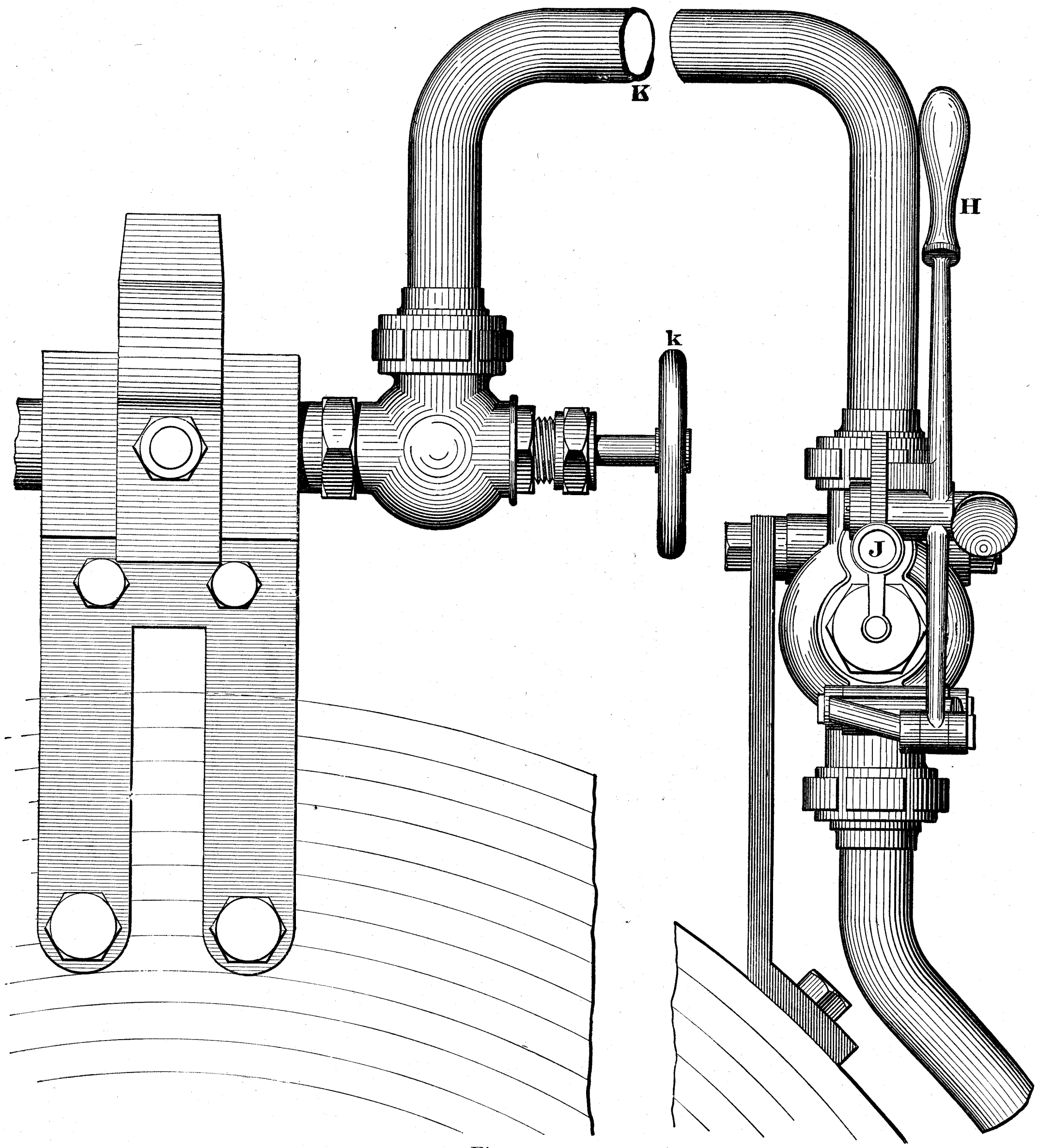


Fig. 3340.

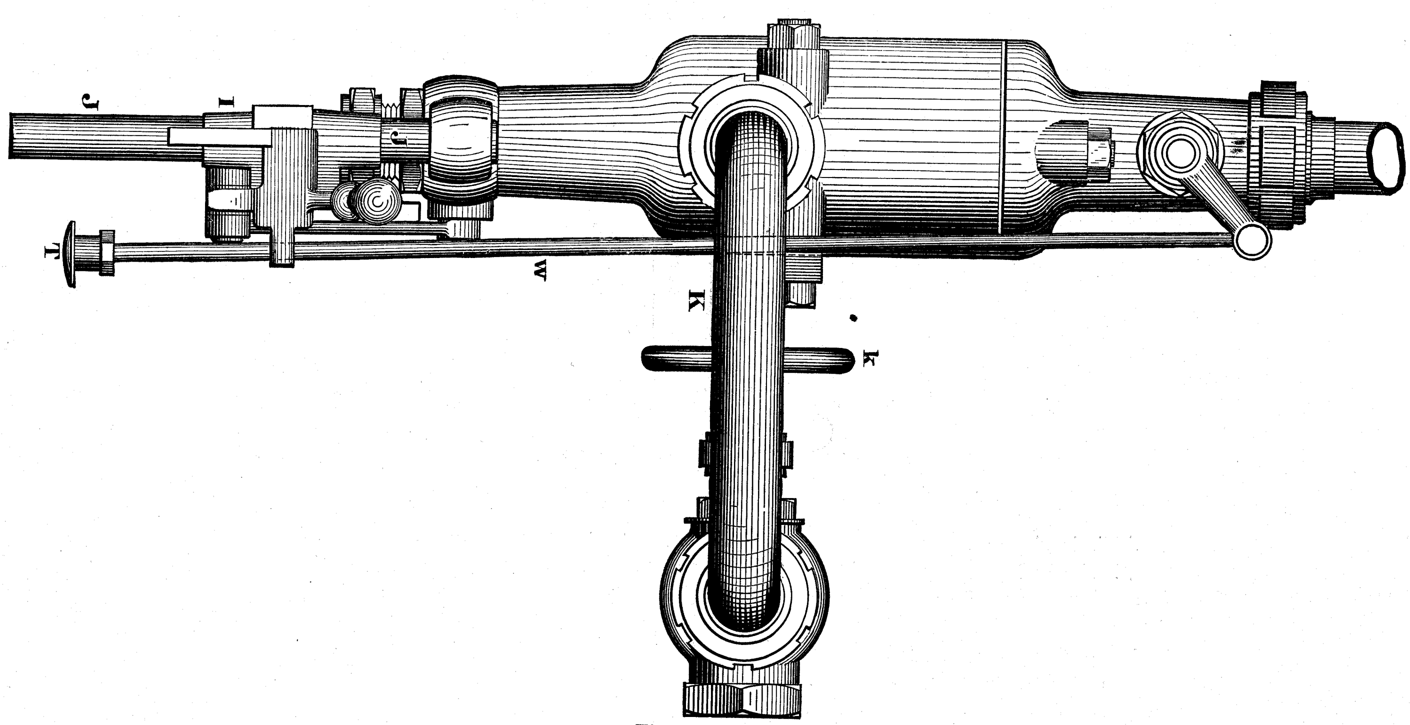


Fig. 3341.

THE WESTINGHOUSE AUTOMATIC AIR BRAKE.

Figs. 3342, 3343 and 3344 represent the Westinghouse automatic air brake applied to an engine and tender, and in the following figures details of the construction of various parts are shown.

its seat the steam is entirely shut off from the steam cylinder, but by operating wheel 8 to unscrew spindle 9, valve 10 is permitted to open and let the steam pass through A and B to the steam cylinder which operates, forcing air into the reservoir and thence into the train pipe. A pipe from the train pipe connects to the upper end

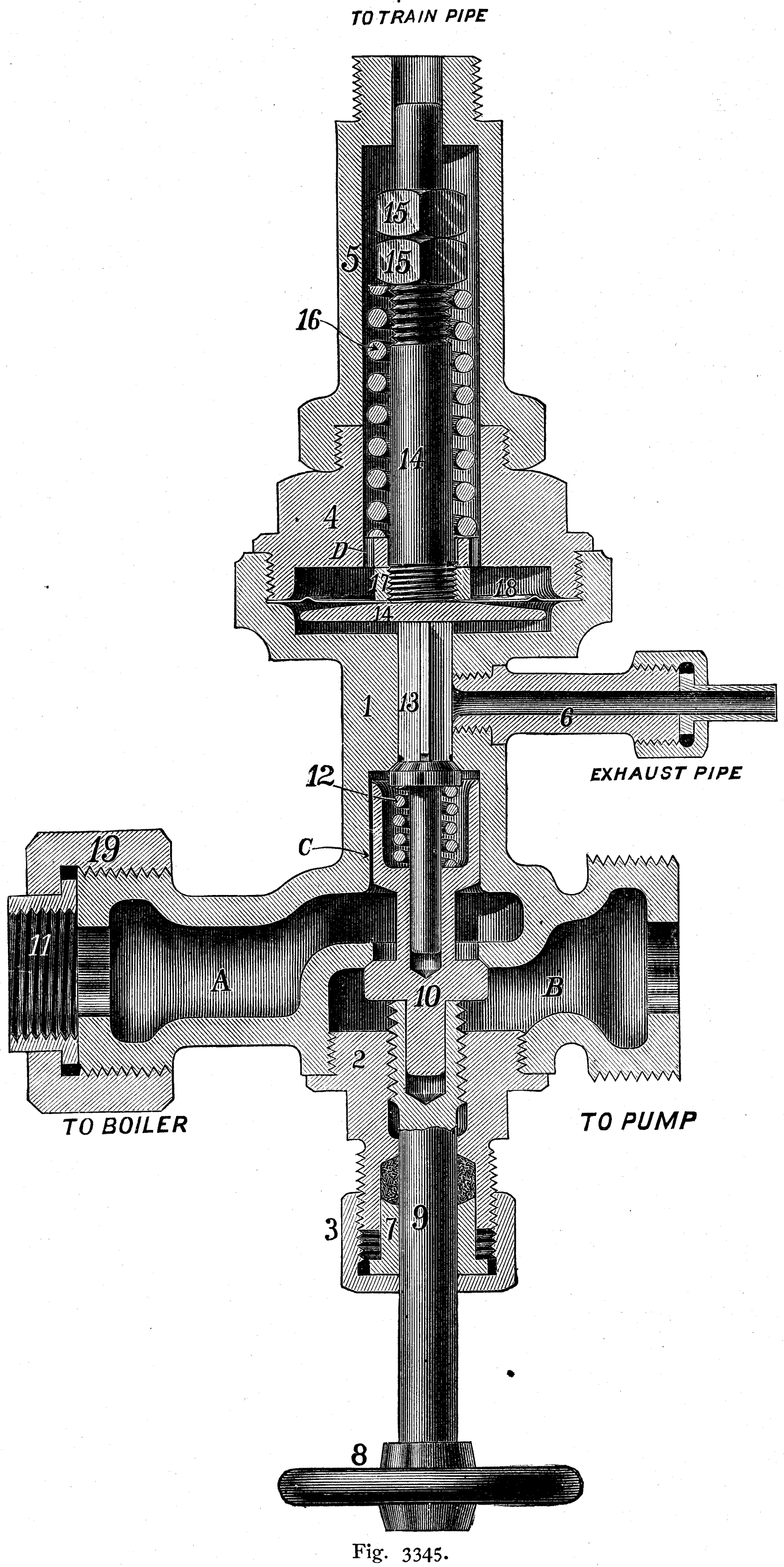


Fig. 3345.

The pump governor, which is shown at G in Fig. 3326, of a modern freight locomotive, is shown in section in Fig. 3345.

The pump governor is employed for the purpose of cutting off the supply of steam to the pump when the air pressure in the train pipe exceeds a certain limit, say 70 lbs. per square inch.

Its operation is as follows:

When valve 10 is (by means of hand wheel 8) screwed home to of the pump governor, hence air from the train pipe passes around the stem 14 to the upper side of the thin diaphragm 18, which is held in its position by the spring 12 with a force sufficient to enable it to resist, without moving, a pressure of 70 lbs. per square inch. But when the pressure exceeds 70 lbs. per square inch it forces the diaphragm down, pushing down valve 13 and allowing the steam in A to pass up through valve 13 and out of the exhaust pipe

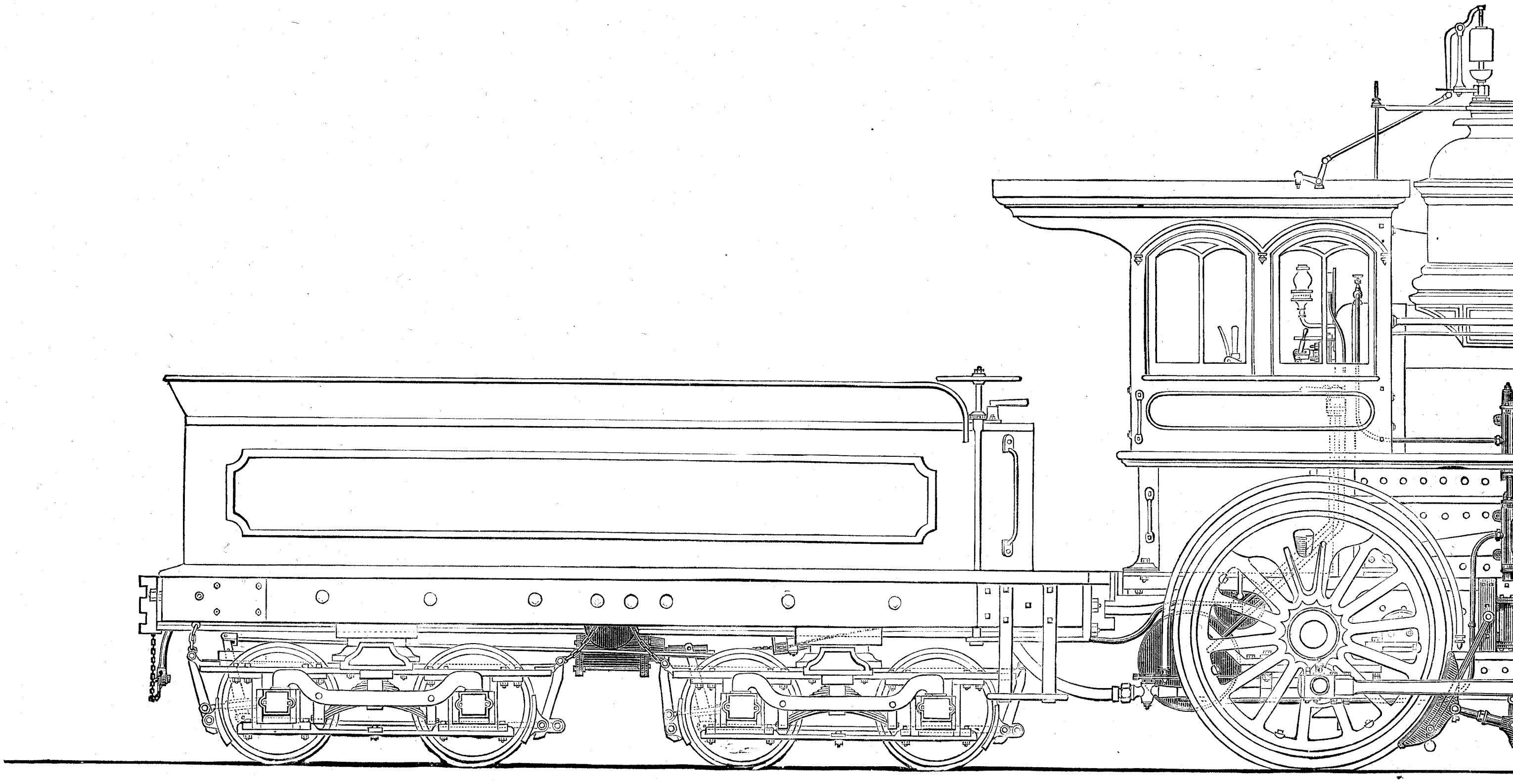


Fig. 3342.

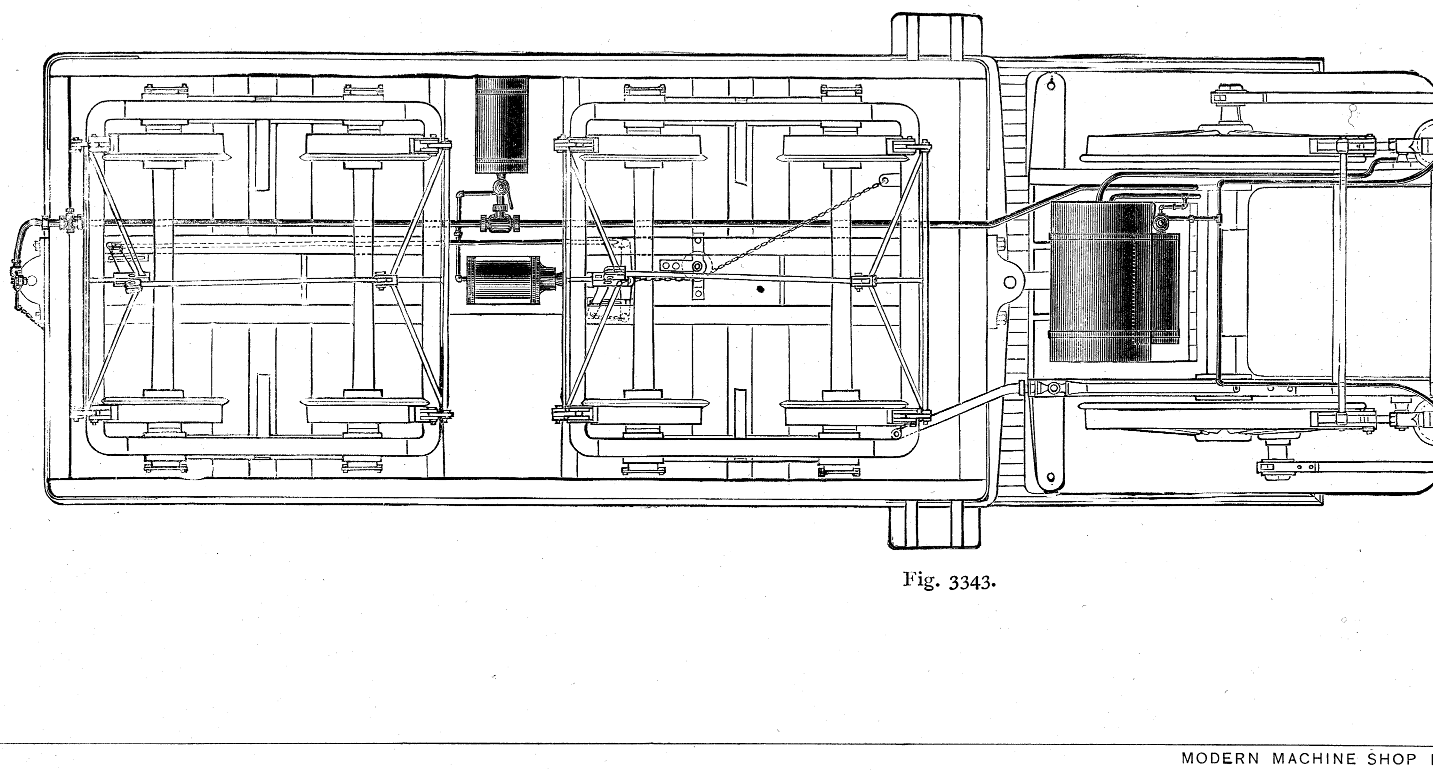


Fig. 3343.

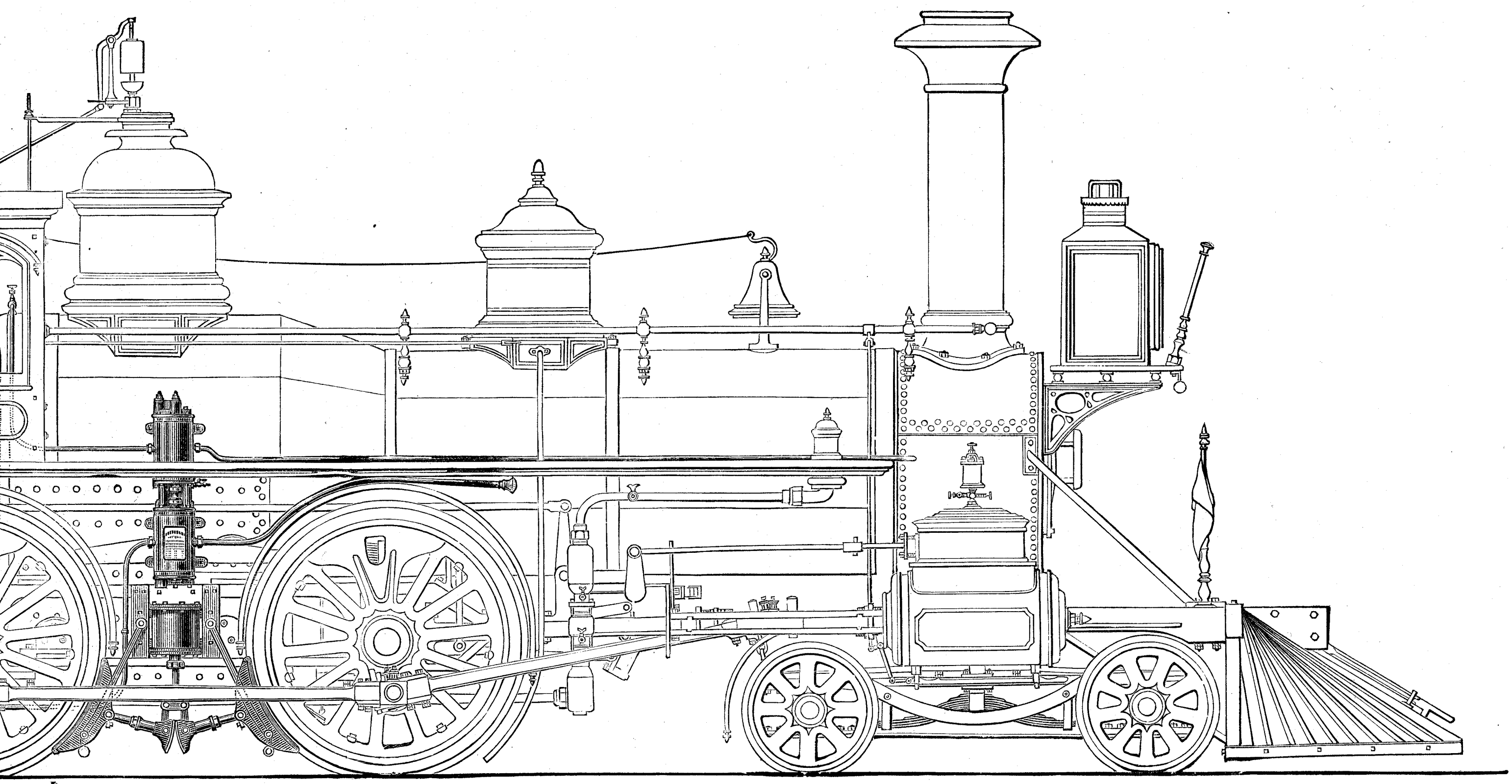
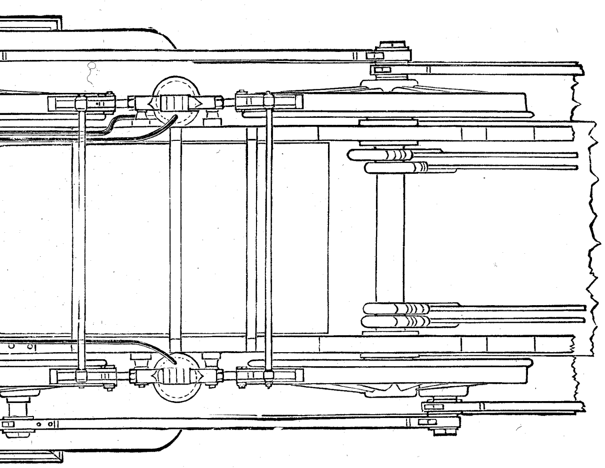


Fig. 3342.



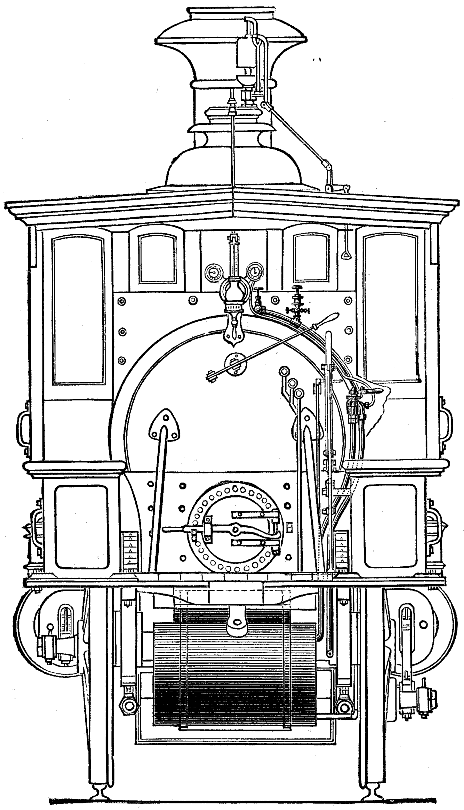


Fig. 3344.

6. The steam pressure in A being thus reduced, that in B acts on the under side of the valve, causing it to rise and seat itself and thus cut off the supply of steam to the pump.

When the pressure in the train pipe is diminished by the brakes being applied, the diaphragm is restored to the position it occupies in the figure by the action of the spring 16. Then valve 13 is seated by the spring 12, and the steam pressure accumulates on the upper end of valve 10, forcing it down and letting the steam from A into B and thence into the steam cylinder, starting it into action, which continues until the pressure in the train pipe exceeds 70 lbs. per square inch.

The use of this governor not only prevents the carrying of an excessive air pressure in the train pipe, which may result in entirely preventing the wheels from revolving and causing a flat place to wear on the wheel tire, but it also causes the accumulation of a surplus of air pressure in the main reservoir, while the brakes are applied, which insures the release of the brakes without delay. It also obviates the unnecessary working of the pump when the desired air pressure has been obtained.

A sectional view of the steam and air cylinders is shown in Fig. 3346, the construction being as follows:

Steam is distributed to the steam cylinder by means of a piston valve, composed of three pistons, marked 16, 14, and 20 respectively, the steam entering between pistons 16 and 14, and, in the positions in which the parts occupy in the figure, steam can pass through the bushing 18 and beneath the steam piston 7, propelling it upwards until the bottom of the hole in its piston rod strikes the end of rod 12, and raises it and valve 13. The chamber 23, in which valve 13 works, receives steam through a suitable port from the steam space between valves 14 and 16; and the steam from chamber 23, it is that (in the positions the parts occupy in the figure), acting on the area of the large valve piston 20, holds the valve down against the pressure on the bottom face of piston 14 of the valve. As soon, however, as the piston rod 7 strikes and raises rod 12 and valve 13, the steam is exhausted from the top of piston 20 of the valve, and the steam beneath piston 14 of the valve raises the valve, opening the lower port in the sleeve 18 for the exhaust, and piston 14 admits steam to the upper side of the steam piston 7. The construction of the air cylinder differs somewhat from that shown in the freight locomotive, Fig. 3326, this air pump corresponding with that shown on the engine and tender, Fig. 3342. A detail list of the parts may be given as follows;

No.		No.	
2.	Steam cylinder head (with reversing cylinder, piston, and valve bushes).	21.	Piston rings.
3.	Steam cylinder with main valve and bushes).	22.	Reversing cylinder cap.
4.	Centre piece.	23.	Reversing valve bush.
5.	Air cylinder (with lower discharge valve).	24.	Reversing valve cap.
6.	Air cylinder head.	25.	Piston rod nut.
7.	Steam piston and rod.	26.	Piston packing gland.
8.	Air piston.	27.	Piston packing nuts.
9.	Piston rings.	28.	Packing glands.
10.	Steam piston plate.	29.	Right chamber cap.
11.	Steam piston bolt.	30.	Left chamber cap.
12.	Reversing rod.	31.	Air valve bushing.
13.	Reversing valve.	32.	Air valve.
14.	Piston valve.	33.	Air valve.
15.	Piston valve rings.	34.	Air valve.
16.	Piston valve rings.	35.	Delivery union.
17	Upper valve bushing.	36.	Exhaust steam outlet.
18.	Lower valve bushing.	40.	Steam cylinder gasket.
19.	Reversing piston casing.	42.	Top air-pump gasket.
20.	Reversing piston.	43.	Bottom air-pump gasket.
		44.	Waste water pipe.
		46.	Exhaust union stud.
		49.	Air exhaust union stud.

A side view of the driving wheel brakes is shown in Fig. 3347 and an end view in Fig. 3348 The brakes are, it is seen, suspended by links so that their weight tends to keep them from the

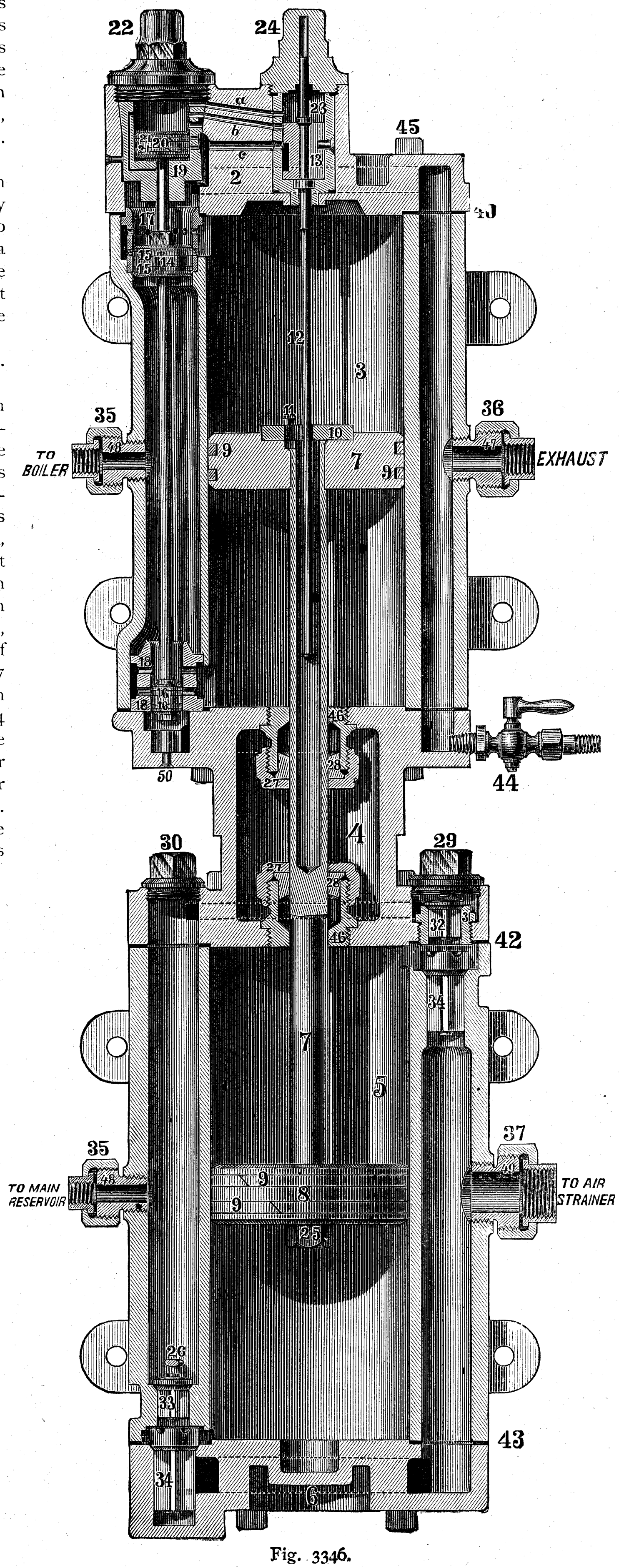


Fig. 3346.

wheels. The brake piston rod carries at its end two links which attach to the arms attached to the brakes. The ends of these arms being curved roll together, the arrangement forming in effect a rolling toggle joint. The construction of the piston of the driving wheel brake is shown in Fig. 3349. The piston is made air tight by leather packing indicated by 11, held out by a spring 12. The piston rod packing, 7, is leather held in place by the cap 6 and the spring 8. The air for operating the brake enters below the piston.

LOCOMOTIVE RUNNING.

The engineer's duty in running a locomotive is more arduous and requires more watchfulness than any other engine running, because of the peculiarities attending it. In the first place, the jolts and jars to which the engine is subject are liable to cause nuts, pins, etc., to come loose, and some of the parts to become disconnected and cause a breakdown of the engine.

This renders necessary a careful examination of the engine, which should be made both before and after each trip.

In the second place, we have that the amount of load the engine has to pull varies with every varying grade in the railroad track, and the variation is so great that on some descending grades the engine may require no steam whatever, while on ascending grades the utmost power attainable from the engine may be required. In firing, feeding the pumps, oiling the parts, and determining the depth of water in the boiler, the grade and the length of each grade has an important bearing, and so has the weather, since it is clear that between the heat of summer and the blizzards of winter there is a wide range of the conditions under which the engine runs.

In former times, from the less perfect construction of locomotives, the engineer's duties were greatly enhanced from breakdowns, which are comparatively rare with modern locomotives, and there is promise that from improved construction and safeguards they will become less frequent in the future.

It is as important for the locomotive engineer to be familiar with the track as it is to be with the engine, and there is no field of engine driving or running in which more scope is permitted to the engineer to exercise judgment and skill in his management, so as to effect economy in fuel consumption.

The quality and size of the coal is another element that requires attention and observation on the part of the engineer, in order that his train may keep its time and the fuel consumption be kept down.

GETTING THE ENGINE READY.

The first thing to be done in getting ready for a trip is to see that there is sufficient water in the boiler, so that if there is not, there is time to supply the deficiency.

If the boiler is cold it may be that the condensation of the steam in cooling may have left a partial vacuum in the boiler, and it will be necessary in that case to open the top gauge cock and let in air so that the water will come to its proper level in the gauge glass.

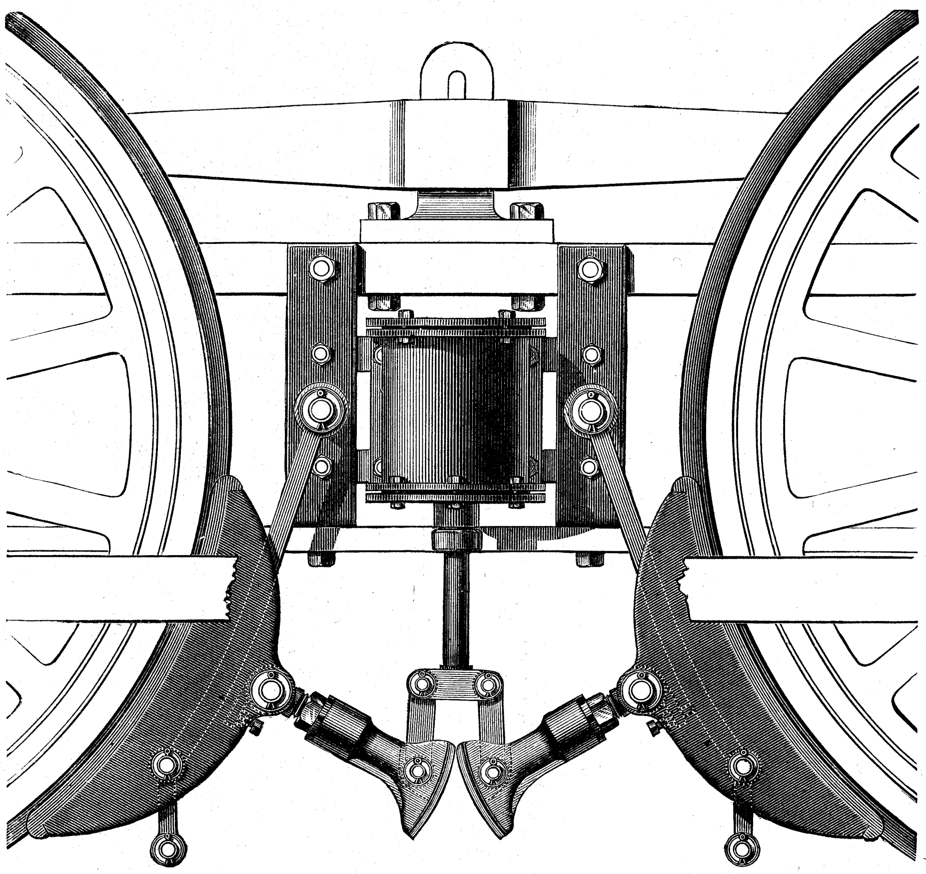


Fig. 3347.

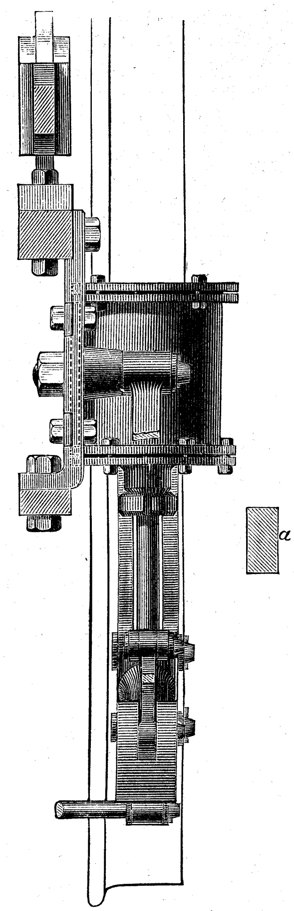


Fig. 3348.

Similarly, in filling the boiler, it may be necessary to open a gauge cock to let the air out.

The lower cock of the gauge glass should be opened to let the steam blow through if there is pressure on the boiler, or to let a little water out if there is not.

The safety valve should next be examined and moved to see that it works properly and does not stick to its seat.

Before laying the fire the fire bars and ash pan should be cleared of ashes and clinkers, and the grate bars tried with the shaking levers to see that the grates will shake properly. It should be seen that the tubes, etc., are clear of ashes.

In laying a new fire an ample supply of lighting material should be used, disposing it so that the fire will light evenly and not in spots, and a good layer of wood should be evenly distributed over the bars, the thinnest pieces being at the bottom as they will light easiest, and it is necessary to light the fire at the bottom, so that the heat from the wood that is first lighted shall pass through that to be lighted.

The wood should be kept burning without coal until the lower

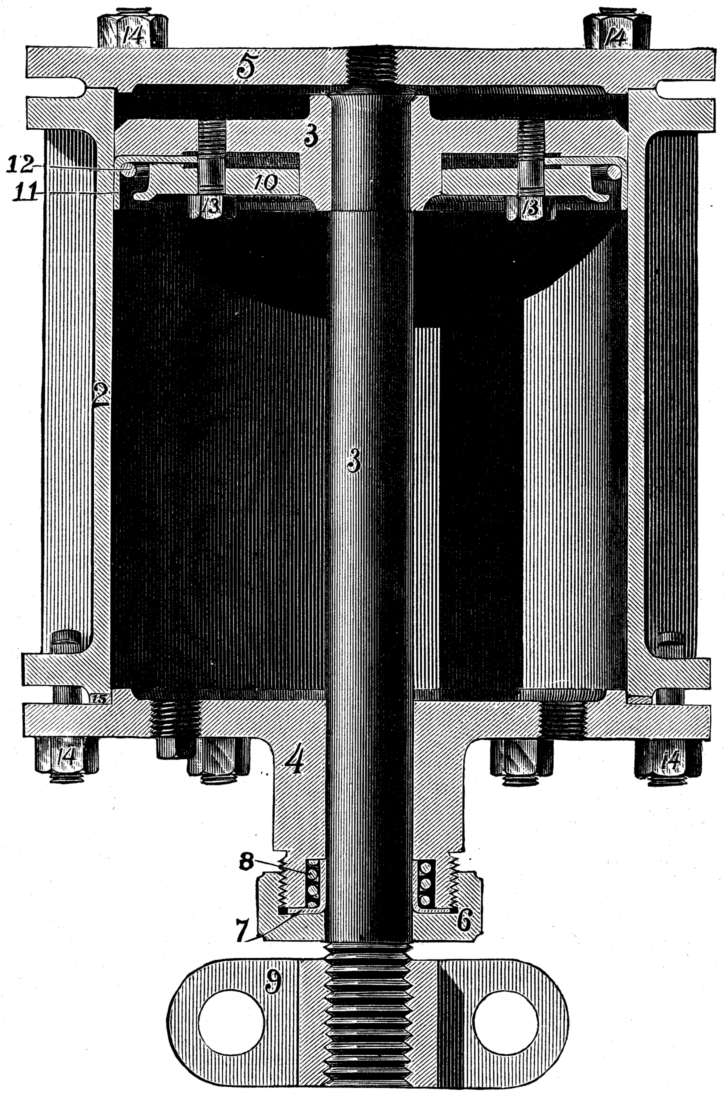


Fig. 3349.

stratum has ceased to blaze and covers the bars, while there is an even layer of blazing wood above it.

The quantity of coal to be fed at a time, and the depth of fire to be kept, depends upon the size of the coal, because the larger the coal the less it obstructs the draught, and the thicker the layer required in order to prevent currents of air from passing through without entering into combination with the gases from the coal.

If the coal is mixed, containing large lumps, they should be broken.

The first layer of coal should be enough to cover the fire to a depth of about two inches, which will permit of a good draught. This will get well alight while the wood is still serviceable, and a second layer may be applied of another two inches. The third feeding should be given with a view to have a greater depth of fire at the sides than at the middle of the fire box, because the cool sides of the box prevent perfect combustion, and currents of cold air are more apt to find their way through the sides than in the middle of the fire box.

Banking a fire consists of piling it up at the back half of the fire box and covering it up with green coal, so that it may keep alight and keep the boiler hot without increasing the steam pressure.

The air passing through the uncovered half of the fire bars prevents rapid combustion and a dead fire is maintained.

In starting up a banked fire, the first thing to do is to clean it of ashes, clinker, etc., shaking up the bars to see that they will work properly. The fire is then spread evenly over the bars, and wood fed to enliven the fire and promote the draught.

The blower or blast pipe is then set going, and coal gradually fed a little at a time, evenly distributed, covering those parts the most where the fire burns through the most brightly.

A steady fire is better than one that is forced, because the combustion is more perfect and less clinker is formed, hence less cleaning will be necessary, and the fire door will not be kept open so long to let in cold air. This is important because a steady temperature in the fire box promotes its durability, as well as giving a uniform boiler pressure. The strains placed upon a fire box by a fierce fire suddenly cooled by a heavy charge of coal or of cold air from an open fire door are highly destructive.

Furthermore, the greatest economy of fuel is attained by keeping the boiler pressure up, and using the steam expansively by hooking up the links to shorten the point of cut-off.

A safety valve steadily blowing off steam, whether the engine is running or not, is a sign of bad firing and wastefulness.

It is the fireman's duty to attend to the fire, but nevertheless a careful engineer will be as much interested in proper firing as in his own duties, and as the engineer has more experience than the fireman, he is warranted in exercising an ordinary supervision on the firing, which will be welcome to an earnest or ambitious fireman.

The engineer should examine, with a wrench in hand, the bolts and nuts about the trucks and axle boxes, as these are apt to become loose and come off on the road. A proper construction would remedy this defect almost entirely, and by a proper construction is meant the more frequent employment of split pins, colters, and other similar safety appliances now omitted for the sake of economy of manufacture.

Nothing in the future of the locomotive is more certain than improvement in this respect, and nothing is more urgently needed, as any engineer will become satisfied if he will gather up along a mile of ordinary railroad the nuts and washers that lay along the track.

The eccentric straps and the pins in the link motion require an examination, which may be done while oiling the parts of the engine.

The oiling requires careful attention ; first the cups themselves sometimes become loose, an argument in favor of having, wherever possible, the cups solid on the parts, as done in European practice.

Oil holes are apt to get choked by gumming, which is that the oil in time forms into a brown gummy substance that fills the oil hole. Perfect lubrication does not imply wasteful lubrication by any means, but a wasteful use of oil is probably less expensive than insufficient lubrication.

A thorough engineer will use no more oil than is necessary ; he will leave nothing to conjecture or chance, but know from personal inspection that his engine is in complete working order, and to this end the lubrication of the working parts is a vital element.

After having oiled the eccentric straps, the link motion and the reversing gear beneath the engine, the reversing lever and the parts above the frame must be oiled, and the reversing lever moved back and forth several times, from end to end of the sector or quadrant, so as to distribute the oil throughout the joints and working surfaces.

The axle boxes require careful attention in oiling. In English practice, tallow is packed in the corners of the cavities of the top of the box, so that if the box should begin to heat the tallow will melt, and afford extra lubrication with a heavier lubricant than usual, which will often stop the heating.

The connecting and coupling rods then require attention, the cups being filled and the lubrication adjusted.

When steam is up the gauge glass should be blown through again, and it will be found that the water stands higher in the glass than it did before the boiler was under pressure.

The packing of the piston and of the pump glands, if the engine has pumps, should be known to be properly set up, bearing in mind that a leaky pump gland lets air into the pump and impairs its action.

The sand box should contain dry sand, as wet sand will not feed properly.

If steam is raising too rapidly, close the lower damper to reduce the consumption of fuel and save blowing off steam through the safety valve, which should always be avoided as much as possible.

Before starting the engine, open the cylinder cocks and keep them open until the sound discloses that dry steam, and not steam and water, is issuing.

Open the throttle enough to start the engine easily and not with a jump, and be prepared to shut off steam instantly if a blow in any part of the engine should indicate an obstruction to its working.

In starting a train, the reversing lever is put in the end forward notch and the cylinder cocks opened. Then the throttle is opened a little at first, so as to avoid starting with a violent shock that might break the couplings.

If in starting (or in ascending gradients) the wheels are forced to slip, the sand lever should be operated, a slight sprinkling of sand serving better than a heavy one. If the sand is damp, it will fall in lumps and not distribute evenly as it should do, while at the same time a great deal more sand will be found necessary.

When the train is fairly under way, the aim should be to maintain full boiler pressure, so as to keep up the required speed with the links hooked up to work the steam as expansively as possible, bearing in mind that the higher up the links are hooked the more expansively the steam is used, and that therefore less steam is used to do the work and the boiler pressure can be kept up easier.

To understand this clearly, let it be supposed that the steam pressure in the boiler is 90 lbs. per square inch, and that the piston area is 400 inches, and the total pressure impelling the piston will be 36,000 lbs.; if this follows the piston for 22 inches, the power becomes 792,000 inch lbs. per stroke.

Now suppose the pressure is 150 lbs. per square inch, and this multiplied by the piston area (400) gives 60,000 lbs. impelling the piston, and this would require to follow the piston but 13.2 inches in order to give 792,000 inch lbs. In the one case we have 22 inches, and in the other 13.2 inches of the cylinder to fill with steam. Of course it will take more fuel under the heat of firing to keep the pressure up to the 150 lbs.; but on the other hand, when the steam is cut off in the cylinder there will be 160 lbs. per square inch in it, and all the work that this does in expanding is gained during the rest of the stroke, so that the required amount of power would be obtained by cutting off earlier than at 13 inches.

The water should, under ordinary conditions, be kept at an uniform level in the boiler. Steam can of course be made quicker with a small than with a large quantity of water, but the smaller the quantity of water the more the steam pressure is liable to fluctuate, and the closer the firing must be attended to.

Furthermore, the more water there is in the boiler, the greater the safety, because the longer the boiler can go without feeding, and, if the pumps or injectors, as the case may be, should act imperfectly, there is more time to get them working properly.

In testing the water level, the gauge glass alone is not to be entirely depended upon, hence the gauge cocks should be opened. The water should not be allowed to go below the middle gauge cock.

It is obvious that when the water is below a certain gauge cock, the gauge glass only can give any information as to how far it is below it, hence it must be used for this purpose.

When using it, it should be blown through by opening its lower cock, and if there is any doubt about its showing the proper water level it should be blown through two or three times, watching the level of the water in the glass at each trial.

A constant boiler feeding is the best, as it is more conducive to a uniform boiler pressure and temperature.

The fire should be fed in small charges, the fire door being kept open as little as possible, because a high temperature in the fire-box is necessary to perfect combustion. If heavy charges of coal are given at once, then for some time the fire box will be cooled, and then, as the fire burns through, a fierce heat will be generated. This alternate heating and cooling is very destructive to the fire box and the tubes, as it causes an expansion and contraction that rack the joints and seams.

There are several ways of firing, each having its advocate. Upon the following points, however, there is no dispute. First, a slow combustion is the most perfect, because it produces less clinker, which saves fuel and also saves a large amount of fire cleaning and therefore of admission of cold air to the fire box. A high temperature is necessary to combustion, and the temperature of the fuel is most difficult to keep up at the sides of the fire box.

By light and frequent firing the bright fire will never be covered up, hence the temperature will be maintained. This favors an even distribution over a large surface of the fire of each shovelful of coal. But if at any point the draught is lifting the fire, and small bright pieces of fire are lifting up, it is an evidence that the fire is thinnest there or else that the bars are cleanest there. In either case, an extra amount of coal is required at that spot.

Some engineers will charge one side of the fire box lightly and then the other, this being done so as to keep up the temperature in the fire box. Others will fire first the front and then the back of the box, which answers the same purpose, but in no case should the charge be heavy.

A fireman may become so accustomed to the road and his engine, that under some conditions he may fire when he reaches certain points on the road, regulating it like clockwork.

On a trip from Philadelphia to Reading, on an engine having a Wooten fire box (whose special feature is a large fire box, which enables slow combustion), the firing was conducted as follows:

The fire was was not fed or touched until just before reaching Bridgeport, 18 miles from Philadelphia, when a thin layer of coal was spread evenly on the fire. Eleven miles were then made without opening the fire door, the next firing taking place just before reaching Phœnixville.

Ten miles were run before the next firing, which occurred just before arriving at Pottstown.

The next firing occurred at Bordenboro', three miles from Pottstown. The remaining 8 miles were made without firing. The steam pressure did not vary more than 10 lbs. per square inch during the trip.

On a trip from New York to Philadelphia by the lightning express train the firing was conducted as follows:

The coal was anthracite and in lumps from 5 to 7 inches in diameter; at one end it reached up to the level of the fire door, while at the tube plate end of the fire box it was about 6 inches deep.

The grate bars were constructed to shake in three sections, and shaking the bars to clear out the fire caused it to feed forward of itself, and the combustion of the coal caused it to break up into lumps about 2 inches in diameter at the tube plate, where the fire was much brighter than at the fire door end. The steam pressure varied about 10 lbs. during the trip.

We now come to the best times to fire, to feed, and to oil the valves, and this depends on the level of the road.

On a level road these matters could be attended to with regularity, but as the engine has most work to do in ascending inclines, it is necessary to prepare for such emergencies:—First, by having a good fire prepared, so that the fire door may be kept closed as much as possible while the engine is ascending; second, by having plenty of water in the boiler, so as to keep steam, without feeding any more than possible when the engine is calling for more steam, by reason of the reversing lever being put over towards full gear.

The speed is kept well up before reaching the incline, and the reversing lever moved forward a notch or two at a time to maintain the speed, while at the same time moving the sand lever to feed the sand as soon as the engine speed shows signs of reducing.

ACCIDENTS ON THE ROAD.

The accidents to which the locomotive is most liable when running upon the road, and the course to be pursued by the engineer to enable him to take the engine to the depot or complete the trip, are as follows:

KNOCKING OUT THE FRONT CYLINDER HEAD OR COVER.—This arises from various causes, such as a breakage of a connecting rod strap, or of a piston rod or cross head. It is the practice of some locomotive builders to cut in the cylinder cover flange a small groove close to the part that fits the cylinder bore, so that the cover shall break out in the form of a disc, leaving the cover, flange, bolts, and nuts intact, and diminishing the liability to break the cylinder itself as well as the cover.

The provisional remedy for this accident is to take off the connecting rod (on the side of the broken cover) and also the valve motion, either at the rock shaft arm or by taking down the eccentric rod straps. Then place the valve in the centre of its travel so that it shall cover and enclose both the cylinder steam ports and leave the exhaust port open. Then block the cross head firmly on the forward centre, and go ahead with the other cylinder.

Heating of Piston Rods.—This the engineer can often discover by sight, or by smelling it from the cab. The remedy is to stop the engine and slack back the gland until the steam from the engine cylinder leaks freely through the packing. Then apply a little extra lubrication or water while *running slowly*.

Breaking of a Piston Rod.—If the piston rod breaks, but does not knock out the cylinder head or cover, pursue the same course as directed for breaking the cylinder cover, taking the additional precaution to block the piston, which may be done by fitting pieces of wood between the guide bars, making the pieces long enough to fit between the cross head and guide yoke.

The cylinder or waste water cocks on the side of the accident must also be opened, to prevent any leakage of steam past the slide valve from getting into the cylinder and driving the piston against the cylinder cover, and breaking the cylinder cover or even the cylinder itself.

If the piston rod breaks from the cross head, it is safest to remove it from the cylinder, though this is unnecessary, if it be securely blocked against the cylinder head so that it cannot move, though steam may leak in on either side of it.

Breaking a Crank Pin.—This is a somewhat frequent accident, but seldom takes place on both sides of the engine at once.

The remedy is to take off all the parallel or coupling rods, and if it is the crank pin on the driving wheels which breaks, take off the connecting rod also, and securely block the cross head, disconnecting the valve motion as before directed, and opening the cylinder waste water cocks. In the case of this accident occurring, it is absolutely essential to take off the parallel rods on both sides of the engine, or otherwise the crank pins on the other side are apt to break.

Throwing off a Wheel Tire.—In this case the best plan is to block the tireless wheel entirely clear of the track, which may be done by putting a block of wood into the oil cellar of the driving box, and then tow the engine to the repair shop; for if the engine is run to the shop, and the wheel touches the rail, it will impair its diameter for the proper size of tire.

Throwing off a Driving Wheel.—This is not a common accident, but nevertheless it sometimes occurs; they break usually just outside of the driving axle box. In this case take out the driving box and fit in its place a block of wood affording journal bearing for the axle. Let this block rest on the pedestal cap, holding the axle up in the centre of the pedestal. Then secure the piston and disconnect the valve gearing and open the cylinder cocks as before, and the engine can be run *slowly* to the repair shop without danger of further accident, or, if convenient, it can be towed by another engine.

Breaking a Spring or Spring Hanger.—Lift the engine with the jacks until the driving wheel axle box is about in the centre of the pedestal, and put any convenient piece of iron across the top of the driving axle box and between it and the engine frame, thus taking the weight of the engine on the frame instead of on the spring. Place also a block of iron between the end of the equalizing bar and the top of the engine frame, so as to prevent the movement of the equalizing bar, and to allow the spring at the other end of the equalizing bar to operate without moving the said bar. Every engineer should carry in his tool box pieces of metal suitable for this purpose, because this is a frequent accident. It does not, however, materially affect the working of the engine, and should not delay a train more than a few minutes.

Bursted Flues and Tubes.—These are usually plugged by tapering a piece of pine wood and driving it into the bursted tube by means of an iron bar. Taper iron plugs are often carried, and then driven into the end of the tube after the wooden one has been driven in. To enable this job to be done, it is necessary to thickly cover the fire with green coal, which operates to cool the tubes and prevent the loss of the water in the boiler. Sometimes careful engineers prepare for use pine plugs turned slightly taper, and a little slack, for the inside of the tube. In case of leak, this plug is inserted in the flue, and driven along it until it covers the fracture, the expansion due to its saturation causing it to become locked in the tube.

Slipping of Eccentrics.—Place the reverse lever in the forward notch of the sector. Place the crank on its forward dead centre, as near as can be judged by the eye, and loosen the set screw of the forward eccentric, that is to say, the eccentric which connects to the upper end of the link. Move that eccentric round upon the axle until the slide valve leaves the steam port at the front end of the cylinder open to the amount of required valve lead. In moving the eccentric round upon the shaft, move it in the direction in which it will rotate when the engine is running forward, so as to allow for and take up any lost motion there may be in the eccentric straps, in the eccentric rod eyes and bolts, and in the other working parts of the valve gear; for if the eccentric was moved backward, all such lost motion would operate to vitiate the set of the valve. The eccentric being placed as directed fastens its set screw securely.

If the backward eccentric is the loose one, throw the reverse lever to the backward notch of the sector, lifting the link up so that the eccentric connected to the lower end of the link may be approximately adjusted by moving it around upon the axle in the direction in which it will rotate when the engine is rnnning backward, until the back cylinder port is open to the amount of the valve lead. Another very ready plan of temporarily adjusting the eccentrics is as follows: Place the reverse lever in the end notch forward, and place the engine crank or driving crank pin as near on a dead centre as the eye will direct, and open both the cylinder waste water cocks. Then disconnect the slide valve spindle from the rocker arm, and move the slide valve spindle until the opening of the cylinder steam port corresponding to the end of the cylinder at which the piston stands will be shown by steam blowing through the waste water cock at that end of the cylinder; the throttle valve being opened but a trifle, to allow a small steam supply to enter the steam chest and cylinder, for if much steam is admitted, it may pass through a leak in the piston and blow through both the waste water cylinder cocks.

The position of the valve being thus determined, the eccentric must be moved upon the driving axle until the valve spindle will connect with the rocker arm without being moved, or moving the valve at all.

Hot Axle Boxes.—If not convenient to reduce the speed of the engine, or if that and free lubrication do not cool the box, a plentiful supply of cold water should be administered, it being well to have at hand a small hose pipe, by means of which water from the tender tank can be used. If the brasses have Babbitt metal in them and it should melt, it is better, if possible, to cool the axle box while the engine is moving, which will injure the journal less than if the journal is stopped to cool the box, because in the latter case the brass or box is apt to become soldered to the journal of the axle, and when the engine is again started, the cutting or abrasion will recommence with extreme violence.

Breaking a Lifting Link or the Saddle Pin that Connects the Slot Link to the Reverse Shaft.—Cut a piece of wood and tie it into the slot of the link, over the link block or die, making it of a length to keep the link in the position for hauling the train. Then fasten another piece of wood in the link slot beneath the sliding block or die, thus securing that die in the proper position for the engine to go ahead. In this case, the engineer must be careful in stopping, as he cannot reverse the engine on the crippled side.

Secondary accidents are almost sure to occur if a disconnected piston is not securely blocked in the cylinder, or from blocking the piston aright and attempting to let the slide valve run, or from attempting to run with the parallel rods on one side only disconnected. There are numerous accidents, which only common sense and a familiarity with the locomotive can provide a temporary remedy for, but those here enumerated are by far the most common.

ADJUSTING THE PARTS OF A LOCOMOTIVE.

When the wedges of the axle boxes are to be adjusted for fit to the pedestal shoes, the engine should be moved until the coupling rods on one side of the engine are in line with the piston rod, because in this position the rod will, to a certain extent, act as a guide in keeping the axles parallel to each other, and at a right angle to the line of engine centres.

Bear in mind that the distance from the centre to centre of axle boxes must be the same as the distance from centre to centre of the crank pins, and that when the coupling or side rods are in line with the piston rod, they act to resist the axle boxes from being set up too close together.

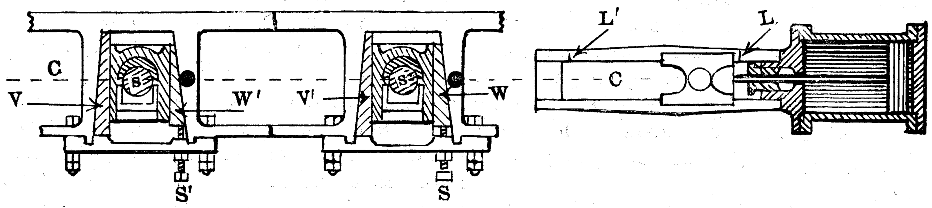


Fig. 3350.

The importance of a proper adjustment of the axle boxes, coupling boxes, and connecting rods cannot be overestimated, and it is necessary therefore to explain it thoroughly. In Fig. 3350, then, *s*, *s* represent two wheel axles, whose boxes are between their wedges. At S, S′ are the screws for setting up the shoes or wedges W and W′ respectively. The axles are shown on the line of centres C, C of the engine, the piston being at the head end of the cylinder, and the crank pins on the line of centres as denoted by the small black circles. The wedges W and W′ are shorter than the leg of the pedestal, so that they may be set up by the set screws S and S′, and take up the wear.

In some engines the wedges V and V′ are also shorter for the same purpose. Now it is clear that setting up the screws S and S′ will move the axles *s*, *s′* to the left, and this will alter the clearance between the piston when it is at the end of the stroke and the cylinder cover.

It is clear that the distance between the centres of the two axles must be the same as the distance between the centres of the two crank pins, or else the frame will be subjected to a great strain, tending to break the crank pins and the side rods.

In order to keep the clearance equal and to know when it is equal, it is necessary, at some time when the cylinder cover at the head end is off, to disconnect the connecting rod and push the piston clear up against the left hand cylinder cover, and from the cross head as a guide, make on the side of the guide a line L′. Then put on the cylinder cover at the head end and push the piston up against it and mark a line L. Then when the connecting rod is put on again, the wheels may be moved around if the engine is jacked up, or, if not, the engine may be moved along the rails with a pinch bar, and the clearance will be equal when the cross head (at the ends of the stroke) comes within an equal distance of the respective lines L′, L when the crank is on the dead centres, and it is well to adjust the wedges W W′ so that the cross head does travel within an equal distance, and mark on the guide bar two more lines, one at each end of the bar.

These lines are a permanent guide in setting up the shoes or wedges, and lining up the connecting rods, and coupling or side rods, because it is clear that from the method employed in marking them the distance between the end of the cross head, when at the end of its stroke, and the line L, and that between the face of the piston and the cylinder cover, will be equal.

A proper adjustment, therefore, should be made as follows: The piston should be at the end of its stroke, the crank pins being on the line of centres.

Screw S should be operated to set up the wedge W, taking up the wear of the sides of the box, and bringing the edge of the cross head the proper distance from the line L. The connecting rod brasses should then be set up to fit the pins, and the screw S′ operated to set up wedge W′ to have easy contact with the side of its axle box. If, however, there has been so much wear on the axle boxes that they are still too loose between the wedges, both wedges may be set up to take up this wear, since it is more important to have the axle boxes a proper fit between the wedges than it is to maintain an exactly equal amount of clearance at each end of the cylinder.

The engine will then be in proper tram on this side, or, in other words, the distance from the centre to centre of the crank pins will be the same as that from centre to centre of the axles.

On the other side of the engine the process is the same, the engine being moved until the crank pins are on the line of centres C C and the wedges set up according to the lines.