great waste of fuel. The designer therefore endeavors to obtain a perfect exhaust, by giving as nearly as possible a perfect steam distribution; the valve setter has to get an even exhaust at all costs. The normal setting for a Walschaert gear is square on dead centers, with a constant lead in all positions of the reverse lever, but there is another setting which is sometimes resorted to, and this is to give no lead at all, or a very slight lead in full fore gear and an increasing lead as the lever is notched up toward mid-gear. This variable lead is a feature which is natural to the Stephenson gear, with open rods, and this gear was commonly set with no lead in both fore and back full gear, but in notching up from either of these positions an increasing lead was obtained. It is not a natural feature with the Walschaert gear, however, and if we produce it in the fore gear we do so at the expense of the back gear.

A prevalent idea seems to be that it is detrimental to have any lead at all in full gear, as it hinders the starting of the engine. Some text books also tell us that the object of lead is to cushion the piston at the end of its stroke. If we study the question closely, we will agree, I think, that both of these arguments are incorrect. Lead cannot hinder starting, unless the admission takes place considerably before the piston completes its stroke, and as a matter of fact, the pre-admission in full gear is so small that it can hardly be measured; as for lead cushioning the piston, a glance at a few indicator cards will show us quite plainly that compression and not lead has to take care of this. The main object of lead is to give an unrestricted supply of steam to the cylinder, when the piston begins its stroke, and with the pre-admission down to about 1/64 in. it is impossible that the steam admitted to the cylinder can exert any appreciable turning moment on the axle until the crank pin has gone over the center. Although the lead is constant, on a normally set Walschaert gear, the pre-admission increases as the lever is notched up, so that if the cushioning effect of the live steam is really required, we have this effect increasing as the lever is pulled toward mid-gear. I do not pretend to say that the pre-admission increases to the same extent as on a Stephenson gear, but I think it is generally admitted that the pre-admission is high on this gear in running position. The real object of setting the Stephenson gear with no lead, or 1/16 in. or so blind, in full gear, was, not to overcome the detrimental effect of lead in full gear, as this is non-existent, but to bring the closure point to such a position that the compression would not be excessive when running at high speeds, so that if this variable lead setting with Walschaert gear is justified, it is through its influence on the other valve events, such as cut-off, release, closure, etc., as the lead itself has no influence one way or the other in starting.

VALVE DIAGRAM
FULL FORE GEAR AND RUNNING POSITION

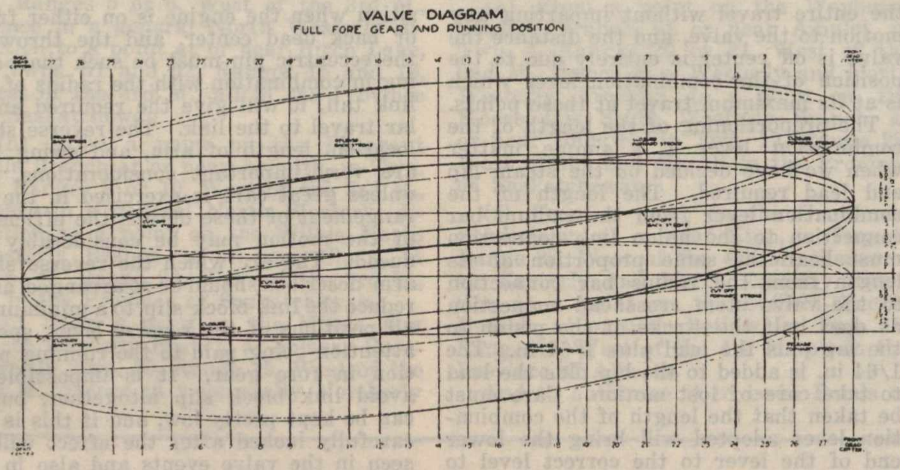

FIGURE 1

FULL BACK GEAR

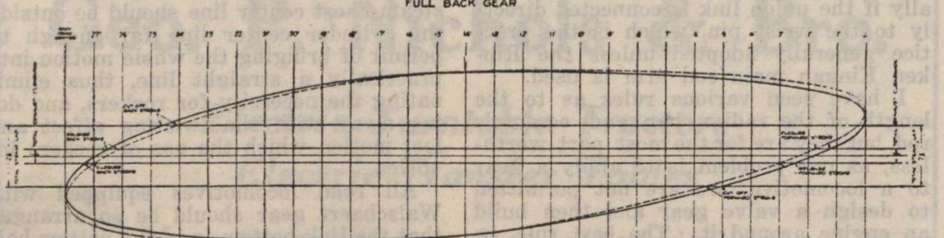

FIGURE 2

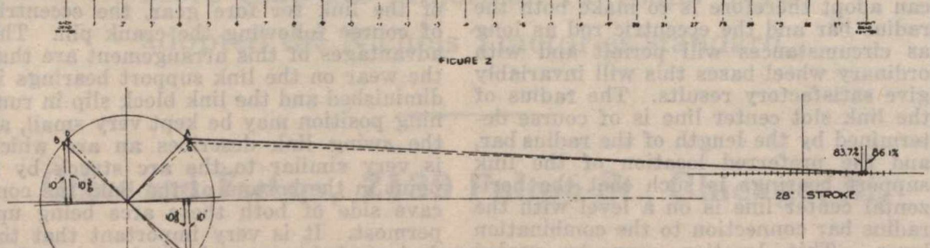

FIGURE 3

FULL FORE GEAR 50% — 25% CUT-OFF

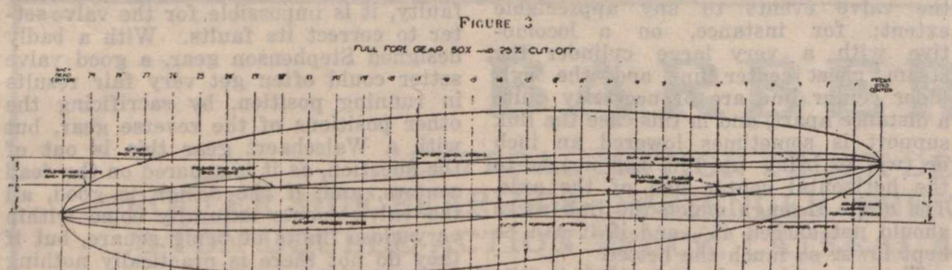

FIGURE 4

We will now take a look at the valve diagram shown in fig. 1, plotted for one of our large passenger locomotives. This engine has 24 x 28 in. cylinder, a 14 in. valve, 6 in. valve travel, ¼ in. constant lead, 1—1/16 in. steam lap and ¼ in. exhaust clearance. The broader ellipse in the center shows the valve travel, in relation to the piston travel, in full fore gear, and the narrow ellipse inside it shows the same thing with the lever notched up to 25% cut-off. The distance from the steam edge to the exhaust edge on the valve over the packing rings is 2¾ in., therefore the similar ellipses which are plotted 2¾ in. above and below the center ellipse, with lighter lines, must represent the movement of the exhaust edges of the valve. The three ellipses shown in dotted lines represent the movement of the valve set with no lead in full fore gear. Picking out the valve events we find that with the ¼ in. lead setting we have the cut-off at 23 in. and 23⅞ in., the release at 25 9/16 in. and 26¼ in. and the closure at 26 13/16 in. and 27¼ in. Set with no lead, however, we have the cut-off at 23 9/16 in. and 24⅝ in., the release at 26⅛ in. and 26¾ in., and the closure at 27¼ in. and 27⅝ in., so that the net result of adopting this latter setting is to delay the cut-off from 83.7% to 86.1%, the release from 92.6% to 94.5% and the closure from 96.6% to 98%, an improvement in the starting position of 2.4, 1.9 and 1.4% of the stroke respectively.

The valve diagram shown in fig. 2 is plotted for the same locomotive in full back gear, the ellipse shown in dotted lines representing the valve movement with the variable lead setting. In this case I have two lines ¼ in. above and below the center line, representing the amount of the exhaust clearance; these lines will determine our release and closure points in the same way that the outside edges of the steam ports did in fig. 1, and will simplify the diagram. A glance at this diagram will show us that the cut-off, release and closure points, are advanced in backgear, by just about the same amount as they were delayed in fore gear, so that whatever we have gained in the foregoing position we have done so at the expense of the back. In the short cut-offs there is so little difference in these two settings that I have only plotted one, which I mentioned before when alluding to fig. 1.

Before we can realize exactly how much or little advantage is to be gained by this variable lead setting in full fore