THE WALSCHAERT VALVE GEAR.*

AN OLD INVENTION WITH A MODERN HISTORY.

BY C. O. ROGERS.

THE Walschaert valve gear, though but lately introduced on any large scale in American locomotive practice, is as old a device as the Stephenson shifting link motion, with which every engineer is familiar. In 1844 Egide Walschaerts, at that time chief shop superintendent of the Brussels Southern Rail-

FIG. 1.—SIMPLEST FORM OF VALVE MOTION.

FIG. 2.—REVERSING MECHANISM.

road, invented the type of valve motion which bears his name. Because of the fact that the rules of the railway company did not allow a foreman in the shops to advertise a patent in Belgium to his own profit, the application for the patent was made by M. Fischer, engineer of the State Railways of Brussels, a friend of Walschaerts, in the latter's name. The patent was granted by royal decree on November 30th, 1844, and the mechanism described in the patent resembles the motion which is now in use on many American locomotives. The so-called Stephenson shifting link motion came into prominence a year earlier, or in 1843. The Walschaert valve gear attracted a great deal of attention in Europe and gradually became the accepted type of valve motion on the railroads of continental Europe, just as the Stephenson link motion came into general use on American railroads.

Although there are a number of special cases in which the Walschaert valve gear has been applied to locomotives in this country as far back as 20 or 25 years ago, it is only during the last few years that it has been used in America on any large scale. With the increase in power and weight of the modern locomotive, however, conditions have arisen to meet which the American designer has turned to the Walschaert valve gear because it offers certain mechanical and structural advantages over the Stephenson motion.

Because of the increase in size of the parts, there is hardly room enough between the frames of a modern heavy freight or passenger engine for the accommodation of the Stephenson gear. The eccentrics are crowded together so that it is almost impossible for the engineer to give them proper inspection or lubri-

FIG. 3.—LINK BLOCK POSITIONS.

cation. The Walschaert valve gear, on the contrary, being outside of the frames, is perfectly accessible, and can therefore be much more easily maintained.

With the high surface velocities of the largest sizes of eccentrics, it is difficult to keep them properly lubricated. With the Walschaert valve gear, there are no large eccentrics to keep lubricated; but with hardened pins and hardened bushings it has an important advantage in maintenance.

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The Walschaert gear transmits the moving force to the valve in very nearly straight lines, so that there is less springing and yielding of the parts than in the Stephenson link motion.

The Stephenson link, under the influence of two eccentrics, moves through wide angles, resulting in a wedging action of the link block which strains the gear and produces lost motion. The Walschaert link, driven by a single eccentric, moves through smaller angles and produces less lost motion.

By removing the valve gear from between the frames, as we do in the case of the Walschaert gear, a better opportunity is afforded to introduce stronger frame bracing, and thus reduce the possibility of frame failures.

The Walschaert valve gear shows a distinct advantage over the Stephenson link motion as regards permanence of adjustment. When a large freight engine is half way between shoppings the Stephenson link motion is slack and loose, while the Walschaert valve gear is in as nearly good condition as when the engine left the shop; consequently the original steam distribution is much better maintained with the Walschaert than with the Stephenson motion.

These are some of the reasons why a large number of American railroads are now equipping their engines with the Walschaert valve gear. Seldom in the history of the development of the locomotive in this country has any improvement, once introduced, been so rapidly accepted as this type of valve motion; and, inasmuch as its use will undoubtedly increase, a clear understanding of its principles and construction is essential.

The best place to begin is always at the beginning; and as the Walschaert valve motion, like any other

FIG. 4.—INTRODUCTION OF THE LAP AND LEAD LEVER.

device, is merely a development of some simpler form, it is necessary in studying it to start with the original form and trace the various steps in the development.

Fig. 1. represents the simplest form of valve motion; viz., a single eccentric of the return crank

FIG. 7.—DIFFERENT POSITIONS OF THE VALVE FOR DIFFERENT POSITIONS OF THE CRANK PIN.

form, driving a plain normal valve without lap or lead by means of an eccentric rod directly connected to the valve stem. Assuming that the engine is to run forward, with the main pin on the back center, as shown, the eccentric crank pin must be on the top

quarter; in which case the valve will be in the central position on its seat with all ports closed. Although it is apparent that if the throttle were open this engine could not start of itself, with another engine of the same kind connected to the wheel on the other side of the axle, and with the main pins at right angles to each other, as is the case in the loco-

FIG. 5.—WALSCHAERT GEAR APPLIED TO A CONSOLIDATION ENGINE.

FIG. 6.—GEAR AS ARRANGED FOR INSIDE ADMISSION VALVES.

motive, the valve of the left-hand engine would be in a position to admit steam behind the piston and start the wheels turning to the right. The eccentric crank on the engine which is shown would then move the valve forward, uncovering the back steam port and admitting steam behind the piston, and the engine would run forward. It is perfectly evident, however, that this engine will only run in one direction; for if, to start it backward, the wheel were pinched to the left, with the eccentric in the position as shown, the valve would be moved to the left and steam admitted ahead of the piston, forcing the crank pin back again to its position on the back center. In order to make the engine run backward, the eccentric would have to be a quarter of a revolution ahead of the main pin and move the valve forward, opening up the back port and admitting steam behind the piston as is necessary.

The first thing to do in the development of this simple form of engine, therefore, is to introduce some means by which it can be reversed. This can be accomplished by introducing a beam between the eccentric and the valve stem, pivoted at its center so that one end moves with and in the same direction as the eccentric and the other end in exactly the opposite direction.

Such a construction is shown in Fig. 2. With the valve stem at the lower end of the link and the main pin on the upper quarter, as shown in diagram A,

the eccentric will have moved the valve to its extreme forward position and the back port will be opened for the admission of steam behind the piston and the engine will run forward. If, however, with the main pin and eccentric crank in the same position,

the valve stem were connected to the upper end of the link, as shown in diagram B, the valve would be moved to its extreme position to the left and the front port would be opened and steam admitted ahead of the piston and the engine would run backward. With a flexible valve stem, or radius rod, connected to a block which slides in a curved slot in the beam, or link, as shown, and with the necessary mechanism for raising and lowering the block, it is evident that we now have an engine that can be reversed.

This engine, however, is still far from an efficient machine; for, as the valve does not close the port for the admission of steam until it is in its central position on the seat; and, as with the eccentric only a quarter of a revolution ahead of the main pin, it is not in this position until the main pin is on the center, whatever the travel of the valve, steam will be admitted to the cylinders throughout the full stroke of the piston, and the engine will use as much steam working against a light as against a heavy load. In order to govern the period for the admission of steam, or, in other words, give a variable cut-off, the valve must be redesigned so that it will close the steam port before it reaches its central position; that is, it must be given "lap," the lap of a valve being that portion of it which overlaps the steam ports when it is on its central position on the seat. But with lap given to the valve and also "lead," which is the width of the opening of the steam port given by the valve when the piston is at the beginning of its stroke, the valve motion must be so changed that the valve will be advanced from its central position on the seat a distance equal to the amount of the lap plus the lead, when the crank pin is on either of the centers.

It is apparent, from an examination of Fig. 3, that this advance of the valve can not be obtained by any change in the position of the eccentric crank relative to the main pin. Fig. 3 shows the same valve motion as was shown in Fig. 2, except that the valve has one

With the main pin on the forward center, as shown in position A, the angle assumed by the lap and lead lever has moved the valve back a sufficient distance to uncover the front port. With the main pin on the back center, as shown in position B, the lap and lead lever is inclined in the opposite direction and

from the bottom of the link, as is usually the case, the eccentric crank is a quarter of a revolution ahead of the main pin when the wheel is running forward, if the valves have outside admission; and a quarter of a revolution behind it, if the valves have inside admission. If the top of the link is used for for-

FIG. 9.—DIFFERENT POSITIONS OF THE VALVE FOR DIFFERENT POSITIONS OF THE CRANK PIN.

the valve moved forward, and the back port is open. This is the way the Walschaert valve gear derives its lead. The distances between the connecting points of the lap and lead lever must be so proportioned that

ward motion, the eccentric crank is a quarter of a revolution behind the main pin, if the valves have outside admission; and a quarter of a revolution ahead of it, if the valves have inside admission. In all cases, if the valves have outside admission, the radius rod is connected to the lap and lead lever below the valve stem, and above it, if the valves have inside admission.

The simple form of direct valve motion, shown in the first figure, has now been so modified that the engine is reversible and has a variable cut-off. It only remains to provide the necessary reversing mechanism and we have the Walschaert valve gear in its complete form as shown in Fig. 5, which represents its application to a consolidation engine.

Fig. 6 shows a general outline of the gear as arranged for inside admission valves on which are given the names of the various parts as recommended by the American Railway Master Mechanics' Association. Starting at the crank pin, we have the eccentric crank, eccentric rod, link, reach rod, lift shaft, radius rod hanger, radius rod, lap and lead lever, lap and lead lever connector, and crosshead arm.

Having studied the functions of the different parts of the Walschaert valve gear, it remains to trace the movement of the valve through a complete revolution of the wheel. Figs. 7, 8, 9 and 10 show a series of diagrams representing different positions of the valve for different positions of the crank pin. For the sake of simplicity, the valve and cylinder are shown in section, while the other parts of the gear are represented by their center lines and center points only. As will be apparent, these diagrams are out of proportion, the valve and the eccentric throw having been

FIG. 8.—DIFFERENT POSITIONS OF THE VALVE FOR DIFFERENT POSITIONS OF THE CRANK PIN.

inch outside lap and the eccentric crank has been advanced to more than a quarter of a revolution ahead of the main pin. If then the link block is at the bottom of the link, as in position A, the advance given to the eccentric will have moved the valve forward a distance equal to the lap plus the lead, and the back port will be opened for the admission of steam and the engine will run forward. If, on the other hand, the link block is moved to the upper end of the link, as shown in position B, the advance given to the eccentric crank will have had the opposite effect and the front port will be opened and the reversibility of the engine thus destroyed. In order to provide lead, therefore, in any engine where there is but one eccentric, some means must be employed other than advancing or retarding the position of that eccentric relative to the main pin, if there is to be any method of reversing the engine.

In the Walschaert valve gear the motion for providing lap and lead to the valve is derived from the main pin by suitable connections with the crosshead.

This brings us to the next step in the development of the Walschaert valve gear and the introduction of the lap and lead lever. Suppose that our link block is in the center of the link as shown in position A, Fig. 4. As the center of the link block coincides with the center of the link support, there will be no movement of the radius rod as the link swings back and forth through the action of the eccentric. If, then, the radius rod were connected with the lap and lead lever at the point R, and the upper end of the lever was connected to the valve stem crosshead at V, and the lower end of the crosshead arm by means of a short link, as shown, as this latter moves back and forth, the point R being fixed, the point V will rotate about it and the valve will be moved back and forth.

the travel of the crosshead from one end of the stroke to the other will give a travel to the valve equal to twice the lap plus the lead. That this lead is perma-

FIG. 10.—DIFFERENT POSITIONS OF THE VALVE FOR DIFFERENT POSITIONS OF THE CRANK PIN.

nent and does not vary as the reverse lever is hooked up will be shown later on.

The position of the eccentric crank relative to the main pin depends on which end of the link is used for forward motion. If the forward motion is taken

enlarged in order to bring out more clearly the positions of the edges of the valve relative to the edges of the cylinder ports. In Fig. 7, the valve is outside admission and the motion is represented as being in full forward gear; or with the reverse lever in the

extreme forward position. Fig. 8 represents the same valve motion, but in this case the reverse lever is hooked up and the link block is nearer the center of the link and the engine is cutting off at about 25 per cent of the stroke. Figs. 9 and 10 represent a valve motion as arranged for an inside admission piston valve; in Fig. 9, the motion being in full gear forward, while in Fig. 10 it is represented with the reverse lever hooked up.

As has already been shown, the valve receives its motion from two distinct sources; first, from the eccentric crank which gives the long travel to the valve; and second, from the crosshead by means of the lap and lead lever, which would give a short travel to the valve even if the eccentric rod was disconnected.

Starting with diagram 1, Fig. 7, as the valve is outside admission, with the main pin on the back center, the eccentric crank is on the top quarter, or a quarter of a revolution ahead of the pin, and the radius rod is connected to the lap and lead lever below the valve stem. The link is in its central position, and the valve would be in its central position on the seat, if it were not for the motion given to it by the lap and lead lever. As it is, however, the crosshead being at the back end of the stroke, the lower end of the lap and lead lever is at its extreme back position and the angle assumed by the lever has moved the valve forward, as indicated by the arrow, a distance equal to the lap of the valve plus the lead. Going to diagram 1, in Fig. 8, the main pin, eccentric crank and crosshead are in the same position as they were in the corresponding diagram in Fig. 7; and the link is in its central position. Thus, although the link block is near the center of the link, the radius of the link being equal to the length of the radius rod, the

front end of the radius rod is the same horizontal distance from the center of the crosshead as it is in diagram 1, Fig. 7; consequently the angle assumed by the lap and lead lever is the same and the valve has been moved forward the same distance from its central position, and the lead is the same as it is with the reverse lever in full gear.

In Figs. 9 and 10, diagram 1 in each case represents the position of the valve at the beginning of the forward stroke; the same as the corresponding diagrams in Figs. 7 and 8. As the valves are inside admission, however, the radius rod is connected to the lap and lead lever above the valve stem. The valve, in each case, has thus been moved back, instead of forward, by the movement of the lap and lead lever; and the back port is open to the live steam and the front port to the exhaust.

Going back to Fig. 7, in diagram 2, the piston has moved forward a distance equal to about 85 per cent of the stroke; the valve has traveled to its extreme forward position and back again, as indicated by the arrow, till it has just closed the back steam port; while the front port is still open to the exhaust. In other words, the valve is at the point of cut-off. In diagram 3, the piston has moved still nearer to the forward end of the stroke. The exhaust edge of the valve is now in line with the edge of the back steam port; so that any further movement will open communication with this port and the exhaust. The front port, on the other hand, has been closed to the exhaust and whatever steam is ahead of the piston will be compressed. In diagram 4, the piston is at the extreme forward end of the stroke; the angle assumed by the lap and lead lever has moved the valve back a distance equal to the lap plus the lead; the front

port is open for the admission of steam and the back port is open to the exhaust. In diagram 5, the piston is moving toward the back end of the cylinder and the valve has just closed the front port to the admission of steam, showing the cut-off position of the valve on the back stroke. In diagram 6, the piston is very nearly at the end of the back stroke and the valve is about to open the front port to the exhaust; while the back port is closed to the exhaust and compression is taking place in the back end of the cylinder.

As the diagrams in Figs. 8, 9 and 10 represent the same valve events as the corresponding diagrams in Fig. 7, it will not be necessary to examine them separately. It will be noticed that in Figs. 8 and 10 the valve cuts off the steam from the cylinders and opens the steam ports to the exhaust at a much earlier period in both the forward and back stroke than it does in Figs. 7 and 9, which shows the effect of hooking up the reverse lever.

These diagrams show very plainly the difference in the arrangement of the Walschaert valve gear for outside and inside admission valves, also the fact that the lead of the valve is the same for all cut-offs.

To change the lead of the Walschaert valve gear, it is necessary to either change the lap of the valve, reducing it to increase the lead and increasing it to reduce the lead, in which case the cut-offs will occur at later or earlier periods in the stroke, respectively; or to change the lengths of the arms or distances between the connecting points of the lap and lead lever. Increasing the distance between the radius rod connection and the valve stem connection to the lap and lead lever would increase the lead; or shortening this distance would decrease the lead.

THE OPTICS OF SKULKING AND SCOUTING.

THE MILITARY VALUE OF LIGHT EFFECTS.

BY W. R. GILBERT.

THE protective coloring of animals has long been a subject of much interest to naturalists. The protective effect is due to the fact that an object is rendered inconspicuous by being of the same color as its background. This is of less importance and interest than the fact that an object is least conspicuous when it harmonizes with its surroundings as a whole; and, secondly, that any object is, on the whole, least conspicuous anywhere when it is least conspicuous in itself. These last two factors are somewhat interwoven, since the ability of the eye to appreciate any color or form effect depends upon what other colors and forms come within its range at the moment, as well as upon the nature of the objects upon which it has just been focused.

One example illustrates these principles: A part ridge is inconspicuous because it is, generally, of colors similar to those of the fields in which it lives; because it may, at a distance, present the appearance of any of several different objects; and because, having neither one color to strike the eye as a mass, nor any very dark or light colors over a considerable area, it is inconspicuous in itself.

The fact of similar coloring is the least important, at all events under normal autumn and winter conditions. If the bird were of one color similar to the average or distant color of a plowed field, it would strike the eye as an object not of a piece with the ground, the upper side lighter and the lower side darker; as it is, it is more like a succession of patches of varying shade and surface, and both its surface and its edges are thereby rendered less conspicuous.

Particularly at certain seasons, but to a great extent at any time, the effects of light and shade are more important in this connection than those of color. For sheer conspicuousness the effect of one color alone is often much greater than that of sharply contrasting colors, the practical limit being reached in the case of the starling, which, at any distance beyond a few yards, appears to be dark gray, so minutely are its brilliant colors divided up. On a far larger scale bright stripes, such as those of the zebra, give the impression of a neutral gray at a sufficient distance.

The effect of one color, a "self color," is not only to make an object more conspicuous in itself, but also to reduce its chances of harmonizing with its surroundings. In almost any place a magpie is far less conspicuous than a crow. Even against a dark background in shady places a dark color fares badly, since the darkness of its surroundings being due to shade, as in a wood, an object already dark becomes darker still, retaining its difference in light emission.

The coloring of lighthouses often shows the inef-

fectiveness of bright contrasts; for example, in passing a chalk cliff, at the foot of which is a lighthouse painted in alternate black and white, a ship's officer failed for some time to perceive the lighthouse; and it was obvious that against the cliff, with its lighter and darker portions, not only would black have been the proper color, but the lighthouse would have been more conspicuous had it been painted all white. It would then have been less like the varying surface of the cliff, and would have been more conspicuous as a detached object. Surveyors know that the usual surveying pole, in which each foot length is painted a different color, is far less easily picked up by the eye or telescope than is a pole all of one color. The danger signals erected to warn motorists furnish an illustration. On a main road leading out of London, England, two neighboring villages are protected by triangle signals. In one case the signal is conspicuous, the red triangle being mounted on a wooden post painted the same color. In the other village the signal is not effective, being mounted on a thin angle iron painted white. This dusty white support not only fails to lead the eye to the red triangle, but is itself much the same color as the wall and road which form its background and harmonizes in color and form with a lamppost a few yards away.

In a naval war a great advantage would be gained by the power which first learned to paint a warship in at least two colors or shades. The surface of a warship should be divided up into uneven, irregular patches in, say, two shades, one considerably darker and one considerably lighter than some good neutral tint. The division would be into a few large patches, not into many small ones, else they will blend at a distance, and the ship will loom as a single object. Each patch may, however, be subdivided into two or more shades of its average tint. This matter will doubtless be of much greater importance when torpedo boats and some larger vessels are propelled by gasoline engines, and leave no trail of smoke. The overhanging parts of a ship and the under sides of all detached objects should be painted in the lightest tint or in white except where, in large vessels, it may be worth while to attempt to neutralize the line of whiteness made by small waves breaking against the side of the vessel. Parts exposed to the light of the sky should be painted with the darkest shades. Light beneath and dark above is the general distribution of color in the animal world, and all the cunning of man cannot do better than nature in these matters.

Although great advances have been made in rendering the soldier inconspicuous, only a few of the more obvious laws of light and vision have been considered and applied. No type of uniform should be passed

for service until it has been examined by an officer who is a real specialist in the subject we are now considering.

In war it is necessary to make each individual soldier as inconspicuous as possible, even to the darkening of the upper side of his hat and the lightening of the under side of the brim, reducing the effect of shadows about his feet, taking advantage of the breaks of continuity afforded by belts and haversacks, so that against a varied background he may lose size and shape. If this be done a marksman, even when he is distinctly visible, will hit him less easily than if he were all of one color. For scouting purposes special colors suited to the country should be chosen; but generally it is worth while dividing the man up visually, not quite in the way of ordinary clothes, and the colors should be some that blend into a neutral tint at a distance. Scouts should carry a few faded rags of different colors. But the individual is not everything; the principles of protective coloring and shading should be carried out in the squad and company. It often happens in modern war that infantry is a mark for artillery at long ranges, and when a single soldier would not be. To get infantry across open country with little loss is a necessity, and much can then be gained by making the bodies of men as inconspicuous as possible. Irregular shape and ragged edges on the march may help this, but my point is that much may be done by adopting uniforms of different shades, and arranging the men so that they march, in their usual places, in irregular patches of different shades. Wagons should be treated in the same way as warships. By treating a gun similarly, darker above and lighter beneath, it will be less easy for the enemy to distinguish the caliber, and by painting it in different colors a gun may be made to appear shorter.

Care should be taken to select horses which have light under parts, and similarly colored horses should be well distributed in the troop. At considerable distances the total light effect is far more important than the color effect, and it should be remembered that some colors are reduced in intensity by mist more than others are.

A patent issued November 3rd to Otto Meyer, of Richmond, Va., has for its subject a new electrolyte for electroplating, one of the chief objects of which is to overcome the evolution of hydrogen at the cathode, which has a tendency to make the deposited metal porous or even spongy. The new process consists in employing an electrolyte comprising a solution of a chloride of a metal in alcohol, which latter may be wood or denatured grain alcohol. One way of