applied to a locomotive. A slot-guide E is used, and it is curved to allow for the obliquity of the valve connecting-rod AE. C is the crank-pin, B the

piston path, and D a fixed centre.

The reversing gears of Walschaert, Brown, and Kitson also dispense with ec­centrics, and are closely related to the invention of Hackworth.@@1 A method of reversing with a common slide-valve, which is used in steam steering engines@@2 and some others, is to supply steam to

what was (before reversal) the exhaust side of the valve and con­nect the exhaust to what was the steam side. This is done by means of a separate reversing valve through which the steam and exhaust pipes pass.

157. When the distribution of steam is effected by the slide- valve alone the arc of the crank’s motion during which compression occurs is equal to the arc during which expansion occurs, and for this reason the slide-valve would give an excessive amount of com­pression if it were made to cut off the supply of steam earlier than about half-stroke. Hence, where an early cut-off is wanted it is necessary either to use an entirely different means of regulating the distribution of steam, or to supplement the slide-valve by another valve,—called an expansion-valve, usually driven by a separate eccentric,—whose function is to effect the cut-off, the other events being determined as usual by the slide-valve. Such expansion- valves belong generally to one or other of two types. In one the expansion-valve cuts off the supply of steam to the chest in which the main valve works. This may be done by a disk or double-beat valve (§ 163), as in the Proëll gear mentioned in § 175 below, or by a slide-valve working on a fixed seat (furnished with one or more ports), which forms the back or side of the main valve-chest. Valves of this last type are usually made in the “gridiron” or many-ported form to combine large steam-opening with small travel. Expansion-valves working in a fixed seat may be arranged so that the ports are either fully open (fig. 80) or

closed (fig. 81) when the valve is in its middle

position. In the latter case

the expansion-valve eccentric

is set in line with or oppo­

site to the crank, if the en­

gine is to run in either direction with the same grade of expansion. Cut-off then occurs at P, fig. 82, when the shaft has turned through an angle *φ* from the beginning of

the stroke. The expansion valve

reopens at Q, and the slide-valve

must therefore have enough lap to

cut off earlier than 180° *-φ* from

the beginning of the stroke, in

order to prevent a second admis­

sion of steam to the cylinder. In

the valve of fig. 80 the expansion

eccentric is set at right angles to the crank, if the action is to be the same in both directions. If not, these angles may be deviated

from, and in this way a more rapid travel at the instant of cut-off may be secured for one direction of running.

158. The other and much commoner type of expansion-valve is one sliding on the back of the main slide-valve, which is provided with through ports which the expansion-

valve opens and closes. Fig. 83 shows one

form of this type. Here the resultant rela­

tive motion of the expansion-valve and

main-valve has to be considered. If *ra* and

*rb* (fig. 84) are the eccentrics working the

main and expansion valves respectively,

then CR drawn equal and parallel to ME

is the *resultant* eccentric which determines

the motion of the expansion-valve rela­

tively to the main-valve. Cut-off occurs at

Q, when the shaft has turned through an angle *φ,* which brings the resultant eccentric into the direction CQ and makes the relative displacement of the two valves equal to the distance *l.* Another form of this valve (corresponding to fig. 81) cuts off steam at the inside edges of the expansion-slides.

159. Expansion-valves furnish a convenient means of *varying* the expansion, which may be done by altering their lap, travel, or angular advance. Alteration of lap, or rather of the distance *l* in the figures, is often effected by having the expansion-valve in two parts (as in fig. 83) and holding them on one rod by right- and left- handed screws respectively ; by turning the valve-rod the parts are made to approach or recede from each other. In large valves the adjustment is more conveniently made by vary­

ing the travel of the valve, which is done by con­

necting it to its eccentric through a link which

serves as a lever of variable length.

160. To relieve the pressure of the valve on the seat, large slide-valves are generally fitted with a steam-tight ring, which excludes steam from the greater part of the back of the valve. The ring fits steam-tight into a recess in the cover of the steam- chest, and is pressed by springs against the back of the valve, which is planed smooth to slide under the ring. Fig. 85 shows a relief ring of this kind fitted on the back of a large double-ported slide-valve for a marine engine. Another plan is to fit the ring into a recess on the back of the valve, and let it slide on the inside of the steam-chest cover. Steam is thus excluded from the space within the ring, any steam that leaks in being allowed to escape to the condenser (or to the intermediate receiver when the arrangement is fitted to the high-pressure cylinder of a compound engine). A flexible diaphragm has also been used, instead of a recess, to hold the ring.

161. The pressure of valves on cylinder faces is still more com­pletely obviated by making the back of the valve similar to its face, and

causing the back to slide in contact with the valve-chest cover, which has recesses corresponding to the cylinder ports. This arrangement is most perfectly carried out in the piston slide-valves now very largely used in the high-pressure cylinders of marine engines. The piston slide-valve may be described as a slide-valve

@@@1 Reversing gears of this type are generally termed radial gears. A discussion of Mr Joy’s and other arrangements will be found in *Proc. Inst. Mech. Eng.,* 1880. Mr Kirk, Mr Bryce-Douglas, and others have designed forms which more or less resemble those mentioned in the text.

@@@2 *Proc. Inst. Mech. Eng.,* 1867.