with numerous openings to allow the products of combustion to dif­fuse themselves throughout the combustion-chamber. This guards against too intense action on the metallic surfaces, and at the same time serves as a reservoir of heat to rekindle the flame if combustion is intermittent. In getting up steam an auxiliary boiler is used to supply the jet.@@l

VIII. The Distribution of Steam.—Valves and Valve Motions.

144. In early steam-engines the distribution of steam was effected by means of conical valves, worked by tappets from a rod which hung from the beam. The slide-valve, the invention of which in the form now known as the long D-slide is credited to Murdoch, an assistant of Watt, came into general use with the introduction of locomotives, and is now employed, in one or other of many forms, in the great majority of engines.

The common or locomotive slide-valve is illustrated in fig. 57. The seat, or surface on which the valve slides, is a plane surface formed on or

fixed to the side of the

cylinder, with three

portsor openings, which

extend across the great­

er part of the cylin­

der’s width. The central opening is the exhaust-port through which the steam escapes ; the others, or steam ports, which are narrower, lead to the two

ends of the cylin­

der respectively.

The valve is a

box-shaped cover

which slides over

the seat, and

the whole is en­

closed in a cham­

ber called the

valve - chest, to

which steam from

the boiler is ad­

mitted. When

the valve moves a

sufficient distance

to either side of

the central posi­

tion, steam enters

one end of the

cylinder from the

valve-chest and

escapes from the

other end of the

cylinder through

the cavity of the

valve into the exhaust-port. The valve is generally moved by an eccentric on the engine-shaft (fig. 58), which is mechanically equiva­lent to a crank whose radius is equal to the eccentricity, or distance of O, the centre of the shaft, from P, the centre of the eccentric sheave. The sheave is encircled by a strap forming the end of the eccentric rod, and the rod is connected by a pin-joint to the valve- rod, which comes out of the valve-chest through

a steam-tight stuffing-box. The eccentric rod

is generally so long that the motion of the

valve is sensibly the same as that which it

would receive were the rod infinitely long.

Thus if a circle (fig. 59) be drawn to represent

the path of the eccentric centre during a revolu­

tion of the engine, and a perpendicular PM be

drawn from any point P on a diameter AB,

the distance CM is the displacement of the valve from its middle position at the time when the eccentric centre is at P. AB is the whole travel of the valve.

145. If the valve when in its middle position did not overlap the steam ports (fig. 60), any movement to the right or the left would admit steam, and the admission would continue until the valve had returned to its middle position, or, in other words, for half a revolution of

the engine. Such a

valve would not

serve for expansive

working, and as re­

gards the relative po­

sition of the crank

and eccentric it

would have to be

set so that its middle position coincided with the extreme position

of the piston ; in other words, the eccentric radius would make a right angle with the crank. Expansive working, however, becomes possible when we give the valve what is called “ lap,” by making it project over the edges of the steam ports, as in fig. 61, where *o* is the “ outside lap ” and *i* is the “ inside lap. ” Admission of steam (to either side) then begins only when the displacement of the valve from its middle position exceeds the amount of the outside lap, aud continues only until the valve has returned to the same dis­tance from its middle position. Further, exhaust begins only when the valve has moved past the middle by a distance equal to *i,* and continues until the valve has again returned to a distance *i* from its middle position. Thus on the diagram of the eccentric’s travel (fig. 62) we find, by setting off *o* and *i*

on the two sides of the centre, the posi­

tions *a, b, c,* and *cl* of the eccentric

radius at which the four events of ad­

mission, cut-off, release, and compres­

sion occur for one side of the piston.

As to the other side of the piston, it is

only necessary to set off *o* to the right

and *i* to the left of the centre, but for

the sake of clearness we may confine

our attention to one of the two sides.

Of the whole revolution, the part from

*a* to *b* is the arc of steam admission,

from *b* to c is the arc of expansion,

from *c* to *d* the arc of exhaust, and from *d* to *a* the arc of compres­sion. The relation of these, however, to the piston’s motion is still undefined. If the eccentric were set in advance of the crank by an angle equal to AC*a*, the opening of the valve would be coincident with the beginning of the piston’s stroke. It is, however, desirable, in order to allow the steam free entry, that the valve be already some way open when the piston stroke begins, and thus the eccentric may be set to have a position C*a*' at the beginning of the stroke. In that case the valve is open at the beginning of the stroke to the extent *mm',* which is called the “ lead.” The amount by which the angle between C*a*' (the eccentric) and CA (the crank) exceeds a right angle is called the *angular advance,* this being the angle by which the eccentric is set in advance of the position it would occupy if the primitive arrangement without lap were adopted. The quantities lap, lead, and angular advance (ϕ) are connected by the equation

outside lap + lead=half travel × cos *θ.*

An effect of lead is to cause *preadmission,* that is to say, admis­sion before the end of the back stroke, which, together with the compression of steam left in the cylinder when the exhaust port closes, produces the mechanical effect of “ cushioning, ” to which reference has already been made. To examine the distribution of steam throughout the piston’s stroke, we may now draw a circle to represent the path of the crank pin (fig. 63, where the dotted lines

have been added to show the assumed configuration of piston, con­necting-rod, and crank) and transfer to it from the former diagram the angular positions *a, b, c,* and *d* at which the four events occur. To facilitate this transfer the diagrams of eccentric path and of crank-pin path may by a suitable choice of scales be drawn of the same actual size. Then by projecting these points on a diameter which represents the piston’s path, by circular arcs drawn with a radius equal to the length of the con­

necting-rod, we find *p,* the position

of the piston at which admission

occurs during the back stroke, also

*q* and r, the position at cut-off and re­

lease, during the stroke which takes

place in the direction of the arrow,

and *s,* the point at which compression

begins. It is obviously unnecessary

to draw the two circles of figs. 62 and

63 separately ; the single diagram

(fig. 64) contains the solution of the steam distribution with a slide-valve whose laps, travel, and angular advance are known, the same circle serving, on two scales, to show the motion of the crank and of the eccentric.

146. A method of representing graphically the relations of valve and piston motion, sometimes convenient in dealing with valve- gears of a more complex character than the single eccentric, is to set off the valve’s and the piston’s simultaneous displacement at right angles to each other, as in fig. 65, the valve's motion being exaggerated by using a coarser scale for it than for that of the piston. The result is an oval curve, from which the events in the

@@@1 See a paper by Mr T. Urquhart, *Min. Proc. Inst. C.E.,* 1884; also *Engineering,* June 11-25, 1886.