(A, A, fig. 40), and finally pass to the back again by an underneath flue B. The arrangement in the Lancashire boiler is the same, ex­cept that there are two internal flues, each with its own furnace. The shell is made up of rings of riveted plates, larger and smaller in diameter alternately to

allow the circumferen­

tial seams to be made

without bending the

edges. The flue is

made up of a series of

welded rings, joined

to each other by a

flanged joint with a

stiffening ring. This

form of joint was in­

troduced by Mr Adam­

son to stiffen the flue

against collapse un­

der external pressure.

Other joints, designed

with the same object,

are shown in figs. 42

and 43. The grate is

made up of firebars,

sloping down towards the back, where they terminate at the “ bridge ” of fire-brick (C, fig. 39). Beyond the bridge the flue is crossed by a number of tapered “Galloway” tubes D, D, which increase the heating surface, promote circulation of the water, and stiffen the flue. The end plates are strengthened by gusset stays

E, E, riveted to them and to the circumference of the shell by means of angle-irons. The gusset-stays do not extend so far in as to the circumference of the flue (fig. 40), in order that the end plates may retain enough flexibility to allow the flue to expand aud contract under change of temperature. To provide for unequal expansion is one of the most important points in the design of boilers ; when it is neglected the boiler is subjected to a racking action which induces leakage at joints and tends to rupture the plates. For this reason the flue is attached to the boiler shell at the ends only, so that it may be free to take an upward camber in consequence of the greater heating of the upper side.

Mild steel is now very generally used for boiler plates, being superior even to the best Yorkshire iron in the qualities of ductility and tensile strength. The following particulars refer to the Lanca­shire boiler of fig. 41, which may be taken as representative of a large number of stationary boilers.

128. The shell is 28 feet long and 7 feet in diameter, and is made up of 9 rings, each of two semi-cylindrical plates. The shell plates are 3/8 inch thick ; their edges are planed and fullered, and the rivet holes are drilled. The longitudinal seams, which break joint from ring to ring, are lap-joints double-riveted ; the circular seams are single-riveted. Each end plate is a solid piece of steel ⅜ inch thick ; the front plate is attached to the shell by riveting to an angle ring ; the back plate is flanged. The flues are each 2 feet 91/2

inches in diameter, made up of rings of steel 3/8 inch thick ; the longitudinal joints are welded and the circular joints are flanged and strength­ened with stiffening rings. The flues are tapered somewhat at the back end to facil­itate expansion, and are attached to the end plates by welded angle-rings. Each flue contains 5 Gallo­

way tubes, tapering from 101/2 inches diameter at top to 51/2 inches at bot­tom. On the top of the boiler is the manhole, covered with a cast-iron plate ; also a nozzle for the steam-pipe and two others for safety-valves. One of the safety-valves is connected with a float so that it opens if the water-level becomes too low. At the bottom, in front, is another nozzle for the blow-out tap ; and

in the front plate below the flues is another manhole. Feed-water is supplied by a pipe which enters through the front plate on one side, near the top of the water, and extends for a considerable dis­

tance along the boiler, distributing the water by holes throughout the length. A pipe at the same level on the other side serves to collect scum. The fire doors are pro­vided with sliding shutters by means of which the amount of air admitted above

the fire may be regulated. On the top of each fur­

nace is fitted a fusible plug which melts if the

furnace crown becomes overheated. No separate steam dome is used ; the steam is collected by an "anti-priming ” pipe shown in fig. 44, which also

illustrates the stop-

valve by which the

delivery of steam

from the boiler is

started or stopped

at will. On the

front plate are a

pair of glass gauge-

tubes for showing

the water-level, and

a Bourdon pres­

sure-gauge. This

last important fit­

ting consists of a

bent tube of oval

section, one end of

which is closed and

free to move while

the other is open

to the steam and is

fixed. The pres­

sure within the tube

tends to straighten

it, and the extent

to which this takes place is shown by a pointer which travels over a circular dial. A common lever safety-valve is shown in fig. 45. In other forms the valve is kept down by a weight directly applied to it, or by means of springs. Spring safety-valves are liable to the objection that when the valve opens

the load on it increases ; to remedy this,

forms have been proposed in which the

spring acts through a bent lever in such

a way that when the

strain on it increases

the leverage at

which it acts is re­

duced. If the spring

is of reasonable

length, however, the

objection is not seri­

ous.

129. A modifica­tion of the Lanca­shire type — the “Galloway” boiler — is shown in sec­tional elevation in fig. 46. In it the two flues are joined beyond the bridge into a single flue, of the form shown in the figure, which is traversed by nu­merous Galloway tubes and is also fitted with water- pockets at its sides.

130. In other types of boiler an extensive heating surface is obtained by the use of a large number of small tubes through which the hot gases pass. This construc­tion is universal in locomotive and marine boilers. It is applied in some instances to boilers of the ordinary cylindrical form by making small tubes take the place of that part of the flue or flues which lies behind the bridge, or by using small tubes as channels through which the gases return from back to front after passing through the main flue. Another form of tubular boiler is an exter­nally fired horizontal cylinder fitted with tubes which carry the hot gases from the back to the front.