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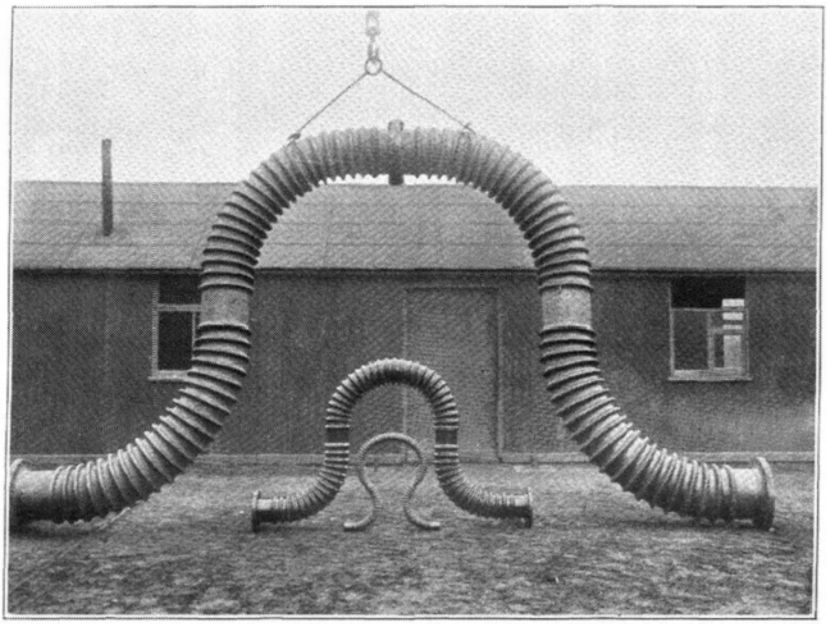

Fig. 1.

14″ × $\frac{7}{16}$″ Corrugated Expansion Loop. 9′ 2″ high.
6″ × $\frac{15}{64}$″ Corrugated Expansion Loop.
2″ × $\frac{7}{64}$″ Corrugated Expansion Loop. 2′ 2″ high.

No. 5

CORRUGATED STEAM PIPES

With the adoption of superheated steam, the problem of providing suitable arrangements for taking up the expansion of the steam pipes became more difficult. Hitherto, two general methods had been in use—for large pipes, expansion glands were fitted and for small ones generous bends were provided in order to obtain the necessary flexibility.

The expansion glands were of two kinds, balanced and unbalanced. In the latter type the break in continuity of the steam pipe leads to a very large end thrust coming on the supports at the terminus of the piping system. In the former this thrust is obviated, but the flow of steam through the slots combined with the sharp angle through which it has to turn causes a considerable drop in steam pressure in the fittings.

With saturated steam, the expansion glands were usually packed with soft packing, and this was found generally satisfactory, but in some cases metallic packing was fitted.

In the early superheated steam installations, balanced expansion glands with metallic packing were fitted in the main steam range, as experience ashore indicated that soft packing would not be satisfactory. The earliest designs did not give satisfactory performance and the packing was modified from the usual " V " type metallic segments to square spring rings, after which less trouble was experienced.

The weight of the glands, the necessity for maintenance work to be periodically undertaken by the ships staffs, and the pressure drop required constituted serious disadvantages, however, and search was made for other means of accomplishing the objective.

By a careful redesign of the main steam piping it was found possible to take up the expansion by means of generous bends, in spite of the fact that owing to the higher temperature the expansion is considerably greater than with saturated steam.

The succeeding designs of superheated steam cruisers were therefore fitted in this manner.

The solution was not ideal, however, as very long steam pipes were required, and in consequence the weight and pressure drop saved over the system with expansion glands was not great, whilst the large bends occupied considerable space.

Attention at this time was drawn to the corrugated steam pipes then being manufactured by Messrs. Aiton, of Derby.

Fig. 1 shows a photograph of the corrugated pipes, the principal feature of these pipes being that their flexibility is considerably higher than that of plain bent pipes so that they can be used in the steam line without requiring an excessive length of pipe or taking up an undue amount of space. The loads coming upon the supporting brackets at the anchors of the pipe line are also reduced. The corrugated pipe was invented in 1911 by M. Maciejewski, a Pole, who was at the time a Russian subject. With the inventor was associated a M. Kossowski, who carried on the business after M. Maciejewski's death in 1914. The pipes were first manufactured in Warsaw and it is of interest to note that the Russian Navy was offered the use of the designs in 1913, but refused them. Subsequently licences were granted to a German and a French firm, and Messrs. Aiton became associated with M. Kossowski and started manufacture in 1923.

Owing to the limited experience available of the operation of these pipes on service, and the doubt, both regarding the liability for water to be retained at the bottom of the corrugations and start corrosion and also regarding the amount of the stresses imposed at the crown of the corrugations, the Admiralty were very cautious in adopting them. They were first brought to the notice of the Admiralty in November, 1925, and a pipe was fitted in *Amazon* for trial towards the end of 1926. The pipe was examined after service in September, 1928, found in good condition and replaced.

Meanwhile, in 1927 an exhaustive test was carried out at Messrs. Aiton's works on behalf of the Admiralty, in which a corrugated pipe was anchored at one end, placed under hydraulic pressure equal to the steam pressure for which it was designed and its free end attached to a crank which was turned by an electric motor and moved the end of the pipe in and out a distance equal to twice the amount of expansion the pipe was designed to absorb. These reversals were carried out 7,680 times, that is to say equivalent to the number of times it would have to contract and expand if steam were raised every day for over 21 years. Careful examination and measurements revealed no sign of distress or permanent deformation under this treatment.

As the result of this test, and the satisfactory behaviour of the *Amazon* pipe, corrugated pipes were generally adopted and are now fitted in all new construction. They were first installed in a Mercantile Marine plant, that of the Canadian Pacific liner *Duchess of Bedford* at about the same time that they were adopted for Naval vessels.

Manufacture.—To form the corrugations, the seamless steel tubing is placed in a press between a fixed and a movable head. A gas ring furnace is placed round the pipe and a narrow band heated. When the pipe has reached its proper temperature, it is compressed along its axis, thus raising a corrugation at the heated section. When the compression has raised the corrugation a desired amount, the press is stopped, the corrugation quenched, and the furnace moved on to form the adjacent corrugation. The first motion of the press causes an upsetting of the material in the heated band before the swelling starts and thus accounts for the increased wall thickness in the radial section through the crest of the corrugation. The fabrication is followed by suitable annealing heat treatment.

Fig. 2 shows the shape of resulting corrugations formed.

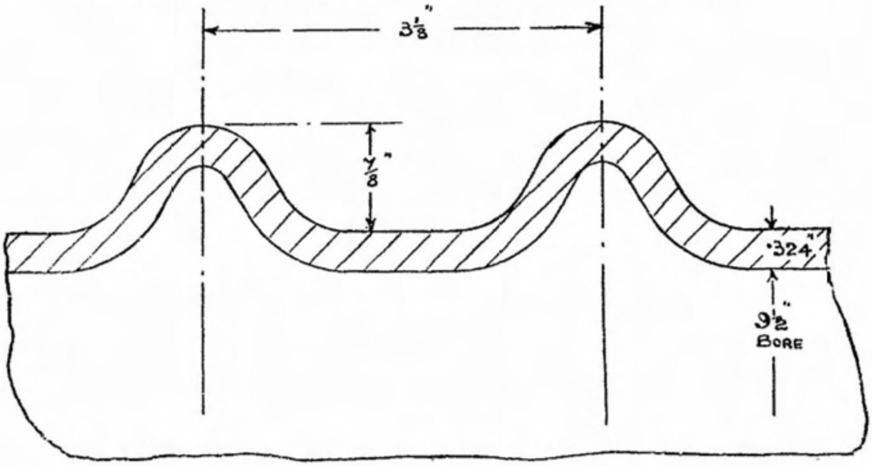

Fig. 2.
Detail of corrugations.

There are two processes of bending in use. In the first, the pipe to be bent is heated in a coke, or for better class work a charcoal fire, in such a way that one side is hotter than the other.

The pipe is then brought to a perforated slab and a wire leading to a winch is attached to one end; the usual pins for holding the pipe are placed in the holes in the slab. The cooler side of the pipe is arranged on the outer radius of the bend. The bending force is put on the pipe by means of the wire and winch, and the operator squirts water from a hose on to the corrugations on the inner radius of the bend during the process, in order to prevent any corrugation from completely closing in, and to ensure that each takes its share of the bend.

The process described above requires great skill on the part of the operator, and is only applied to small and medium diameter pipes where the shape of the bend is simple. For large pipes and for difficult shapes each corrugation is heated in turn by means of a gas furnace put round the pipe and is then bent; although this process is longer, far better control of the bend is obtained.

After bending, the pipes are annealed, checked for dimensions and galvanised. The galvanising shows up any surface defects and so facilitates inspection. The pipes are flanged in the usual manner and the jointing surfaces are then hand scraped to a surface plate.

The high pressure steam pipes used by the Admiralty are of course solid drawn but lap-welded pipes can also be treated in a similar manner, the corrugating process then forming an excellent test of the welding.

Lap-welded corrugated eduction pipes between the H.P. and L.P. turbines have been fitted in recent construction, and Fig. 3 shows two of these pipes. With welded pipes, care should be taken that the weld lies on the neutral axis of the bend, so that it is not subjected to any undue strains.

Flexibility of Corrugated Pipes.—The flexibility of corrugated pipes, in comparison with plain pipes of the same size, shape and thickness, varies according to the ratio of thickness to diameter, very thick pipes being proportionately less flexible than thin ones. There is therefore somewhat less advantage to be obtained using corrugated pipes for very high pressures when the pipes must be thick than for normal and low pressure work.

The drop in steam pressure through a corrugated pipe, length for length, is larger than through a plain pipe of similar size and shape, but this is compensated for since a very much smaller total length of piping is required when the former pipes are used.

The weight of a corrugated pipe is also some 30 per cent. greater, length for length, than a plain pipe of the same dimensions, but the total weight of steam piping in the installation is reduced by the use of the corrugated type.

It might be expected that corrugated pipes would tend to corrode more rapidly than plain pipes owing to water lying at the bottom of the corrugations when they are not in use. Experience, however, does not indicate that they suffer from any undue corrosion.

The thanks of the writer are due to Messrs. Aiton for assistance in the preparation of this article.

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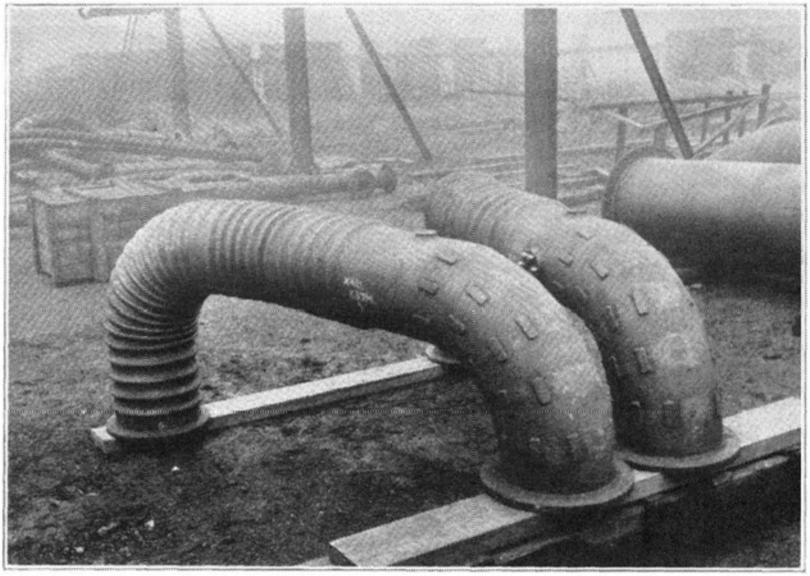

Fig. 3.
18″ Bore × ¼″ Thick Lapwelded Corrugation Eduction Pipes.