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Steam Pipes for Extra High Pressure and Temperature.

BY J. A. AITON, C.B.E.

READ

On Tuesday, September 14, *at* 6.30 *p.m.*

CHAIRMAN: R. S. KENNEDY (Chairman of Council).

The CHAIRMAN: I have much pleasure in introducing Mr. Aiton and in calling upon him to read his paper. The subject is one of very great interest at the present moment in view of the contest which is going on between the advocates of high pressure superheated steam and the oil engine respectively, and of course, in the former case the pipes are a very important consideration when dealing with superheated steam.

A paper on this subject was read more than a year ago before the Institution of Engineers and Shipbuilders in Scotland. This paper is based upon it, and in parts is the same, but it has been altered in others in the light of further experience, and to make it more particularly applicable to marine practice.

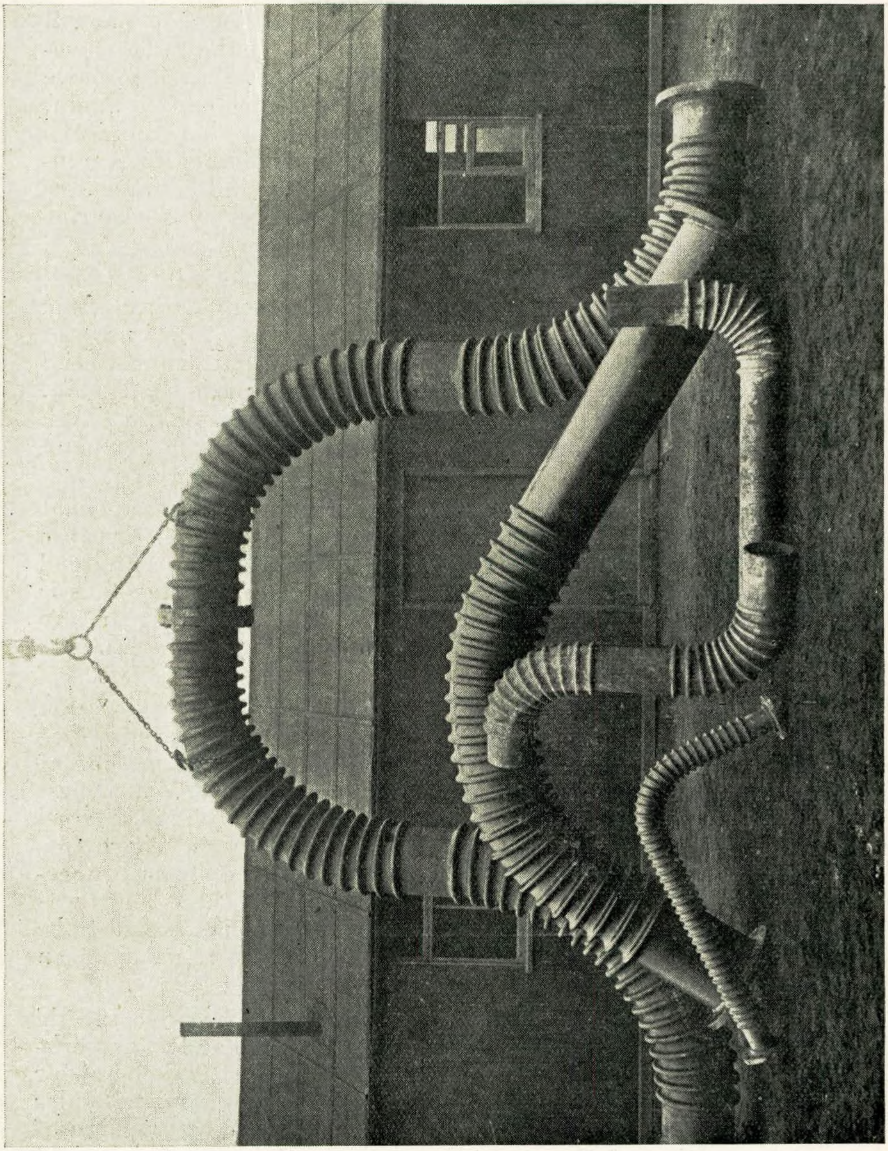
The first matter to decide is what is meant by extra high pressure and temperature, and for the purpose of this paper these have been fixed at steam at 400 lbs. pressure and superheated to 750°, as these may be considered to be the limits of normal working at present.

Experience of these conditions has so far been chiefly in land practice in electric power stations, some of the difficulties to be met with in laying out piping on land are either much smaller or are not met with in marine work at all, but on the other hand, due to the confined space on board ship, others are much exaggerated; for instance on board ship the run of the piping cannot be varied to any great extent, although here also simplicity should ever be aimed at, but for the same reason the method of allowing for the movement of pipes due to expansion by means of wide bends in the run of the pipes cannot be adopted. For this reason sliding expansion joints or ball joints have been largely used and have been fairly satisfactory with lower pressure saturated steam, but with superheated steam they are not satisfactory and have practically disappeared from land practice. We are thus thrown back on bends, but these must be of short radius and consequently so very stiff that excessive thrust comes upon the fixed points if any serious movement has to be allowed for, and great stresses are set up in the joints, moreover, bends made to short radius show quite appreciable thinning of the wall on the outside of the bend. Undoubtedly the most serious difficulty which will be found in fitting pipes on board ship to carry high pressure steam is this one of dealing with the movements due to expansion, and if the two methods of meeting the difficulty, mentioned above, were the only ones the position would appear to be very difficult indeed, but fortunately another method has been devised whereby bends are made which are much more flexible than those made from plain tube.

This method is to form a series of corrugations on the tube, these in themselves strengthen the tube, especially as the process of manufacture thickens the wall of the tube; the corrugated pipe is then formed into a bend in the usual way and there can be no thinning of the wall in bending as all that happens is that the corrugations are somewhat opened out on the outside of the bend and are closed up on the inside.

These corrugated pipes can be bent to a much smaller radius than plain pipe, in extreme cases they can be bent to the same radius as an elbow; in all cases, to stand corrugating, the tubes must be of a good soft quality of steel and must be well made, free from variations of thickness; they are usually solid drawn tubes, hot finish, 24 tons to 28 tons tensile, 25% elongation in 8ins.

Bends made from corrugated tube are five times as flexible as similar bends made from plain tube, that is to say, that if



the same thrust is applied to both bends the corrugated one will move five times as far as the plain one, or if the same movement is required only one-fifth of the thrust required to move the plain bend need be applied to the corrugated one, or again, if the same amount of movement is required and the same amount of thrust can be applied to both bends then the corrugated bend can be made to a much smaller radius, and it is this last quality which will be found so useful by the marine engineer.

Comparison of the lyre type of expansion bend is interesting, such a bend made from plain tube 10in. bore is 138in. high from the centre of the main to the centre of the pipe at the crown of the bend and allows for a movement of 2½in. out or in; a bend made from corrugated pipe of the same bore can be made 55in. high and gives 2¼in. out or in, and a similar bend 72in. high gives 3⅜in. out or in or 50% more than the much larger plain bend.

For expansion purposes straight corrugated pipes are not often used for end-on movement between the flanges, because the corrugations are not high and to obtain a very small end movement, ·01 in. per corrugation, a pressure of many tons is required, but corrugated pipes, both bends and straights, are used with great success to overcome vibration or movements due to the working of a ship.

The severest test of their behaviour under severe vibration has been on steam hammers and an interesting case was that of a 5-ton steam hammer which, on account of the method of working, was subject to excessive vibration. When first started to work, steam was connected to it by a 5 in. plain steel bend, the vibration was so great that the steam chest was broken off, a stronger chest was fitted and the steam connection made through a copper bend. The life of these bends was so short, not more than a month, that replace bends had to be kept in stock, and the steam joints had to be re-made on an average once a day.

A 5 in. corrugated bend 24in. x 20in. made from stock solid drawn hot finish tube, 7/32 in. thick, was fitted and after working for two years, without re-making a joint, was taken out for examination. It was sectioned and the metal examined under the microscope and the report stated that there was no sign of deterioration of the structure of the metal or of incipient cracks, and that there was no corrosion: the replace pipe put in is still working under the same conditions.

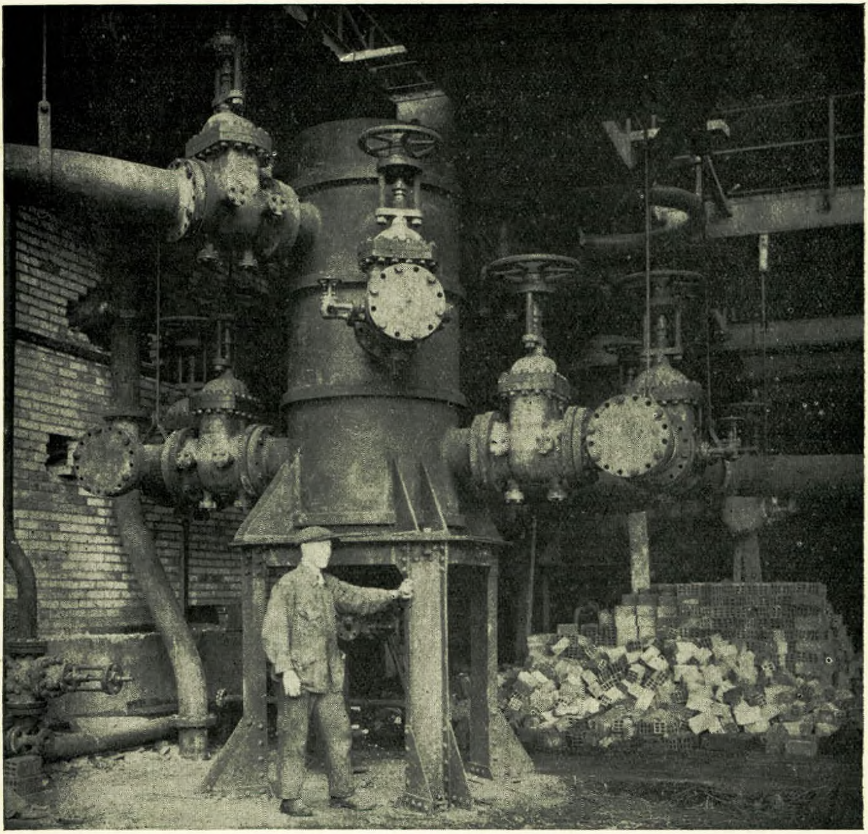
This question of corrosion taking place owing to water collecting in the corrugations is often raised: practice has not shown that there is any more corrosion in a corrugated pipe than in a plain pipe, it may be that the reason why corrosion does not take place is that the water does not lie long enough to start the action, it lies in very small separate quantities exposing a very large surface to steam and to hot metal and is consequently very soon evaporated off, but undoubtedly this dividing up of the water is a great safeguard against water hammer.

The friction loss in steam passing round a corrugated bend is double that for a plain bend. This in itself is not a serious matter, but when it is remembered that the number of corrugated bends is much fewer to do the same amount of work, the advantage in this also is usually on the side of corrugated bends. In the exceptional case where this is not so and the extra drop in pressure is not allowable, it is a simple matter to make the corrugated pipe a size larger in the bore, as this does not entail a stiffer pipe or one which takes appreciably more room. Exhaustive tests have shown that corrugating a tube does not punish the metal and practical working experience bears this out, as there are no records of a corrugated pipe ever having failed in service.

A method of making a bend from plain pipe to a radius much smaller than that to which plain tube can be bent is by cutting pieces out of the pipe, bending it with the cuts on the inside of the bend until the sides of each cut meet, and then welding up the cuts. This is a method which should not be used with steam pipes for any great pressure, and certainly not with the pipes under consideration.

There are other classes of expansion which can be at least minimised by care in design. Water in pipes is the cause of the most serious stresses. It is not possible entirely to prevent it from getting into the pipes, but the amount which passes along with the steam does not do much harm. Water, however, which is allowed to collect and lodge in the pipes may do considerable damage. When steam is turned into horizontal pipes in which water has been allowed to collect, unequal expansion is set up in the pipes, hogging takes place, and stresses arise, the ultimate effect of which cannot be calculated.

Pockets where water may lodge must be avoided at all costs. Valves are a great cause of water pockets, and if no valves



were required in a pipe line it would be possible to keep water from lodging in the pipes by making all ranges drain into suitable headers, but although this is not possible it should be kept in mind, and the number of valves reduced to a bare minimum. Simplicity of pipe design is a great desideratum, for redundant valves are often placed in positions where they are bound to form water pockets, as at the bottom of drop legs, but this cannot be wholly prevented, and when valves have to be placed in such a position they should be by-passed for drainage. Valves, of course, are not the only cause of water pockets. Bends rising off valves cause a pocket above the valve, and expansion bends are sometimes set in a vertical position in mains, possibly causing two pockets. These are very obvious cases, but experience shows that constant watchfulness is necessary to prevent such errors creeping into otherwise well-designed pipe lines and causing trouble in working.

Injudicious anchoring causes expansion stresses by endeavouring to force the pipe into a position where it would not naturally go. The ideal plan is to have no anchoring at all, as it is frequently only necessary to guide the pipe in the direction in which expansion should take place, but this ideal cannot always be obtained, in which case anchors must be fitted, but considerable experience is required to place them in the right position.

The working of modern steam pipe lines is a new problem, and must be treated in a new way, for that which can be done with comparative impunity on lower temperature work will cause very serious trouble if attempted with high temperature work. For instance, to bring a boiler on to a main, carrying superheated steam, ought to be a very slow process if trouble with pipes is to be avoided.

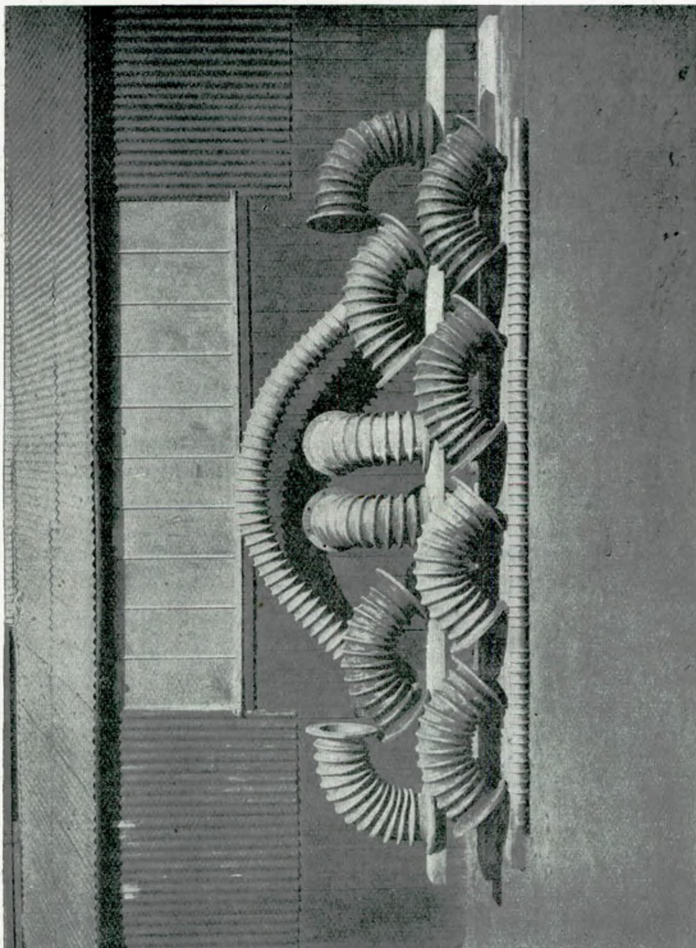
Referring to questions of the design and manufacture of the pipes themselves, undoubtedly the weakest part of the pipe line is the joint, and as every joint is a potential cause of trouble, the obvious aim should be to reduce the number of joints to a bare minimum by making each pipe as long as possible. As castings, even of steel, are no longer used in first class pipework, and as modern methods allow branches to be fixed to any part of the pipe, it is possible to use straight pipes up to 35 feet or even more, and 30 feet is quite a common length. Obviously, it is not always possible to take advantage of the longest lengths of tube, especially with bends, owing to the lack of facilities for transport, and, of course, this applies to marine work, but even there, joints could sometimes be eliminated by taking fullest advantage of modern practice.

The entire elimination of joints by butt welding up pipes end-on in position is very attractive, and there is an instance at work in this country. This main is 6in. bore, one straight length is 260 feet long, steam pressure is 350 lbs. per sq. in., and the temperature is 750° F., there are two anchors 200 feet apart and the expansion is taken up by one corrugated lyre type expansion bend 100 in. high. There is only one pair of flanges on the job and these are at the crown of the expansion bend. Care is taken to keep the pipe true to alignment by means of roller guides which prevent cross stresses coming upon the butt welded joints, and where, in spite of this precaution, there is any possibility of cross stresses coming upon the joint it is reinforced by having collars welded over the butt weld. It is early yet to say that this method of joining pipes will supersede flanges, but in special circumstances it will be found very useful.

A joint which aims at a similar result is that known as the "Sargol" joint, used in America, in which the end of the pipe is rolled over and loose flanges, are used. All mechanical stresses are taken by the flanges, and a steam tight joint is made by welding round the edge of the rolled-up portion of the pipe. This system has its drawbacks which have so far prevented its adoption in this country, where fixed flanges are almost universal for high pressure work.

In the use of flanges for piping there are two main questions to consider, namely, how to attach the flange to the pipe, and how to make the joint between the flanges. Regarding the first, there are nowadays only two methods of fastening flanges to pipes, namely, by riveting and by welding, except in the case of small pipes, which nearly always have flanges fixed by screwing. It seems on the face of it to be wrong that holes should be made in a pipe to be afterwards closed by rivets. A satisfactory job, however, can be made in this way, but sudden variations in temperature may start a leak even after the pipe has been in use for a long time, and if a rivet does leak under high pressure high temperature steam it is almost impossible to make it tight. Frequently the presence of rivet heads inside the pipe, coming very close together, seriously reduces the area of passage.

With high velocity steam this either means a continuous loss due to a greater pressure drop, or a larger sized pipe to pass



the same weight of steam, with resultant loss in working due to increased radiation surface and higher capital outlay.

Riveting is highly skilled work, for under existing conditions it must be perfect from the start. In the days of low pressure saturated steam, free use of caulking would make almost any rivet tight and would cover up bad work, this is far from being the case with high pressure conditions.

Flanges properly welded to pipes are subject to none of these disadvantages, but unfortunately there are many methods of welding flanges, and they are not all satisfactory, and for this reason welding of flanges is still received by some with disfavour, but experience has proved that welded flanges can be entirely satisfactory for highest pressure and temperature work.

The oldest and cheapest method of welding is to heat the pipe and flange in a furnace to a welding heat, and to make the weld by hammering either by hand or by machine. To control the temperature in order to obtain a welding heat on the thick flange at the same time as on the thin pipe is by no means an easy operation, especially with the larger sizes of pipe, and the risk of failure with this method is so great that this type of welding should never be used with steam above 100 lbs. pressure per square inch.

The only satisfactory method of fastening flanges to pipes is by welding them on by means of the carbon arc process. Unless the flanges are exceptionally thick, a continuous weld should be formed right through the flange from back to front, and in addition, a good fillet should be worked up at the back of the flanges. As this is a process of building up the weld bit by bit, it takes considerable time, and demands skill on the part of the operator, but it should be pointed out that he is able to control the work and the temperature quite easily at every instant, provided he is given the right current, the right type of machine, and the right materials to work with.

In the early days of welding it was very difficult to prevent testers caulking up a pin hole leak in a weld, for a soft weld lends itself to this treatment, but highly superheated steam soon finds out the weak places, and trouble results. To attempt to caulk a leaky weld is very short-sighted policy, although it seems to be such an easy way out of the difficulty. An argument frequently used against welding flanges by any process is, that so much depends upon the human element, but is this more so with welding than with most engineering work, or than with riveting?

In the past, regulation of the current, and consequently the temperature, depended upon the length of the arc maintained by the welder, a very delicate operation, and one which by the very nature of things was constantly varying with the physical condition of the man, but with specially designed plant the current remains constant within wide ranges of arc, and so the regulation of the temperature does not now depend much upon the operator, although great skill is still required in the welder.

But accepting that there is as much possibility of trouble with riveted flanges owing to poor workmanship as with welded ones, it is contended that, however badly riveting may be done, no serious accident can happen, as the flange cannot be blown off, whereas such a thing might happen with bad welding.

It certainly could happen, but except with fire welding it is not at all probable that it would happen, and so far as I know never has happened with a carbon arc welded flange. If the process of welding be considered it is easy to see why this should be so. The welding is done piece by piece, and the welder goes round the flange adding the metal in layers. By carelessness he may fail to make a weld in places, but it is highly improbable that a competent man could do his work so badly that the flange would be liable to come off and yet pass the hydraulic test, hammering under pressure, and close inspection both under pressure and after the blanks were taken off. It is not difficult to see a bad weld after the flange has been faced, and if there is any doubt the judicious use of an oxygen torch will open up a defect.

Having fastened the flange to the pipe, the next important question is how to make the joint. Many methods are employed to accomplish this, but before considering them some essentials of a good joint, whatever the method adopted, may be enumerated. The flanges must be heavy to reduce to a minimum the probability of springing, the joint must be made on a raised face inside the bolt holes, and a ground face is very desirable, tnough not essential. There is no mystery about the making of high pressure joints. By care, experience, and the use of good materials, joints made by the same methods as have been used for many years are giving satisfactory service to-day, that is to say, with an ordinary corrugated metal ring and a wash of thin cement.

Many such joints, subjected to the working conditions of large power stations have been in use for years, and have never been touched since they were made, but it must be added that in the original lay out of the piping, expansion stresses must be reduced to a minimum and every care taken to prevent water collecting in the pipes. Expansion stresses and water are the two great enemies of pipe joints, and water is by far the worse.

The effect of water on joints, subjected alternately to high temperature steam and water, is to set up a chemical action with the paste used for the joints, and so to produce a slight acidity in the water. This acidulated water seems to set up electrolytic action, which quickly destroys the joints. It has not been found possible to make a paste which will not be affected by the action of water and at the same time be satisfactory in all other respects.

No good joint can be made with the wrong type of bolt, bolts made from steel of from 30 to 35 tons tensile strength have given most satisfaction, and have been adopted as a standard. Bolts made from high tensile steel have shown a liability to brittleness after being subjected to variations of temperature.

Where branches have to be taken off pipes this should be done by means of welded-on stools, and experience has shown that the oxy-acetylene process is the most suitable for this work. At one time branches were welded on by the carbon-arc process, but, though to all appearance the weld was quite normal, it sometimes broke down under test, and as there was a possibility that one such branch might pass the test and yet break down in working, the risk was considered too great, so this process was given up. Oxy-acetylene welding is more expensive, but it has given no sign of failure in working. In branch welding there are only two thin pieces of metal to be dealt with. Therefore, the period during which the full temperature of the carbon arc can be kept on the metal with safety is very short. This is possibly the root of the trouble, and if so, it is inherent in the process. The branch piece is not taken through the pipe, because it is necessary to get access to the joint from the inside both with the blow pipe and with the hammer, and as this can often only be done through the branch the joint must be inside the branch. Cast steel tees must be ruled out of this class of pipework, owing to the great increase in the number of joints, and riveted stools, owing to the fact that they must usually be riveted by hand, are not often satisfactory, and, as they can only be fixed near the end of the pipe,

they cause a lot of otherwise unnecessary joints in the main. It is advisable to have as few joints as possible. With simple design and large units, it should be possible to do away with branches, and to bring the pipes into vessels which serve as collectors and distributors as well as drainage points. Collector vessels should be placed with the axis vertical, for in this position it is easier to arrange the branches and the drainage, and vessels so placed are not subject to hogging stresses which are prevalent in vessels placed horizontally when water accumulates in them.

It is still necessary to provide means for extracting water from steam, but this presents little difficulty; complicated arrangements of internal baffles and spirals are difficult to adapt for high pressures, and they are quite unnecessary, a simple diversion of the flow of the steam gives quite satisfactory results. When the inlet is at the top of the separator the inlet pipe should be carried down internally to blow the outlet branch, and when the passage is straight through, the inlet pipe should be carried through and bent down to discharge below the outlet branch.

There certainly should be no joint in the water space of a separator, and it is best to have no joint in the vessel at all.

Riveted vessels are very seldom satisfactory, owing to the very large number of rivets and to the very severe stresses brought upon the vessels by expansion in the connecting pipes and by the variations of temperature to which they are subjected, and they are being displaced by vessels welded throughout, which are working at the highest pressures and temperatures with entire satisfaction. Welded vessels have been in use for 15 years at pressures up to 200 lbs. per square inch, but when it became necessary to apply much higher pressures to this class of vessel it was found from experiment that the methods of manufacture, although fundamentally the same, had to be modified to suit the altered condition. As a result of these modifications, it may be said that vessels manufactured for high pressures have a far greater margin of safety than those formerly made for lower pressure. These vessels illustrate the fact that no one method of welding is suitable for all conditions, for the body seam is welded by the water gas process, the ends and the flanges by the carbon arc process, and the branches by oxy-acetylene. As the walls of the vessels are thick and the body is large enough for a man to get inside, the branches are carried through the wall, and are welded both on the inside and outside. Rings are shrunk on the welded bodies of these vessels as an additional precaution.

I may sum up by saying that no drastic alterations are necessary either in materials or in the method of manufacture to meet modern conditions in piping, but great care and experience are necessary in all departments of the work, especially in design. An eminent engineer said lately that there were so many places in a power station where trouble could be met that he did not intend to have any with pipework; in fact, he wished to, and did, forget all about it. This desirable position can be realised, but not if the pipework is forgotten or treated as a very subordinate consideration in the design of the power station.

The Chairman: I am sure we have listened with very great interest to Mr. Aiton's remarks. He has dealt with the subject very fully and has given us a good deal of detail. I was going to ask what is the size of the corrugations, but on seeing the excellent series of slides shown by the Author, I think we obtained an idea of this. Apparently the design is of the suspension type, or is it like the circular or semi-circular corrugation of the Fox furnace? I think that if the author could give us some idea of the pitch of the centres between the corrugations it would help us to realise more clearly the size and formation of the bends.

The Author: As an average it is about 2½ in., but this dimension varies with the diameter of the pipe.

The Chairman: The methods of construction have evidently been very carefully considered, and any risks due to defective welding have been minimised. Every possible means have also been taken to secure the flanges.

With regard to the Author's comments on the use of the various types of welding I, personally have had more experience with the metallic electrode which I have found very suitable for ordinary heavy work, but for anything under ¼in. thick I quite endorse the author's conclusion that the oxy-acetylene flames, owing to its lower temperature is more suitable. It is possible to use the electric arc with thinner sections, but it is necessary to use smaller electrodes and to take other precautions.

The whole subject reviewed by the author is of special interest to marine engineers in view of the recent developments in high pressure steam propulsion on the Clyde.

*Capt. P. T. Brown, M.C.: We have to thank the author of this paper for bringing to our notice some of the difficulties to be faced if the proposal now before us of introducing high steam pressures and superheat mature.

Power stations and ships have little in common, but it behoves us to take the maximum advantage of that little and to avail ourselves of the experience, obtained in power station work, which is applicable.

The author has evidently considerable experience of his subject and I would like to put before him some of our difficulties and invite his co-operation in their solution.

In the first place; I venture the opinion that we can quite well cut out the possibility of the smaller and lower powered vessels ever adopting high steam pressures and superheat. Owners of medium sized vessels to whom first cost is not a primary consideration will be influenced by the undoubted success and economy of the Diesel engine.

The possibilities of high pressure being adopted may be confined to high speed cross-channel boats and liners of high power. In these types a leading consideration is limitation of space. Our next fundamental difference to power station work is flexibility of platform.

These considerations provide real problems.

Take the question of expansion. The author very rightly rules out sliding expansion joints, but how are we to place the large bends he substitutes? Even in roomy cargo boats of moderate powers it is frequently found necessary to use sliding joints on account of space limitation so that there seems very little chance of using bends of the sizes indicated on vessels where space is constricted.

"Bellows" joints, well drained, appear to offer a partial solution, but I foresee here the "jointing" difficulty.

What does the author think?

Reduction of Valves.—It does not seem likely that this will be possible. The argument is all the other way. Valves must be provided to enable any boiler to be shut off and for the work of the vessel to still proceed. With higher pressures and temperatures the safety arrangements will be of greater importance and additional means of isolation may be requisite.

* Contributed by correspondence.

Anchoring is another difficulty. Owing to the vibration (sometimes considerable) inherent in all ships, anchorage is of first importance if joints are to remain tight.

I should like to hear more from the author on the subject of branch pieces and his objections to castings. I fear we will have to retain our cast branches.

In advocating long lengths of piping the author will get the sympathy of all marine engineers, but 30 to 35 feet will seldom be found possible.

The author does not appear to favour machine hammer welding-on of flanges. Having found it satisfactory for pressures up to 300 lbs. per square inch I would like to hear more detail of his reasons for objection.

The subject of the personal element is well brought out, but whilst defective riveting may result in a "leak," defective welding would probably mean a "burst." In dealing with high pressure and high superheat, leakage is very difficult to locate, for the "blow" will not be seen. I would like the author to tell us something of the design of valve spindles, stuffing boxes and glands. Would it be necessary, at say 600 lbs. pressure and 700 degrees of superheat, to have deep glands with metallic packing; also, would it be necessary that the diameters of spindles be greater than in ordinary practice and that the spindles be highly polished?

I thank the author for his paper and hope that it and its discussion may help to form some decided views on the question of the design of high pressure steam pipe systems.

Reply to Contribution from Capt. T. P. Brown, M.C.—The difficulty of restricted space on board ship is the very reason why corrugated expansion pipes should have a wide field of usefulness, as they can be bent to a very much smaller radius than ordinary bends, and at this much smaller radius they are more flexible than ordinary bends. As regards flexibility of platform they have been tried highly in the instance mentioned of the steam hammer, and they are widely used where vibration is the chief cause of trouble with joints. The bellows type of joint is quite good for low pressures, but is unsuitable for high pressures as the exigencies of manufacture make them so stiff as to be of little value.

As regards elimination of valves this principally applies to land work where valves have been introduced for the purpose of sectionalising, which often do more harm than good.

Anchoring is a very difficult subject, and my continual aim is to do as little anchoring as possible, but every case requires special consideration.

As regards cast tee pieces, these have nearly entirely disappeared from land practice, the objection being that they introduce a great number of unnecessary joints. As branches can be welded on at any position of the pipe, advantage can be taken of this to reduce the jointing to a minimum. In a recent case where the castings were done away with and welded branches introduced, the joints were reduced to one-third, and as joints are always the weak point of pipe installation, this was a great advantage.

I go further than saying that I do not favour machine hammered welded on flanges, I am entirely opposed to it for high pressure work. The danger is in trying to get the thin metal of the pipe and the thick metal of the flange to a welding temperature at the same time, on the one side you have the danger of overheating the thin pipe, on the other of not heating the thick flange to a welding temperature, and I have seen so many instances where the flange has actually come off the pipe with the tool marks still visible in it and where there has been no weld at all, that I have long considered the risk of serious mishap far too great. They may be made satisfactory, but it is difficult to know whether they are really welded or not, and for this reason I never use this method of welding except for very low pressure work.

As regards defective welding resulting in a burst, this is not so unless the weld is so bad as to be palpably defective to any even superficial examination. The method of electric welding differs from that of fire welding or of hammer welding in that the welding is done bit by bit, and assuming that the welder does make some mistake this would result in leakage, and it is inconceivable that any welder could weld so carelessly that the flange would actually come off, and as a matter of fact no such experience has yet been heard of.

DISCUSSION.

Mr. W. E. Farenden: The author refers to only two methods of fastening flanges to pipes, by riveting and by welding. Could he give us any information regarding the screwing of flanges? I notice in an article in a technical paper this week, describing the trials of the *King George V.* on the Clyde, that the steam pipes are solid drawn steel tubes tested to three times the normal working pressure, and that the flanges are screwed on to the ends of the pipes with a vanishing thread. The end of the pipe thread at the flange is welded electrically.

With regard to the joints, they seem to be simply metal to metal faced joints. I understand that so far this arrangement is giving every satisfaction and that no difficulties have arisen. Perhaps the author could give us fuller information regarding these pipes and flanges.

Mr. W. Hamilton Martin: As Mr. Farenden has remarked, the author mentions that one of the main questions to be considered in the use of flanges is how to attach the flange to the pipe, and that there are only two methods in use to-day, namely, welding and riveting, while for small pipes screwing is adopted. I understand that in the high pressure installation on the Clyde, the flanges of the main steam pipe are screwed with a vanishing thread, the latter being welded at the flange for sealing. Also several liberal-sized expansion bends are provided.

The author admits that there are still many methods of welding to-day which are not all satisfactory. This being so, it may be of interest to mention a method which has completely eliminated such uncertainties, and has done away with either riveting, screwing or welding. My father, the late Engineering Director of the Flushing Royal Dockyard, introduced fully thirty years ago for all his naval and mercantile work, main steam pipes from four to ten inches diameter designed in one style with their flanges. These were made from mild steel solid forgings similar to shafting with couplings at the ends. The fibres of the metal ran in the right direction as the flanged ends were forged out from the bar ensuring maximum strength and homogeneity all through.

They were turned down to the required size on the outside, and their bore was trepanned. Their cost was not excessive, as might be supposed, while the trepanned core could be used for other work. They have been standard fitments on all work over there since, and have proved completely immune from trouble.

By allowing a suitable margin for turning from the rough, the finished pipe would be taken out of that diameter of the material which one knows to be the soundest.

These pipes have, I understand, justified confidence in them, they are at present also being fitted to some destroyers building for the Dutch Navy by other builders.

The building up of a fillet as a flange by welding, on the other hand is a laborous operation still greatly dependent on the human element, and is often very much more expensive in the end. Solid flanged pipes have many attractive points, the chief of which are that:—

1. There is no joint between flange and pipe to cause leakage.

2. Flanges are of much smaller diameter, as no shoulder is required, and consequently are appreciably lighter.

3. Bolts can be placed much nearer centre of pipe. Spigot can be made larger, nearer bolt holes, reducing springing to a minimum, and lessening chances of leaky joints.

4. The pipe can be gradually thickened up towards the flanges, thus strengthening them by placing extra metal where it is most required.

5. Saving of weight in lay-out, as each pipe is designed to suit its particular load, ensuring a maximum of safety and freedom from trouble.

6. General neatness of design; greatest strength with least material.

7. These pipes can be bent just like solid-drawn ones.

It is necessary, however, to see that the outside as well as the inner surface is smooth and free from tool marks, which might otherwise be the cause of cracks developing.

8. Expansion bends can be made successfully from these, avoiding expensive, nasty, and unsatisfactory sliding joints, liable to blow-outs or collapsing of packing—especially with high superheat—and consequent danger to life and limb.

Although the author contends these cannot be adopted in marine practice, such bends, often quite large, have and are nevertheless constantly being successfully housed on all sizes of vessels, which is well worth noting.

9. One feels, and has, at all times, the greatest security possible in the pipeline.

10. What is most important: satisfactory service for *least expenditure* and *upkeep*.

If not always for all extra high pressure work, then most certainly until welding has found general favour and confidence for such work, this method of construction would seem to be the one to gain wider adoption, especially for high speed naval work, so as to enable the designer to provide the lightest, strongest, safest and neatest arrangement, ensuring perfect freedom from trouble.

It would be interesting if the author could give us his valued opinion on this method and on the simpler manufacturing processes it undoubtedly offers.

His paper is certainly a welcome and opportune one at present, for which I would like to add my appreciation.

Mr. Evans (Visitor): In all the photographs shown on the screen, it appeared that the weld was made from both sides. In the case of the long pipe line mentioned by the author, would he tell us whether the weld was made from the outside only, or from both sides?

Mr. R. H. Gummer (Visitor): After hearing Mr. Aiton's paper read, one first has to comment upon the author's extreme modesty in his remarks.

As Mr. Aiton was not aware of my presence this evening, my subsequent remarks should be accepted as fully spontaneous.

The welded pipe installation he mentions was installed in the works where one was in responsible control. The working pressure was 350 lbs. per square inch and due to the fact that this pipe line linked up with some experimental plant, it has often been subjected to steam having a temperature approaching 1,000°F. These very severe conditions occurred on a pipe line where, with one exception, the whole of the joints were welded from end to end. The author was quite sincere in his remarks when he said that the only difficulty in connection with such installations was with the insurance companies and in the present instance the full responsibility was undertaken by the firm in question and the results obtained have fully justified their confidence.

Turning to the subject of corrugated pipes, here a similar experience was obtained. Amongst other processes, we had several steam hammers in operation, forging axles. This operation is very drastic, for there are two grooves in the hammer tools, one for roughing and the other for finishing. The impact, therefore, is not dead central and due to the excessive vibration set up, we had endless difficulty in keeping the steam joints tight. Most of the repair staff were men who had had sea-going experience and thus could claim considerable experience in the making of steam joints, yet the fact remains that we tried every known system (and you know how many different kinds there are). After experiencing so many failures, we approached Messrs. Aiton and Co., with a request for one of their corrugated bends which proved from the beginning an immediate success. After some two years' operation, this pipe has been purchased back by Messrs. Aiton and Co., to enable them to carry out searching analysis, the results of which have been shown upon the screen to-night and have proved of wonderful interest to many power station and marine engineers.

With many experiences of inaccessible steam joints, particularly in one's own sea-going period and having seen in the course of one's investigations many fine stations where welded steam mains have been used throughout, leads up to this conclusion, that it is possible to do without joints in steam mains.

The result of such a policy can be seen in operation now in this country and in the considerable number of European power stations and industrial plants. Therefore, it will be of much interest to hear the author's comments as to the reason why we have so many of these objectionable steam joints which are non-efficient and are certain to cause difficulty sooner or later. By eliminating them altogether you can get efficient lagging throughout the whole length of the main and make better provision for the supporting of the mains and also the anchoring and expansion.

Another point is that I have never yet seen any effort made by steam piping manufacturers or associations to standardise the conditions for mains. This has resulted in people coming along and selling the different designs of joints, jointing material and other requisites until you have considerably over 100 different types to choose from.

It should be possible for us as engineers to set up definite standards even to the consideration of the possibility of grouping mains in ranges say from 2in. to 4in. and keep one diameter of flange with bolts of equal length and diameter throughout this range. By such standardisation, the necessity for carrying stocks of bolts, odd sizes of flanges and jointing material of all descriptions will be overcome and thus release valuable stores accommodation in many large works and power stations. It will be interesting to hear Mr. Aiton's remarks upon this point.

Another matter to which there appears to have been given little attention, is in connection with the bolts which are used for steam joints.

In many instances these are bought in the cheapest market, and thus become the weakest link in the chain. Can I ask Mr. Aiton what he can suggest as a standard, also what can be approximated as a reasonable like for a joint, also if he considers it feasible to substitute new bolts after a predetermined life, changing these singly without disturbing the joint?

Mr. J. WARD, B.Sc.: The author remarks in the paper that "for marine purposes sliding expansion joints or ball joints have been largely used and have been fairly satisfactory with lower pressure saturated steam, but with superheated steam they are not satisfactory and have practically disappeared from land practice." He does not state any reason why they are unsatisfactory. Personally, I think that sliding expansion joints will still be retained for marine practice for the pressures and temperatures of superheated steam. The Admiralty still retain sliding expansion joints for high pressure superheated steam.

As regards friction loss in steam passing round a corrugated bend, I should like to know the author's authority for his estimate, *i.e.*, double that of a plain bend. The only research work I have seen so far on corrugated pipes is by Professor A. H. Gibson in a philosophical magazine recently. There appears to have been very little information published.

Referring to the pipe line 260ft. long in the "Power Engineer" for September there is an article on welded steam mains, which describes mains of much greater length; one 14in. main for instance is 1,100ft. long; also an 8in. main of the same length is mentioned, with all welded joints and no couplings. I think these are in connection with a heating plant operating at 175 lbs. pressure, but I do not think it is mentioned where the installation is fitted.

A Visitor: At Commines.

Mr. WARD: With regard to the American method of making a joint by rolling over the ends of the pipe and fitting loose flanges, that is not a new idea, as it has been used for some time past in this country and is known as Pope's flange, and was introduced by a Dumbarton firm. The method has been applied to copper pipes from $1\frac{1}{2}$in to 16in. diameter.

As regards the riveting of all flanges, I think a successful job can be made if the necessary precautions are taken, that is, if the hub of the flange is not made too long, the rivet holes well placed in relation to the root of the flange, and a small clearance allowed in the rivet holes. The hub should be turned with a bevel of 75° for caulking on the outside. Rivets should be pan or snap head, otherwise you incur the risks mentioned in the paper; they should be slightly countersunk on the outside and well countersunk on the inside.

I would like to ask the author for a little more information about the oxygen torch.

With reference to the welding of the receivers shown in the lantern slides, the author says "Rings are shrunk on the welded bodies of these vessels as an additional precaution." It seems rather surprising that there should be this lack of confidence in the welded joint.

A Visitor: One point not touched on by the author is the possibility of distortion occurring. It seems to me that the corrugation should eliminate that. I know of several cases where the old bolts have had to be taken out and new one's fitted in order to eliminate distortion. I believe this difficulty does occur more frequently than one imagines, especially in turbine installations.

As regards water lodging in these corrugated pipes, I think it is impossible that any large quantity of water could do so, because there could not possibly be any flow of water through the pipe; it is impossible even to blow the water out of the corrugations.

Mr. F. O. Beckett: I would like to question the author's recommendation that joints should be made "on a raised face inside the bolt holes." Does he mean a spigot joint?

Mr. J. H. Graves: I should like to express my appreciation of such an excellent paper at the opening of our session. It would be interesting to know the author's views regarding present-day tendency in power production, and what is the chief advantage to be obtained by the introduction of super-high pressures?

The author states that extensive tests have shown that corrugation does not adversely affect the metal. It would be interesting if he could give some idea as to how these corrugated bends are made; also how they compare, as regards costs, with standard expansion bends. Could he also say whether any of these corrugated bends have been employed in marine practice?

The author would perhaps also give us the benefit of his experience regarding the changes in the tensile properties of materials due to super-high temperature. He deals largely with the question of drainage. If you are using steam at high degree of superheat, can he say what is the reason for the great importance which it seems necessary to attach to the question of drainage of the pipe lines? If you have a high degree of superheat you would not expect much condensation to take place.

Mr. G. B. Plows : I was pleased to hear the Chairman raise the question of metallic arc welding as compared with the carbon arc process, as I wondered whether the author intended his reference to the carbon arc process to include the metallic arc, for it is a daily practice to weld steam pipes, flanges, and steel castings for a working pressure of 350 lbs. and 700°F. superheat, successfully by metallic arc process. I know of one large steam installation where all flanges were welded *in situ* before the war and all pipes fitted since have been supplied with welded flanges.

I was also pleased to note the design of the cylinder shown on the screen in which the shell was flanged over the end plate. I think it the duty of every welder, no matter how confident he is of welding, to provide mechanical strength as well as welded strength, wherever possible.

Mr. J. Ward, B.Sc. : When heating a welded flange, does any distortion occur, necessitating the refacing of the flange? Of course, that is an operation which cannot be performed on a long length of pipe. According to a paper which was read before an American society recently, the practice there is to weld a short length of pipe, and then to butt-weld that on to longer lengths as required, so as to avoid distortion.

Mr. J. Clark : I suppose most of us are aware of modern practice as regards steam pressures, and many of us are also aware of the results of modern practice. The author has confirmed my impression that it is very difficult to get a perfect weld. I think I agree with the opinion that there is no such thing, but that some welds are better than others.

There are other points to consider besides flanges when dealing with super-high pressures. As regards piping arrangements, we must be allowed plenty of latitude in this respect, as I think that the ideal piping arrangement has yet to be found. In America the flanges have been riveted end to end, but in that case the pipes are placed in position once for all. I am sure that these flanges do not give trouble by blowing out.

One speaker remarked about the friction loss in corrugated bends, and I also had noted the author's interesting statement that it was double the loss in plain bends. I would like to know how that figure was ascertained.

I would also be glad to know what, in the author's opinion, is considered good practice as regards the velocity of steam through a pipe at these high pressures. Does it vary with the bore of the pipe or is it constant for most bores? At the present moment these super-high pressures are only just coming into use, and later on, no doubt, we shall be dealing with still higher pressures.

The AUTHOR: With regard to the Chairman's enquiry as to the size of the corrugations, there is no fixed size. Each pipe is designed for its special work, and the corrugations vary with the thickness of the walls of the pipe and with the radius of the bend. Roughly the corrugations are about 2½in. pitch. They are not like the corrugations of suspension type of furnace as I understand it. I understand that in that case the top of the corrugation is brought rather sharply together. These are round, and the radius at the root is the same as at the top.

The CHAIRMAN: Like semi-circles brought together?

The AUTHOR: Yes. Usually, if the pitch is 2½in., each curve of the corrugation is 1¼in.

The Chairman referred to the metallic arc; I did not refer to that. We do not use it. It is cheaper, but it has one serious objection for use in connection with these flanges. You notice that we have a very deep weld. Our great bugbear is slag, and as you know, slag is provided for keeping the oxygen away from the arc. We only use this method for small sizes, 1¼in. to ½in. We very seldom use it on the high pressure work. We sometimes use it on the face weld of the flange.

I may say that the factor of safety on these flanges is very high. We take very little risk. I have tested a pipe with a weld at the back only to 1,800 lbs. and it did not budge, so that one might say that the front weld could be dispensed with. However, we do not like to take any unnecessary risks. I have conducted welding for the past twenty years, but I always take the precaution to have a mechanical safeguard at the back of me if at all possible.

Mr. Farenden enquired about the pipes and joints in the *King George V*. These pipes are 4in. diameter, which we consider to be small pipes. We seldom weld a flange on a pipe less than 6in. bore. In this instance the weld is at the face and is of little value. We should be quite prepared to fit pipes of this size without the welding, only screwed. We sometimes weld the back of a screwed flange but it should not be necessary.

Mr. Martin spoke about the pipes in the Flushing vessels. I know those of old, having been associated with Flushing when these ships were supplied. In making pipes by the method which Mr. Martin describes, you have all the work of turning the bar outside and trepanning it. The flange is raised by forging. I should have the objection that the grain of the metal is in the wrong direction. You can make up for that by putting in a much heavier pipe. I should expect the pipes to be more expensive.

With the advent of superheated steam the question of dealing with expansion is much more difficult, and plain bends might be successful in the past but would not be so now, hence the introduction of corrugated bends.

With regard to the question from Mr. Evans about welding a pipe from the outside, the pipe referred to was only a 6in. pipe, and could not be welded on the inside, the edge of the tube was veed so as to enable one to get down to the bottom of the weld.

Referring to Mr. Gummer's remarks, there are flange standards, which have been determined by a committee of the Engineering Standards Association during a long period of investigation connected with pipes and flanges for pressures up to 450 lbs.

I should not like to attempt to replace the bolts in a flange. They are not so easy to take out after they have been under superheated steam for some time. I have no information as to how long they will last; I should think as long as an ordinary pipe will last, but they must not be made of high carbon steel. In my opinion, that develops brittleness and they break off at the ends.

Mr. Ward mentions that sliding expansion joints have given satisfaction, but the difficulty is the packing, if it is not tightened up it leaks, and if it is tightened up unknown stresses may be put on the pipes.

With regard to the friction losses in the bends, most elaborate tests were carried out by the Germans at Charlottenburg. It is impossible for me to tell you all the details, but they arrived at the result which I have mentioned, that the loss in a corrugated bend is double that in a bend made of plain pipe.

Mr. Ward mentioned long pipe lines working at 175 lbs. The steam was probably not superheated, in which case it is a simple matter to make the pipes practically as long as you like. Having worked under Pope, the originator of the Pope flange, I know this flange and liked it very much. It is made of a soft copper collar brazed on the pipe and held together by heavy steel loose flanges. We used to go round that flange with a hammer until we made the copper practically homogeneous, after which we never had trouble. You cannot do this with steel joints.

Mr. Ward also asks how we open a weld by the oxygen flame. You take a blow pipe and play the flame round the weld, if there is any flaw present it will open. Mr. Ward suggested that in fitting the reinforcing rings to cylindrical vessels, I have shown a lack of confidence. It is the people who buy the pipes and vessels who have lack of confidence, and at whose desire these rings are fitted. I have never heard of a body weld failing, these are water gas welds of about 3in. to 4in. lap. We have had a great deal of trouble in inspiring confidence in the insurance companies.

With regards to Mr. Graves' remarks, torsion stresses will not occur, nor will you get water hammer in corrugated pipes. In the first case the pipes are so flexible, and in the second the water is in small pockets, and you cannot set up the wave action in a corrugated pipe

Fuel economy is the reason for high pressure. It is certainly interesting to notice how satisfied we have been with 200 lb. pressure, but the oil engine has now made us adopt high pressure steam and superheat, if steam is going to compete with the Diesel engine. I am convinced that pressures will go much higher still, but if temperatures are to go much above 800° the pipes will have to be made of some other material than mild steel, the elastic limit falls very rapidly as the temperatures rise above 750°.

I believe that corrugated pipes are in use in the *Cap Polonio*, a German built vessel. They are also fitted on board some vessels in this country, but they have not had long experience yet.

As regards the comparative cost of expansion joints, the cost of a corrugated expansion joint is of course higher than that of a plain pipe. It is, however, much easier to bend and that means a certain economy, but 25—30% more tube is required to make it. You may say that a corrugated expansion bend of the same size would cost practically double, roughly speaking, but you do not make them the same size; they can be made much smaller. Sometimes they are cheaper and sometimes a little more costly. If for any reason you must make them the same size, you are getting something very much better in the corrugated type.

In reply to Mr. Beckett, it is a spigot joint. If you make a joint all over the face of a flange, the tightest part of the joint is on the outside, round the rim. You may have a leak and it will come through the bolt holes. Now if you make a raised joint inside the bolt holes, the tightest part of that joint is inside the bolts, and if you get no leakage through the joint, you cannot get it through the bolt holes.

Mr. Beckett: What about the tension on the bolts? With a leverage like that it would be excessive.

The Author: I believe the Engineering Standards Committee's figure is about 8,000 lbs. per square inch. The raised face on the joint is very small, and there ought not to be any spring in the flange; there may be a certain amount, but not enough to make the joint weak. The important point is to make a flange heavy enough.

Mr. Ward asked about distortion. We always face a flange after welding. Welding does not leave a flange in a fit condition to make a joint, and when you reface it you find out whether it is sound, especially when you grind it.

I do not believe in the American method mentioned; if you are going to butt weld, why have a flange at all?

With regard to Mr. Clark's remarks about welds not being perfectly reliable, there are many bad welds and none perfect, but we allow a high margin of safety. An example of end riveting, such as he mentions, exists at Barking Power Station. The point which Mr. Clark raised concerning the velocity of steam through pipes is very interesting. I could never get that point settled; what worried me was—what causes the velocity? I could read in text books that 90ft. per second was a good velocity, but how was that figure obtained? The velocity is not the important point. The drop in pressure which produces the velocity, is the important point; if you have a range of high pressure piping it is my opinion that you should have a very high velocity, because if the pressure drops it involves no serious loss, but it will increase the velocity enormously, and that is a serious loss. Also your capital expenditure and heat and radiation losses will be much more. I recommend a high velocity and a small pipe. The tendency in power stations is to keep the pipes down to a small size. The largest steam pipe in the large power installations which I showed on the screen was 12in. Most are 10in. pipes. It is a matter of working out which pays you best, to keep the pressure up or to lose a certain amount of pressure and to save capital expenditure and heat losses. In land work this question enters very considerably and in present-day installations we are frequently asked to guarantee what the drop in pressure will be through our pipes, and we give it. We guarantee a definite drop of pressure; we never go as far as 10 lbs., but I think it might be economical to go much higher.

The CHAIRMAN: I hardly think I need make any further remarks. I have already referred to the very interesting and able paper which Mr. Aiton has given us, and personally I think his reply to the discussion has been more interesting still. He has imparted a great deal of information, for which we are very grateful. Those people who, like Mr. Aiton, are interested commercially in these matters are not usually disposed to give this information away, but I think Mr. Aiton has given us freely of his best. I propose that a very hearty vote of thanks be accorded him. (Carried unanimously.)

The AUTHOR: It is always a pleasure to come and talk to practical people, particularly to marine engineers, as we have a good deal in common. Before I took to land practice and pipe work I was a marine engineer myself. As far as giving away information goes, if you think I have told you all about pipes you do not realise the great variety of questions that arise, in the designing and making of them, it would be impossible in one lecture to deal with all.

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PAPER ON "BEARING METALS," BY MR. GRIFFITHS. CONTRIBUTED BY CORRESPONDENCE.

Capt. P. T. BROWN, M.C.: This paper is one of the most useful contributions to the Transactions of our Institute and we owe Mr. Griffiths a large measure of thanks for the work he has done in bringing such a wealth of information to our notice.

"Rule of Thumb" methods in the making of bearing metals occasionally obtain, and to eliminate this possibility it has become the general practice for a standard brand of metal to be specified.

It does happen, however, particularly in emergency repair work, that a metal of unknown reputation is offered and the information contained in this paper will be of great assistance to any one whose duty it may be to decide on the advisability of acceptance of an unknown metal.

Mr. Griffiths mentions some of the disadvantages of lead as a constituent, but—I hope he will correct me if I am in error—I gather from the general trend of his paper that he is not antagonistic to its use. Pitting is a serious defect and frequently obtains in the cheaper varieties of metal. May we assume that lead renders a metal very prone to this defect? Another defect one encounters is the squeezing out of the metal from the sides of bearings. Would the inclusion of zinc instead of lead prevent this?

The remarks about the temperature of pouring and the shell temperatures are very interesting, as "brittleness" and "bad adhesion" are undoubtedly common defects. Could the author give some reliable and simple methods which could be adopted when pyrometers are not available.

I am pleased to note the author issues a warning on the subject of "tinning" and the undesirability of "peening." A large amount of expense would be saved by the following of his advice.

In regard to "tests." Could the author suggest a range for Brinell numerals and Compression Tests.

I would also like to know whether the author would indicate his ideal mixtures for the following:—

(a) Bearings subject to high temperatures.

(b) Bearings which have a high load due to impossibility of increasing their size.

(c) Bearings subject to normal load, but with the liability to "pounding."

As an amateur metallographist I am impressed by the microphotographs and would be grateful for a little information.

(1) What means are adopted for polishing?

(2) What reagents are used for etching?

(3) What are the powers employed in the micro-photos of the paper.

I hope Mr. Griffiths will excuse the "Oliver Twist" attitude of demanding more. He has given us a most useful paper and I warmly thank him for his work.

Mr. Griffiths: I much appreciate Captain Brown's kind remarks, and am gratified to hear that the paper is considered helpful.

I am certainly not antagonistic to the use of lead as a constituent metal of an antifriction alloy, and indeed, consider that it might be more often used where low loads are involved. Although it certainly does increase the tendency to pitting, the effect is quite negligible if good quality lubricants are employed. Time tends to stiffen up a bearing metal but, perhaps for this reason, it has an adverse effect on the antifriction properties.

For suitable ranges of Brinell hardness figures and Compression tests, I would refer Captain Brown to the tables at the end of the paper, which give typical results for certain more or less standard alloys.

The recommendation of "ideal" mixtures is one of some difficulty, as other factors have to be taken into account besides those referred to. Alloys containing from 83/86 per cent. Tin, 8/10 per cent. Antimony and 7/8 per cent. Copper may be used where temperatures are liable to be somewhat higher than normal or the working conditions very severe. Alternatively, for extreme conditions of temperature or loading, bronzes must necessarily be employed. Where much "pounding" is likely to occur the high grade Tin Alloy containing about 93·5 per cent. Tin, 3·5 per cent. Antimony and 3·5 per cent. Copper may be utilised, the alternative again being a bronze.

The usual procedure was followed in polishing the alloy specimens for the photo-micrographs, rubbing down on emery papers of increasing fineness. Great care is necessary with the softer alloys to ensure that the pressure on the specimen during every stage of the polishing is as light as possible, as a deep scratch once formed is difficult to eradicate, while "flow" of the metal surface over scratches is liable to give a false impression of the work—until etching brings disillusionment. Very uniform emery papers only should be used and moistening the surface with paraffin oil is sometimes helpful. The final polishing is best carried out by hand on a soft cloth of the "Selvyt" type, using one of the gritless metal polishes now on the market. Dilute hydrochloric acid was used for etching the white metals and a ferric chloride solution for the bronzes. Owing to an error, the magnification of all the photo-micrographs was omitted from the advance proof copy; it was 100 diameters in every case.

Notes.

The following interesting summary of America's view of Gas and Oil Engine progress is from "Gas and Oil Power" of January 7th:—

Side by side with the achievements of British and other European internal combustion engineers, great progress has also been made during the past year by the United States in the different engineering branches. The American Society of Mechanical Engineers has done well to invite a series of world retrospects from its different professional divisions, and the resultant reports are published in the December issue of "Mechanical Engineering."*

Of special interest to our readers is a report on "Progress in Oil and Gas Power Engineering," prepared by a divisional committee, consisting of Messrs. Edgar J. Kates (Chairman), L. H. Morrison (Secretary), Elmer A. Sperry, Robert Rennie, George D. Pogne, and John W. Morton. The report is as under:—

There is no more efficient method of producing mechanical power from petroleum than that employed by the modern oil engine. Similarly, the gas engine using blast-furnace gas to produce electric power and to compress blast air, does more work per unit of gas than any other known type of machine.

The field of oil and gas power is ever widening. Starting with engines used only for stationary plants, it next was developed for marine use. A start has lately been made in the application of oil power to driving locomotives, tractors, and automobiles, and before long we shall undoubtedly see oil engines driving airplanes.

15,000-H.P. Now Reached in One Unit.—Not many years ago the field of application of the oil engine was greatly restricted by the comparatively small capacity of the units available. Power users requiring thousands of horsepower were not interested in oil engines whose rating was of the order of hundreds of horsepower. This prevented the use of oil engines in central stations except those of small size, and limited the marine use to comparatively small and slow freight vessels. However, that condition is now rapidly passing, and the experience gained with the smaller sizes has brought about the

* May be seen in the Library.—J A.

development of successful oil engines of much larger sizes which are now invading fields formerly dominated by steam power.

Current Installations Present Novel Features.—Several interesting installations are under way or have recently been completed. Among them may be mentioned:—

1. The U.S. Shipping Board has on order 18 large Diesel engines ranging from 2,700 b.h.p. to 3,000 b.h.p., each for converting existing steamships to motor-ships. Nine of these engines are single-acting four-stroke-cycle, four are single-acting two-stroke-cycle, one is double-acting four-stroke-cycle, and four are double-acting two-stroke-cycle. Note the trend towards double-acting engines. A few years ago single-acting engines were quite the rule, but in this order the double-acting engines comprise one-third of the total.

2. Three Diesel engines of 3,750 b.h.p. each have been ordered for a new power plant at Miraflores in the Panama Canal Zone, as auxiliary to the Gatun hydroelectric plant. These engines are of the Nordberg two-stroke-cycle single-acting design, having 6 cylinders 29 in. in diameter by 44 in. stroke, running at 125 r.p.m., and direct-connected to 25-cycle generators of the flywheel type. These are the largest individual engines so far built in the United States.

3. The United States Helium Production Plant at Fort Worth, Texas, is operated by seven 500-h.p. Bruce-Macbeth natural-gas engines which supply power to compress the natural-gas to 3,000 lb. per sq. in. for extracting the helium. The engines consume about one-eighth of the gas processed, the remainder going back into the mains. The low-pressure steam required is furnished by exhaust-gas economizers connected to the engines.

4. The Port of Portland's 30-in. pipe-line dredge *Clackamas*, which is one of the largest and most efficient dredges ever built, has been powered with two 800-b.h.p. and two 900-b.h.p. McIntosh and Seymour Diesel engines driving electric generators, which in turn operate the electric motors driving the dredging pump, the cutter, and the auxiliary machinery.

Remarkable Increase in Marine Application.—There has been a remarkable increase in the number of motor-ships being built as compared with steamships. The gross tonnage of motor-ships under construction in September, 1921, was but one-tenth of the steamship tonnage, whereas in June, 1925, it had tripled and was practically equal to the steamship tonnage. It is apparent that in the present period of depression in the shipping business the economic advantages of the motor-ship are being generally recognized.

Different Marine Drives.—There is at present no sign whatever of the standardization of any one type of oil engine for marine drive.

The motor-ship of to-day presents a variety of drives designed with the object of reducing weight or space, or of increasing propeller efficiencies. These are:—

(*a*) Direct drive.

(*b*) High-speed engines with gear transmissions.

(*c*) High-speed engines with hydraulic transmissions.

(*d*) Diesel-electric drive.

The last one is gaining ground in this country for use on smaller vessels, tugs, and ferry boats. However, for larger vessels the direct Diesel drive is still well in the lead, and especially the long-stroke engine introduced for converting steamships and saving the old propeller equipment.

Locomotive Application.—There has been no noteworthy advance in this country in the application of Diesel engines to locomotive drive since the 300-h.p. Ingersoll-Rand 60-ton locomotive, except for a 1,000 h.p. locomotive just completed by the Baldwin Locomotive Works, employing an oil engine of unusual design hitherto unapplied to practical use. This locomotive is now in experimental use on the Philadelphia and Reading Railroad.

In Europe, however, the tempting improvement in overall efficiency promised by the oil-engine locomotive (about six to eight times that of the steam locomotive) has been the spur to many interesting developments. In Germany two 1,200-h.p. Diesel locomotives have recently been built. Each of these is powered by a six-cylinder ($17\frac{3}{4}$ in. in diameter by $16\frac{1}{2}$ in. stroke), 450-r.p.m. M.A.N. Diesel engine weighing 29 tons. One of these locomotives has electric transmission and the other has gear transmission. The total weight of the Diesel-electric locomotive is 137 tons, or 230 lb. per h.p. This is a development of the original Diesel-electric locomotive built in Russia in 1909 from the designs of Dr. Lomonossoff.

Another interesting type of Diesel locomotive is being built by the M.A.N. works, using the Diesel engine to drive an air compressor. The compressed air is heated by the exhaust gas from the engine and then develops its power in the ordinary type of locomotive cylinders. It is expected to produce at the locomotive wheels 27 per cent. of the power represented by the heat value of the fuel.

The real problem in the application of oil engines to locomotive drive is hardly in the design of the engine itself, but rather in the mechanism for transmitting the engine power to the locomotive drivers. The electric drive answers the demand for high starting torque and ease of control, but suffers from too much weight. That is the reason for the search for improved forms of other types of transmission.

Gas Blowing Engines.—The first American blast-furnace gas-engine plant was installed by the Lackawanna Steel Company at Buffalo in 1903 to 1905, but according to C. G. Sprado there are now in America steel plants 118 gas blowing engines, having a total capacity of 3,600,000 cubic feet per minute, and 110 gas-electric units, having a capacity of 275,000 k.w.

Gas blowing engines are generally of the four-stroke cycle double-acting type with the air cylinders directly in line with the gas cylinders; they are of the tandem type, having two double-acting gas cylinders for each double-acting air cylinder. The design of the air cylinders or "tubs" has changed from positively operated inlet and discharge valves to plate valves. Fifteen years' experience has shown that gas blowing engines are fully the equal of steam engines in reliability.

An Airplane Oil Engine Under Test.—An oil engine designed for aircraft use is now on trial at the Naval Aircraft Factory, Philadelphia. This is known as the "Attendu" engine, the experimental model being a two-cylinder, airless-injection, self-igniting, two-stroke-cycle engine, designed to develop 125 h.p. at 1,800 r.p.m. The engine weighs 3½ lb. per h.p., and is said to run with clear exhaust, burning 19 deg. B. fuel.

A valuable document is the Technical Report for 1924 of the British Engine, Boiler, and Electrical Insurance Co., Ltd., prepared by Michael Longridge, Chief Engineer. This report contains accounts of breakdowns and failures of steam engines, oil engines, boilers, electrical equipment, etc., selected from the casualty list of the year either on account of some interesting pecularity or as suggestive to manufacturers and users of the various sorts of machinery covered. Each accident is reported in detail, with drawings, photographs, photomicrographs, etc., and the evidence is closely analysed to bring out the cause.

A report of like character to cover similar classes of accidents in this country is much to be desired.

Trends in Cycles, Processes, and Equipment. — *Double-Acting Principle.*—Reference has been made before to the increasing use of the double-acting principle. This applies to both the four-stroke-cycle engine and the two-stroke-cycle engine, and is, of course a natural development to be expected where large powers are required. Among recent applications of the double-acting principle may be mentioned the Worthington two-stroke-cycle, the Burmeister and Wain four-stroke-cycle, the M.A.N. two-stroke-cycle, and the Werkspoor two-stroke-cycle engines.

Solid Injection.—Oil-engine development tends more and more to the elimination of the air compressor for supplying air to inject the fuel. Not only are more manufacturers adopting the principle of airless or solid injection, but this principle is being applied to larger and larger sizes.

The oldest Diesel-engine manufacturers of all, the Maschinenfabrik Augsburg-Nürnberg A.G. (known as the M.A.N.) have developed an airless-injection engine for small sizes. Sulzer Bros., of Switzerland, who have been building air-injection Diesel engines for 25 years, have adopted the airless-injection system for a line of small engines.

As an example of the application of solid injection to larger sizes, the De La Vergne Machine Company now has in regular production solid-injection engines of 1,000 h.p. using six cylinders 21 in. in diameter by 30 in. stroke.

Superchargers.—These have been increasingly used for:—

(1) Increasing power and reducing first cost.

(2) Providing reserve power for peak loads.

The gain in power through supercharging is ordinarily 10 to 15 per cent., though on some German installations a gain of 30 per cent. has been claimed without injury to the engine.

Centrifugal compressors are now being widely used for supercharging. This type of supercharger has been highly developed by the General Electric Company in this country, and by Brown, Boveri and Co., in Switzerland.

Independent Auxiliaries.—There is a tendency in the case of large engines to make independent units of the blast-air compressors, and also of the scavenging compressors in the case of two-stroke-cycle engines. The motor-ship *Gripsholm* contains two 6,750-h.p. Burmeister and Wain four-stroke-cycle double-acting engines, no compressors being mounted on the main engines. Injection air is furnished by three air compressors driven by 600-h.p. Diesel engines. It may be noted in passing that this ship also contains three 500-h.p. Diesel generating sets, making a total Diesel installation of 16,800 b.h.p.

The two-stroke-cycle Sun-Doxford engines of the ore carriers *Henry Ford II* and *Benson Ford* receive their scavenging air from centrifugal compressors built by the General Electric Company, which are rated 12,000 cubic feet per minute at 2·5 lb. pressure, and are driven by electric motors developing 180 h.p. The principal advantages to be obtained aboard ship with this method of scavenging are saving in weight and space, and also better control of the scavenging air when manœuvring the ship.

A centrifugal compressor connected through gears to the engine shaft furnishes scavenging air to the 1,000-h.p. two-stroke-cycle Knudsen engine used on the Baldwin Diesel Electric compressor, previously referred to. This is a General Electric compressor, rated at 4,500 cubic feet per minute at 2·5 lb. pressure.

Jacket-Water Systems.—Although the harmful effects of scale in oil-engine water jackets have long been known, the practice in the past has generally been to permit the scale to form but to remove it occasionally before serious damage resulted. However, a more logical procedure is now being followed in many cases, which consists in using soft water in the engine jackets, thus preventing the formation of any scale whatever. Such soft-water systems usually consists of a closed-circuit system in which the same supply of soft water is used repeatedly, and after being heated in the engine jackets is re-cooled by means of pipe coils or other heat exchangers, which deliver the heat to the raw-water supply. There are a number of cases on record where plants which had suffered repeated cracking of cylinder heads caused by scale completely overcome the trouble by adopting enclosed cooling systems as above described.

Centrifugal Purifiers for Fuel Oil.—Centrifugal purification of heavy fuels before entry to the engine has received impetus, particularly aboard ship. In order that the separation of water and dirt may be rapid and effective, it is necessary to preheat the oil before admitting it to the centrifuge, the preheated temperature ranging from 120 degrees Fahr. in the case of comparatively light fuels, to 210 degrees Fahr. for very heavy fuels. Such purification of the fuel has been found to result in greatly reduced wear of pistons and liners, and longer periods of good seating of the exhaust valves and spray valves.

Air Filters.—Interest is increasing in the use of air filters for cleaning the intake air of oil and gas engines in order to reduce wear on liners and pistons, and also possibly to increase the life of the exhaust-valve seats between regrindings. In industrial districts the dust content is about 2 to 4 grains per 1,000 cubic feet of air. This is equivalent, in a 200-h.p. engine running continuously, to 3½ to 7 lb. of dust and grit drawn into the cylinders each week.

Measurement of Exhaust-Gas Temperatures.—On a multi-cylinder engine it is, of course, desirable that each cylinder should carry the same proportion of the total load on the engine. This is especially true when the engine is operating near full load, as otherwise one or more cylinders may be heavily overloaded, resulting in unsatisfactory performance. A simple means of checking the distribution of load among the various cylinders is to measure the temperatures in the individual exhaust outlets. If the engine is in good mechanical condition, with tight exhaust valves and piston rings, also with correctly timed fuel injection, the temperature in the exhaust outlet of any cylinder will vary practically in direct proportion to the load on that cylinder. In a test on one engine it was found that the exhaust-gas temperature varied 5 degrees Fahr. for each 1 per cent. change in load over the whole range of 25 per cent. to 110 per cent. of rated load. The exhaust outlet temperatures, therefore, serve as an excellent check on the engine performance, and pyrometer equipments are now being widely used for this purpose.

Utilization of Waste Heat.—Within the last few years exhaust boilers have received considerable attention in this country, especially for marine use. While it is, of course, desirable to try to save some of the heat rejected in the exhaust of an oil engine, the commercial advantage is limited by the comparatively low temperature of the exhaust gases due to the high thermal efficiency of the engine. Consequently to recover any large proportion of the heat in the exhaust, requires a large and expensive exhaust boiler, whose first cost, maintenance charges, space occupied, weight, etc., may or may not be justified from a commercial point of view.

In this respect the oil engine differs from the gas engine, as the heat in the gas-engine exhaust is very much greater, and is often well worth recovery.

Another possible application of the exhaust heat is to employ it in a gas turbine driving a blower for supercharging the engine. This system, whilst the subject of experiment, has not yet been commercially adopted.

A Few Problems Awaiting Solution.—Among the outstanding mechanical problems in the field of oil and gas power engineering are:—

1. Reduction in weight and cost of oil engines by—

(*a*) Improvement in materials used.

(*b*) Improvement in design affecting simplicity and standardization for the purpose of reducing manufacturing costs.

(*c*) Supercharging.

2. Standardization of accessories to permit their purchase at lower prices.

3. Obtaining information from the users of oil engines to help designers and manufacturers to improve them. An organization of oil-engine users, similar to the Diesel Engine Users' Association of Great Britain, is much to be desired in this country.

4. A real survey of the relation of the oil engine to the economic production of power, and conclusions as to limitations, etc.

5. Quality and grades of fuel obtainable in the future for oil-engine use.

6. Purification of future fuels for oil engines and study of the problems in burning heavy oil.

7. Elimination of harmful effects of critical speeds and torsional vibrations in multi-cylinder engines.

8. Prevention of harmful heat strains in cylinder heads, pistons, and liners of large oil engines.

9. Application to large oil engines of airless injection of fuel.

10. Improvement of combustion efficiency of airless-injection oil engines, resulting in greater m.e.p. and lower fuel consumption.

11. Improvement of thermal and mechanical efficiencies of oil and gas turbines, with special reference to metallurgical research for improved materials.

12. Development of oil engines and transmissions suitable for locomotive drive.

13. Development of oil engines and transmissions suitable for truck and tractor drive.

14. Utilization of waste heat.

15. Life of engine parts as related to (*a*) piston speed, and (*b*) revolutions per minute.

In "The Foundry Trade Journal," of March 25th, there is an article on moulding and casting, with illustrations, including a description of the best methods to adopt in the moulding and casting of oil and gas engine pistons.

In "The Iron and Coal Trades Review," Sept. 17th, the following interesting notes are given as to recent discoveries of iron ore:—

"The first iron mine in French Morocco, about 4½ English miles from Tiflet, was started recently. The mine is connected by a railway line, about 30 miles in length with the port of Rabat. During the opening ceremony the first train of ore was started from the mine to the port."

"An announcement was made by Mr. A. C. Marten at a recent meeting of the Burma Engineering Society that at about 64 to 68 miles from Rangoon, a rich deposit of iron ore has been discovered. Analyses of samples sent to America, Germany and Japan show the ore as containing no sulphur. Japan has offered to take all the iron that Burma can produce."

No comment is made as to samples not having been sent to Britain. It may be that the want of coal has led to the non-inclusion, on the understanding that the working of iron depends on coal and where coal is lacking other industries suffer by unemployment.

The following is from "The Nautical Gazette," New York, of July 3rd:—

STEAM AND MOTOR DRIVES FOR SHIPS.—At the general meeting of the German Engineers' Club held June 12th to 14th in

Hamburg, Dr. Fraham, the technical director of Messrs. Blohm and Voss, gave a review of the most important problems of shipbuilding, in which the valuable latest experiences of German naval architecture were made known.

Problems of shipbuilding are for the most part not entirely new, but they lie chiefly in the direction of bringing developments which have for some time been under consideration, to technical and economical perfection. While ship construction runs more or less in fixed lines, the main problems in engineering and the most important among all construction questions is that of steam versus internal combustion engines.

From a general point of view it must be stated that all difficulties of the application of the internal combustion engine for ship's drive have been overcome. Units of about 5,000 brake horsepower at one screw propeller are running continuously for a much longer time; some larger units have been put into service only recently; but there is no reason to doubt that they and even very large motors are absolutely reliable. Wear and tear of Diesel engines have been found not to be excessive, from the experiences of the first sea-going motor vessels, which have been running long enough now to allow definite judgment. The conclusion may be drawn that internal combustion engines are even superior to steam engines inasmuch as only single parts such as cylinder liners and pistons may eventually need to be replaced, while with a steam plant the boiler needs replacement sooner or later. In the question of economical superiority, due consideration must be taken of all items concerned, though the fuel price question is the most important. It is a drawback for the motorship that the development of fuel oil prices cannot be foreseen even for a few years, to say nothing of the uncertainty prevailing for the lifetime of a ship. The question of engineers for internal combustion engines no longer present any difficulties, for it has been found that steam engineers very soon get familiar with Diesel engines.

The fight for development and superiority is going on on both sides: steam engineering and motor engineering. As regards steam, a British vessel gives the remarkable results where steam at 570 lbs. pressure and a temperature of 750° F. is used, but it must be doubted whether the complication involved will pay for a saving that is estimated at 10 per cent. Other improvements under consideration are automatic stoking of boilers and the use of pulverised fuel, but they are only in their infancy as yet. Motor engineering strives to use boiler fuel oil, to extend the application of supercharges and to make a more general use of combustion gases for the generation of steam.

If the steam drive of freighters is considered, it must be stated, that the reciprocating engine prevails, because geared turbines have been disappointing. The faults were with the gears and might have been avoided by proper construction and material. For units of 3,000-5,000 horsepower turbines should be more used, as they allow a saving of about 10 per cent.

Fuel consumption of the different systems of internal combustion engines fit for freighters is about the same. With respect to space requirement and weight, the double acting two stroke cycle system is much superior for larger units; its height is of no importance for freighters. The weight f.i. for a 3,000 brake horsepower engine is 270 tons only against 430 tons for a single acting four stroke cycle engine and 375 tons for a single acting two stroke cycle engine; the costs of building compare similarly. Upon the whole the oil engine is an economical proposition for cargo boats on long voyages, where oil may be had at a moderate price.

For large liners some shipping companies still refrain entirely from motor drive, though progress is going on also on this field. Only the double acting engine comes into consideration for really large powers. The two cycle and four cycle systems are fighting for superiority; the four cycle system is favoured in other countries, but the two stroke cycle system is superior in output per cylinder in weight and in building cost. In special cases for passenger vessels, where small height of engines is of advantage, the engines may be connected with tooth gearings without hydraulic couplings. A double acting two stroke cycle engine of 15,000 brake horsepower is at present undergoing trials, but there is no difficulty in building even decidedly larger units.

A thorough investigation of the economy of large liners of the *Albert Ballin* (13,000 b.h.p.) and the *Cap Polonio* (24,000 b.h.p.) class shows a slight superiority of motor drive against steam turbines with oil fired boilers. If in spite of this fact, the German shipping companies have decided in favour of steam drive, the adherents of motor shipping may be consoled by the probability that the balance may later pull in favour of the motorship.

Other problems touching the question of ship's drive are those of propeller guide blades and of improved rudder systems.

Propeller guide blades have proved an undoubted success. For fast boats with fine lines it may be said that the efficiency of the propeller can be improved upon by suitable guide blades by about 5 per cent. A still better improvement in efficiency has been experienced with freighters and other craft of a more robust form; the gain depends in each individual case upon the interference between the ship's hull and the screw propeller. Decided improvements have also been made in the construction of rudder forms, which are so built that they offer a small resistance only to the stream from the screw propeller.

In conclusion it may be stated that none of the questions which are under discussion now in technique of shipping is such that its solution would bring any overwhelming improvement in economy. We have come now to the point where gains are only made by small strides and savings are measured by single percentages.

The following is from "The Iron and Coal Trade Review," of August 6th:—

British Association.—The annual meeting of the British Association opened on Wednesday, August 4th, at Oxford, where the Prince of Wales delivered, in the Sheldonian Theatre, his presidential address, pointing out that one of the principal aims of the British Association was to obtain more general attention for the objects of science and the removal of any disadvantages of a public kind which impeded its progress. Referring to the present attitude of the State toward science, His Royal Highness said that it marked a definite step in human progress, taken after long hesitation, but in itself new; and because it was new, they might believe with some reason that they lived not merely in an age of science, but at the beginning of it. The movement for co-operation had borne fine fruit already in other lands, and in particular it was active in our own Dominions. The Indian Empire stood in a somewhat different category from these; there was there a tradition, so to say, for the application of science in its government, and the scientific results of its census investigations, its surveys, its agricultural, forestry, and other administrative departments, had long been famous. That was not to imply that brilliant scientific work had been wanting in the Dominions—far from it—but the co-operative movements with their Governments had followed that in this country, and with a laudable promptitude. The trend of developments had been similar, broadly speaking; it was sought to take a comprehensive survey of the natural resources and industrial opportunities of each Dominion, to explore the means by which science might be best applied to their exploitation, to provide, whether in State institutions or in university and other laboratories, for the pursuit of the necessary researches, to co-ordinate the work, and to ensure the dissemination of knowledge acquired. The nature of the researches themselves was conditioned to a large extent (though by no means wholly) by geographical circumstances in the respective territories; agricultural, pastoral, and forestry problems, for example, were not identical in all of them, and that very fact added to the interest and value of coordinating the results of research work throughout the Empire. While problems might differ, solutions might point to a common end. Nothing but good could follow from personal contact between scientific workers in different parts of the Empire. Nothing but good could follow from their researches if they added, as gradually they must add, to the wider knowledge of the Empire, not only among the workers themselves, but ultimately among the whole body of informed Imperial citizenship; not only in the overseas territories, but here at home.

In "Fairplay" of Sept. 16th the following paragraph appears:—

The Board of Trade call the attention of owners and masters of oil carrying vessels to the necessity of seeing that the electric installation is maintained throughout in a satisfactory condition. Lamps and other fittings and the wiring leading thereto should be suitably protected, and every precaution taken to avoid the risk of explosion which may be caused by sparks from defective fittings and connections. Where it is necessary to introduce a lamp into a compartment, cofferdam or other enclosed space, before it has been ascertained that the space is free of gas, only battery-fed hand lamps of a type approved by the Home Office for use in fiery coal mines should be used. Ordinary portable lamps, such as pocket torches, and lamps attached to cables, are, it is pointed out, unsuitable for use in dangerous spaces.

The foregoing may be considered carefully by Associates in view of the subject set for Awards under the Stephen Legacy.

The following letter was in "The Times" of September 17th, directing attention to "A New Scheme for Industry":—

Sir,—In your issue of to-day is a brief notice of an article by Mr. Wickham Steed in the "Review of Reviews," calling attention to an industrial scheme, hailing from New Zealand, where it has obtained legal sanction, which is represented in this country at present by Messrs. Frank Harty and Harry Valder. This scheme seems to some as interesting, original and practicable. It is much to be desired that men of business who are not blind to the need of fundamental reforms should study it. It has not the weaknesses of the ordinary profit-sharing projects and appears to be capable of solving what is perhaps the deepest economic problem of to-day—How to make the "workers" feel that it is worth their while to do their best, because they are fully partners as well as workers. I will not repeat a description of the project such as is briefly given in your notice referred to above; but perhaps you will allow me to mention that the promoters' pamphlet entitled "Wanted" is procurable from Messrs. Mowbray, Margaret-street, W.1.

I am, Sir, &c.,

CHARLES GORE.

6, Margaret-street, W.1, Sept. 15.

The following is from "The Nautical Magazine" of Sept:—

Sailing Ships Again.—It will come as news to "old timers" to learn that fleets of sailing ships are again to spread their white wings to the trade winds of the Northern and Southern Hemispheres. Within the next five years those navigating on the bridges of our big liners will gaze with admiration and wonder at the tall masts supporting great spreads of white canvas to the breeze. It will call their minds back to the times, which doubtless many of them have read about, of the famous wind-jammers that raced across the waters of the world carrying honours and prestige under the glorious flag of our Empire. It is further stated in the article that the sailing ships are being built by ship owners in France, Germany and Finland, modelled on the lines of the famous tea clippers, but about six to eight times larger in proportion under the latest type of construction.

The first ship laid down in a German yard has been launched and another of greater tonnage is on the stocks, and when completed will be the largest sailing ship that ever crossed the ocean.

The battle for the sea is thus not confined to the steam and internal combustion engined ship, of which we have heard so much recently.

The above recalls the memorial booklet issued recently to commemorate the centenary of the Dundee, Perth and London Shipping Co.

Boiler Explosion Acts, Report No. 2757.—This deals with the explosion from a cast iron stop valve chest on the *Montrose*, when the 4th Engineer was slightly scalded on the leg, but soon recovered, fortunately. The stop valve chest in question was globe shaped and when tested by hydraulic pressure to 300 lbs. when new, and on subsequent examinations, had shown no indication of defects. The valve was part of the steering gear installation, it was $3\frac{1}{2}$ in. diam., of brass, with brass seat, gland and spindle, the casting was $\frac{5}{8}$ in. thick, the flanges $9\frac{3}{4}$ in. diam. by $1\frac{1}{2}$ in. thick, with 9 bolts $\frac{5}{8}$ in. diam. Its object was to control the admission of steam to the starboard steering engine, situated in a compartment on the lower deck above the shaft tunnels at the stern of the ship. The pipes, well lagged, pass through the starboard tunnel and lead up the tunnel escape along a passage to the steering engine, where the stop valve was situated. A water interceptor—steam separator—having a water gauge glass and drain led through a steam trap, was provided. A cross connection steam stop valve joining the two ranges of pipes is fitted overhead; also a reducing valve, which was on the steering engine range in the after tunnel recess.

The explosion occurred when the vessel was alongside the quay, finishing the loading, on the eve of sailing for Canada. The Junior Engineer was warming the connections up, preparing for a run. He had opened the exhaust valve on the starboard engine and the main exhaust valve on the cross connection. All the steering engine drains had also been opened. He then opened the drains on both water interceptors in the tunnel. Soon afterwards the cross connection stop valve in the tunnel was eased slightly off the face. The steam separator drains were then by-passed direct without going through the steam-trap. The water gauges were tested and showed the pipes to be clear of water. The valve on the starboard steering engine was then eased off the face and soon afterwards, without any shock of water hammer, the chest gave way. Careful examination subsequently revealed that there were two inherent flaws in the casting and probably some water had been in the bends of the pipes and dashed along, thus causing the blow-out in the weakest part. The new valve chest was fitted with drain cocks as a precautionary measure. The investigation was carried out by Mr. E. F. Moroney, Board of Trade Surveyor, Liverpool.

Mr. Carlton's observations were that the valve chest was obviously defective. Fortunately, considerable care was exercised in opening up the steam to the pipes, otherwise the valve chest might have burst with serious consequences to anyone in the confined space in which the valve was situated.

PATENT ACTS.—Referring to the notice as to observations or suggestions being desired with a view to improve the conditions under which Patents are granted, the following paragraph is from our Annual Report of 1919/20:—"The revision of the Patents Act received consideration at Conferences, by a General Committee consisting of representatives of the Technical Institutions with a view to improvements in several of the details of the proposed new Act. The Act has now been passed with modifications, but it does not embody all the recommendations and improvements aimed at with a view to give, as it ought to give, the most ample encouragement to the inventive faculty for the benefit of the nation."

Engineers are given facilities and receive every courtesy to assist them at the Patent Office and to guide them in their searches, so that any suggestions will be welcome, by the Secretary of the Committee, Patent Office, 25, Southampton Buildings, W.C.2.

THOMAS GRAY MEMORIAL TRUST PRIZE FOR AN IMPROVEMENT IN THE SCIENCE OR PRACTICE OF NAVIGATION.—Under the terms of the Thomas Gray Memorial Trust the Council of the Royal Society of Arts offer a prize of £50 to any person who may bring to their notice a valuable improvement in the science or practice of navigation proposed or invented by himself in the year 1926 or in the years 1921-5 inclusive. Preference will be given to an invention of 1926. In the event of more than one such improvement being approved, the Council reserve the right of dividing into two or more prizes at their discretion. Competitors must forward their proofs of claim on or before December 31st, 1926, to the Secretary, G. K. Menzies, Royal Society of Arts, John Street, Adelphi, London, W.C.2.

Books Added to the Library.

By the courtesy of the Council.—The Annual Report of the Council of The Royal Sanitary Institute for 1925. The History of The Royal Sanitary Institute; with special articles on The Progress of Sanitation during the past fifty years. It may be observed that the Institute has been represented at the R.S. Congress each year.

The Journal of Scientific Instruments for October.

By the courtesy of the Council. The Transactions of The Liverpool Engineering Society, Vol. XLVI., Session 1924-5. This volume includes, amongst other papers, the following, which are of special interest to our members:—"Manœuvring of Ships," by E. M. Keary, A.M.Inst.N.A.; "Methods of Preventing Corrosion of Condenser Tubes," by J. Austin; with a description of the method of spraying the tubes with a bitumastic solution.; "Notes on the Longitudinal Strength of Ships," by E. F. Spanner, M.Inst.N.A.; and "Heat Treatment of Tool Steel," by S. N. Brayshaw, M.I.Mech.E.

By the courtesy of the Council.—The Transactions of the Institution of Engineers-in-Charge. Vols. 29 (Session 1923-4) and 30 (Session 1924-5).

By the courtesy of the Education Committee.—The Journal of the Municipal College of Technology, Manchester. Vol. 12.

By the courtesy of the Council. A copy of the "Regulations for the Electrical Equipment of Ships." 2nd Edition, June, 1926.

Report of the Committee on Tabulating the Results of Heat Engine Trials.

By the courtesy of the Council.—The Journal of the Institute of Metals. No. 1, Vol. XXXV., 1926.

"From Slip to Sea," by A. C. Hardy, A.M.I.Mar.E. J. Brown and Son, Glasgow. 10/6 net.—We have, on former occasion, had the pleasure of noticing the works of the author of "Merchant Ship Types," "Bulk Cargoes," and "Motorships," and the present volume maintains the reputation for thoroughness, which the previous works led us to expect. The avowed object of this book is to familiarise all those who have not had actual experience in ship construction with the methods and processes involved, the principles governing these, and the technical nomenclature of the various members of which a ship is composed. In the comparatively small compass of 236 pages, with excellent and well chosen illustrations, the author has contrived to present as full a statement as one could expect in any one volume, and the man with any small degree of knowledge of ships who is anxious to extend that knowledge will find this work excellent for his purpose. At the same time we are sure that the author would be the first to agree that the art of shipbuilding can no more be learned from books alone than, say, the art of surgery, and the utmost any book can do in these things is to help the layman to a more intelligent understanding of the general principles involved. The navigating officer will find the book of value in this respect and in the total absence of any yard experience he will not, in reason, expect any more. The engineer officer, however, with mechanical training and experience, will reap a larger harvest of knowledge, and to him the book has correspondingly higher value. In this connection, we note with approval the shrewd remark of the author on page 178, where, after speaking of the enormous growth of intricate mechanical equipment on shipboard, all of which is under the care of the engineer, he says that, "it is possible that in the near future the engineer will develop into an engineer-navigator or vice versa."

He says what many are thinking, and the time cannot be far distant when the anomalies which have grown out of conditions long obsolete must receive attention already overdue.

Amongst the many excellent features of this book, which sets forth in chronological order and vividly describes all the operations which go to the making of a ship, we particularly welcome the preliminary chapter on the nature of the materials used.

We have drawn attention to this matter on more than one occasion and we are the more gratified to find that the author has dealt so well with this important phase of his subject, for we do not hesitate to say that it is a phase in regard to which the average mind is not at all well informed, and no one can be unaware that to-day the metallurgist is in the very van of progress and the problems of his art are of paramount importance to every branch of engineering.

We note the following errata, which will no doubt be duly dealt with in following editions:—

On page 81: "worth" of marking off for "work" of marking off.

On page 124: axis of "tuning" for axis of "turning".

On page 131: "9/19ths in." for "9/16ths in." declivity of ways.

On page 133: "1/33rd in." for "1/32nd in." diameter of sight-hole.

And on page 148 the author speaks of a "light screen watertight" bulkhead between engines and boilers in ordinary cargo vessels. This of course is a contradiction of terms, a bulkhead is either watertight or it is not, and no light screen will serve for watertight purposes. The simple screen non-watertight sheeting is, of course, usually found on purely cargo steamers.

The reference to cable on page 196 speaks of lengths between shackles of 12½ fathoms; this is not British practice, we usually have 15 fathoms of chain between shackles in our ship's cables.

We close this brief notice with a sincere recommendation to all who are concerned with ships, and especially to engineer officers in the merchant service, to obtain a copy of this excellent book.