SESSION 1909–1910

Notes on Boiler Covering.

By Mr. A. P. STROHMENGER, F.C.S.

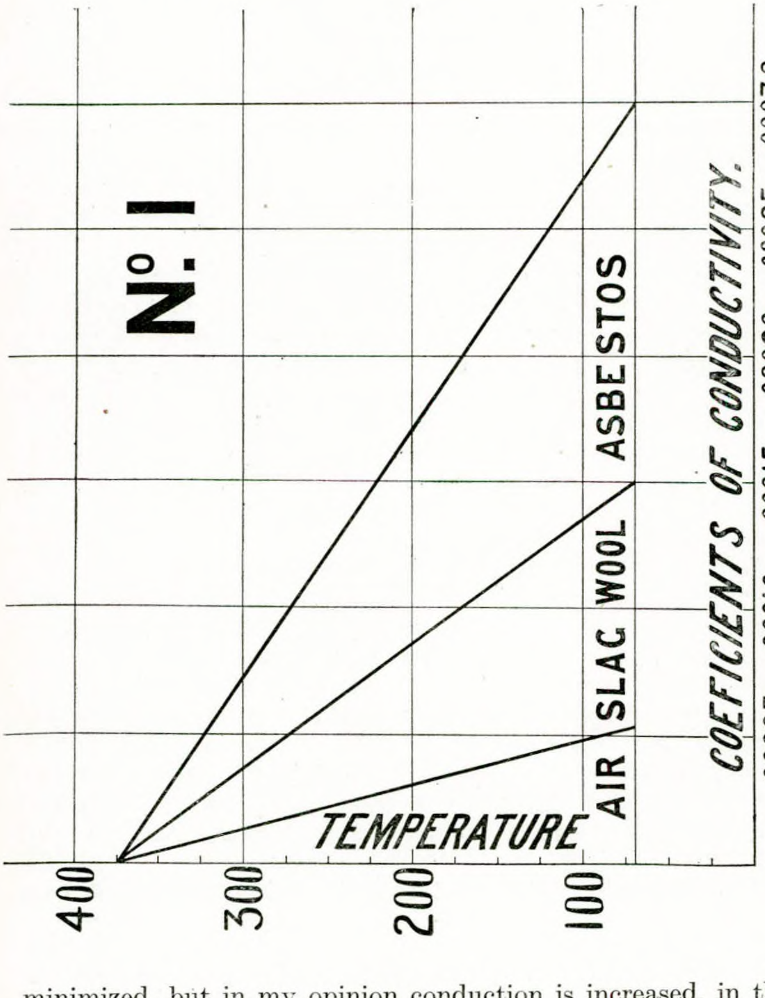
Monday, November 22, 1909.

CHAIRMAN: Mr. JOHN LANG, R.N.R. (MEMBER OF COUNCIL).

CHAIRMAN: The lecture to be delivered this evening by Mr. A. P. Strohmenger on "Boiler Coverings" is one which interests us greatly as marine engineers and deserves very careful consideration. I will now call upon Mr. Strohmenger to proceed with his lecture.

Although much has been written on this subject, one cannot help noticing the haphazard way many of us regard the serious losses that occur from boiler to engine, brought about by so-called radiation of heat energy. I venture to think that if we could picture more clearly what actually takes place, we should more readily realise the advantages to be gained by the most efficient non-conducting laggings. I appreciate that I am speaking to "live" practical engineers, and will therefore endeavour to present data, of whatever value, in as practical a way as possible. First let us consider how the losses are brought about. These losses are generally termed losses by radiation. By radiation is meant the transference of heat from one body to another, through a medium which may not in itself be heated.

I think we may safely assume that the losses through direct radiation from conveyors carrying heat energy in the form of steam, are exceedingly small. From an uncovered boiler or pipe the losses are undoubtedly primarily due to conduction and convection. Convection is merely the hustling of heated particles, due to a difference in the specific weight or volume. When the vessel carrying heat energy is lagged, convection is

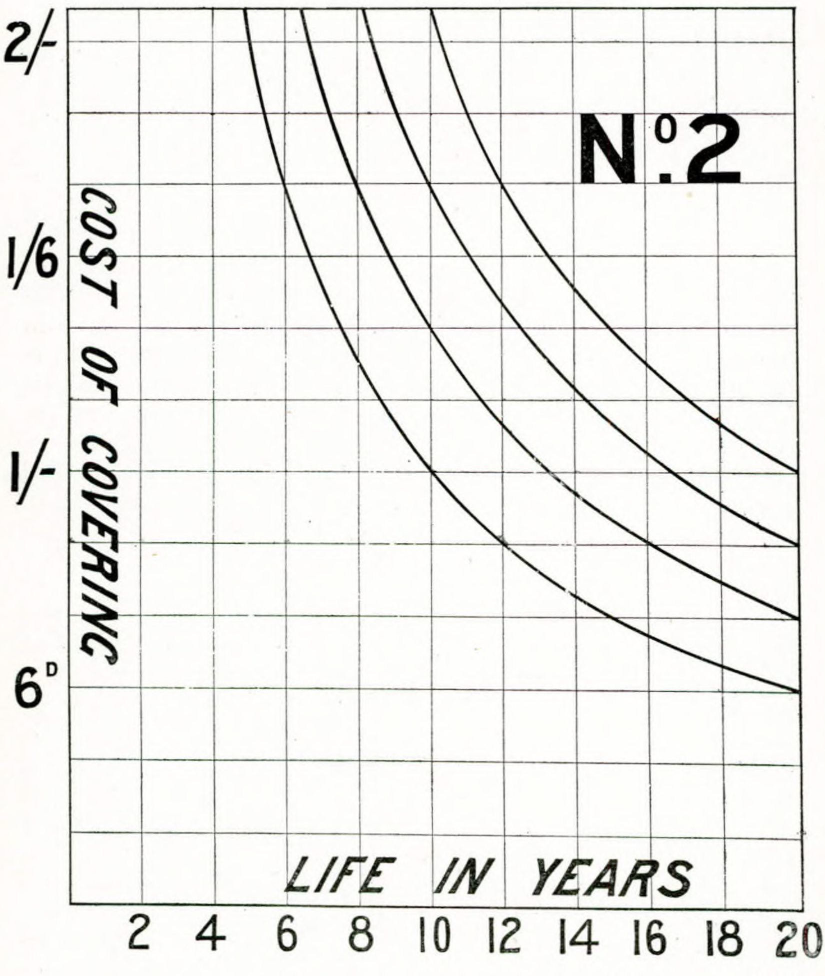


minimized, but in my opinion conduction is increased, in the way I will endeavour to show you. My methods of deduction may possibly, to a scientist, appear crude, but an acceptance of the conception will aid the solution of some otherwise unexplainable phenomena met with when investigating the properties of commercial laggings.

I will attempt to explain the differences met with in various coverings by the diagram No. 1. This diagrammatically illustrates the path of heat energy through different materials, supposing one end of the material to be heated to a temperature of some 400° F., and a drop through the material, so that the other end is at the temperature of the atmosphere. On the base line I have had plotted the co-efficients of conductivity. The figures for the materials chosen have been taken from standard works on the subject. You will see that air has a co-efficient of conductivity of ·00005, slag wool ·00015 and asbestos ·00030.

If no heat could pass from a column of air otherwise than by conduction along its length, we may diagrammatically illustrate the length of path necessary to obtain a certain drop in temperature, as shown. The same applies to the other materials plotted. It will thus be seen that slag wool and asbestos offer a lower resistance path for heat than air, and to obtain the same drop in temperature, longer lengths are necessary. An analogy could be taken, and this may appeal to electrical engineers, to the path offered and taken by a current of electricity. If we have two wires, of equal cross-sectional area, but of unequal electrical conductivity, in parallel with a difference of potential at their jointed extremities, then to obtain an equal current density in both wires, the wire with the higher electrical conductivity, or lower electrical resistance must be longer by an amount varying with the relation of the co-efficient of conductivity or resistance the one wire bears to the other. Applying this to our materials to be used for heat laggings, in order that the potential difference, or in other words the temperature difference, shall be the same for air as for, say, asbestos, it will be necessary to increase the length of asbestos by an amount equivalent to the difference in conductivity.

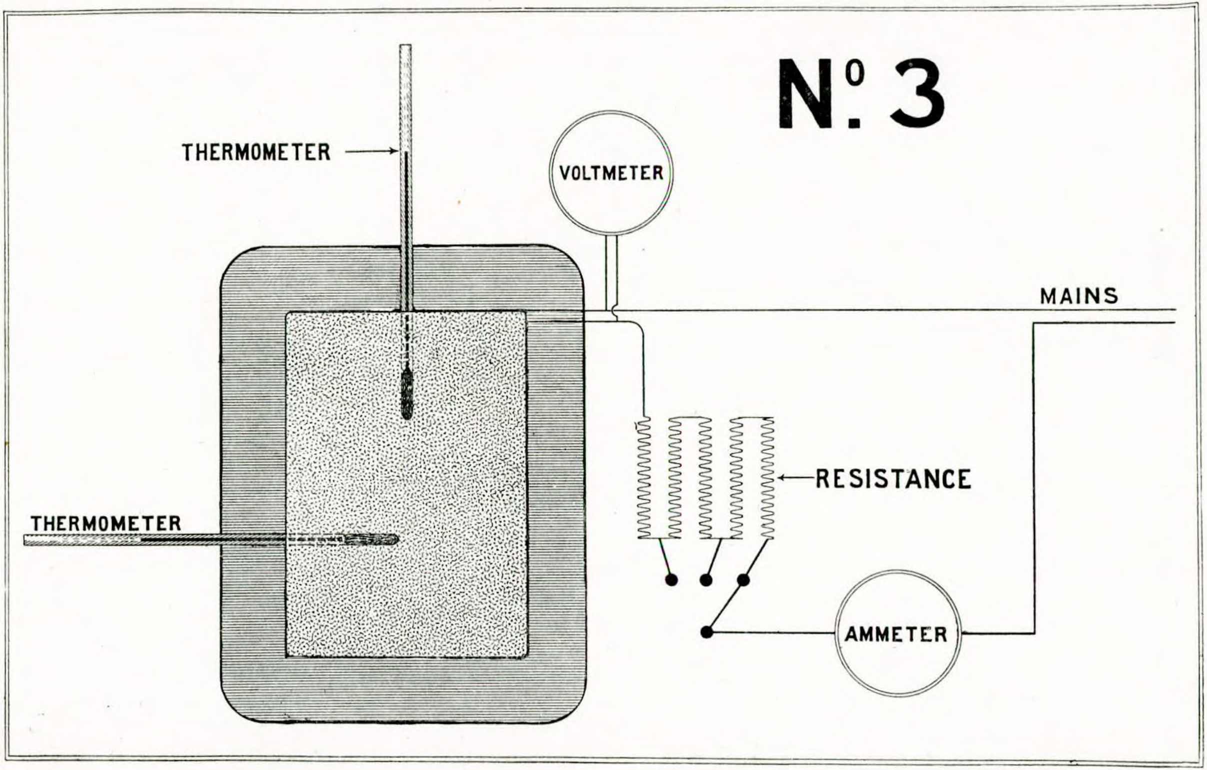
It is generally stated that the more air cells present in a covering, the more efficient will be the covering. Although this is true, I wish to make it clear that it is not because of the air cells, but because of the longer path, and therefore increased resistance of the material we are using. The total sectional area of the material considerably exceeds the total sectional area of the air cells. If the losses in B.Th.U. for a particular material be plotted against varying temperature differences, it will be found that most materials give a curve with a gradient decreasing as we approach extreme temperature differences ; that is to say, the material is a more efficient non-conducting



covering when used at higher temperature differences. This improvement is generally explained by stating that the excess of air is expelled as the temperature rises. Possibly this may be so to some limited extent, but I venture to suggest that it is chiefly due to an increase of resistance, or a decrease in conductivity of the material used. Surely the path of least resistance is the governing factor in losses by conduction. I expect to find many present here to-night who will not agree with my view of the problem, and I trust they will not hesitate to frankly criticize, for it is only by discussion that we can arrive at the true facts of the case.

The choice of a covering is not an easy matter. There are many things to be taken into consideration. Life generally governs cost, cost generally governs efficiency, but it does not follow that a covering with a short life and low efficiency is cheaper than a covering with a long life and high efficiency, or even of a covering with a short life and high efficiency. As far as life and cost go we can, with the help of a similar diagram to that shown on No. 2, clearly illustrate how a covering low in first cost, but with a short life, may, over a term of years, cost more to maintain than a higher priced covering with a long life. Assuming the term to be twenty years, and that a covering costing 2*s*. will last for the whole of this time, we have merely to follow the curve plotted for lower values to the point of intersection, to obtain the number of years the cheaper covering will have to last, before it can compete with that having a higher value, not taking into consideration any saving which may have been made in plant economy.

This brings us to what should be the principal consideration in the choice of a covering—namely,—efficiency. Of late years there have been devised various methods for testing the efficiency or non-conducting properties of commercial coverings. It has been my pleasure during the last ten years to test and report on coverings of every description, and I have found no more reliable method than that of using electrical energy as the source of heat. This method presents many disadvantages over the use of dry steam at constant pressure, weighing the water condensed over a definite period. It is exceedingly difficult to procure perfectly dry steam, and the determinations being somewhat expensive are not checked to the same extent as they can be, by the use of a less costly and quicker method. I personally adopt the method suggested by Mr. Darling in his book on "Heat for Engineers," and described by me in a report dated a few years previously. The apparatus consists of a piece of steam pipe 12 in. long and 6 in. diameter, the external surface being completely lagged by the covering


No. 3
THERMOMETER
VOLTMETER
MAINS
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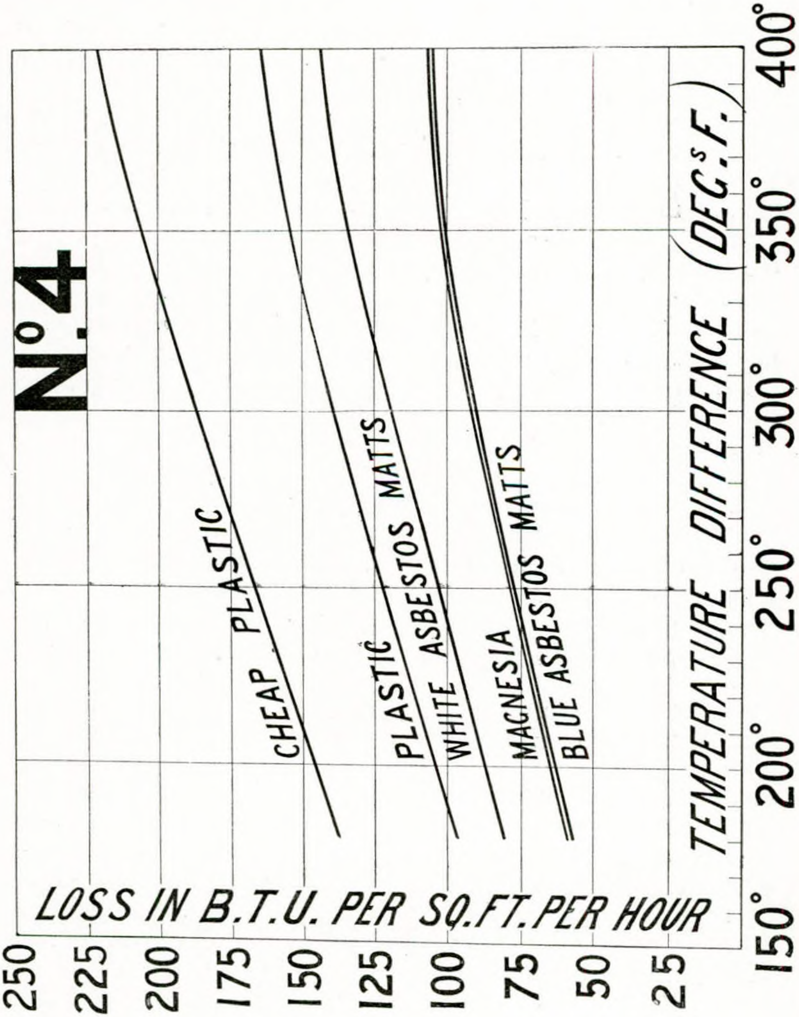
AMMETER

under test. Mr. Darling suggests an electric lamp with carbon filament for the heater. I prefer to use a long length of wire evenly distributed over the whole internal space. A current of electricity is passed, and can be varied at will by means of the variable resistance shown on the diagram No. 3. The energy necessary to maintain a definite temperature difference between the interior of the lagged vessel and the atmosphere, and therefore the energy lost, is calculated from a knowledge of the current passing in amperes and the potential difference across the terminals of the heater in volts. The drop in voltage multiplied by the current in amperes, multiplied by the factor 3·42, will give the loss in B.Th.U.'s per hour. This, divided by the surface area of the vessel in square feet, will give the loss in B.Th.U.'s per hour per square foot covered, for the particular covering under test. It is a simple matter to vary the external resistance until any temperature difference desired is obtained. This method enables us to rapidly compare the non-conducting properties of any coverings at any temperature difference. On diagram No. 4 I have had plotted some curves, showing the variation in the heat escaping per square foot of lagged surface per hour, with varying temperature differences. The results were obtained from coverings all 2 in. thick. You will notice the marked improvement in the more efficient coverings with higher temperature differences. I do not propose to cite every covering at present supplied or applied for the prevention of loss from conveyors of heat energy, as such, if possible, would be rather outside the scope of this paper. I have therefore confined my results to a few typical samples. You will notice that the figures obtained for magnesia sectional covering and for blue asbestos mattresses are practically identical, and one wonders why good long fibre white asbestos mattresses are not such good insulators of heat when applied. I think an examination of the fibre will make this fairly clear. On the table is a sample of good long fibre blue asbestos and a sample of pure long fibre white asbestos. You will notice that the blue fibres are considerably more resilient than the white, and that after compression, there is a far greater tendency for the blue fibres to spring apart. If it were possible to give to the white fibre an equal power of resiliency, I do not think any appreciable difference in the non-conducting properties of the two materials would be found.

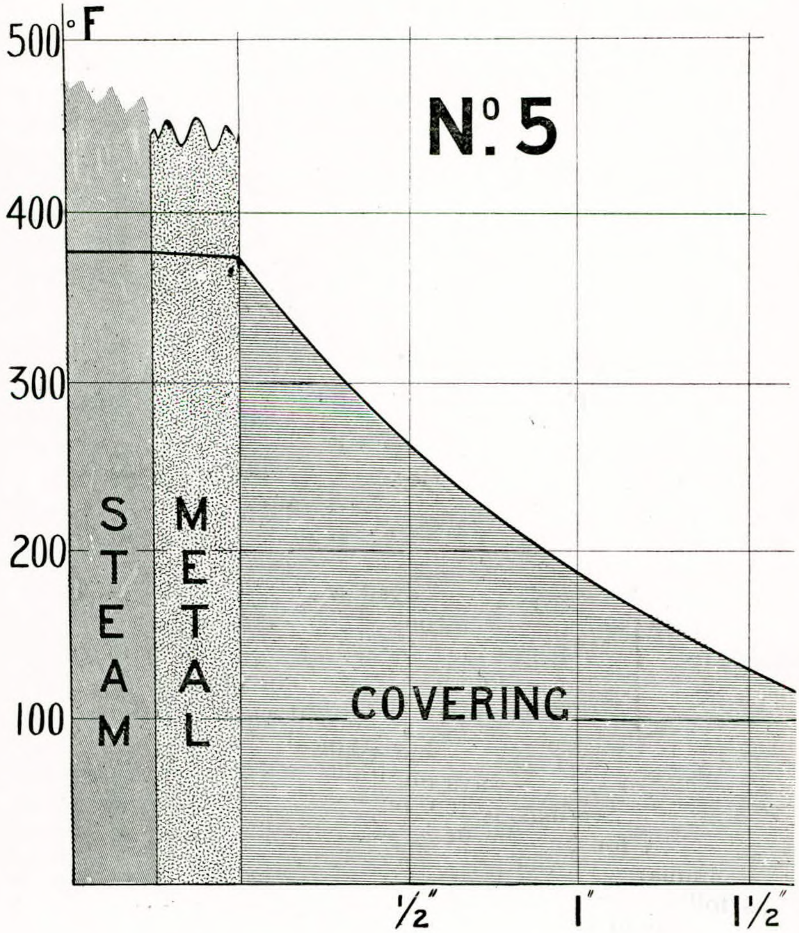
As I understand magnesia composition is a mixture of carbonate of magnesia and white asbestos, if carefully examined



with the aid of a microscope, it will be seen in the best samples to consist of small threads of white asbestos entirely enveloped with fine crystals of magnesium carbonate. These crystals prevent the close contact of the asbestos, and therefore the path of least resistance is lengthened.

Laggings in practical use are made up and applied in many different forms. Broadly they may be divided into four different classes. In the sectional form they are shaped before applying and bound into place, generally by strips of metal. You are probably all familiar with the well-known type, samples of which are on the table. Another class is the mattress form which consists of a cover, preferably woven from pure asbestos, containing the material which is to function as the heat insulator. Unfortunately this very convenient form of covering allows of a considerable amount of unfair competition. The cover should consist of a strong pliable woven asbestos. One often meets with covers containing as much as 25 per cent. of combustible material. A common practice is to use a vegetable fibre in order to assist in spinning short fibre asbestos. This is undoubtedly a bad practice, and should be condemned, for sooner or later the cover will go to pieces, owing to the decomposition of the organic matter present. Pure long fibre asbestos, sufficiently strong to allow rough handling and of being walked upon, appears to me to be absolutely necessary. The material used for filling the mattress, if of asbestos, should also be of long fibre, in order to obtain the highest efficiency. On the table are varying grades of fibre, and it can be readily seen that a material more in the form of powder cannot hope to compete with the fibres of greater length. Rope covering, really an offspring of the mattress type, appears to be exceedingly convenient for pipe covering. It is very important in this form to have the plaiting as loose as possible. On the table are samples tightly plaited and also samples of material as it should be applied for the best results. It is again a question of the path of least resistance. The more the material is consolidated the greater the cross sectional area of the pathway for heat. Bends are exceedingly simple to cover with rope covering, and for pipes of small diameter there is probably no more efficient mode.

The plastic form of covering is doubtless the cheapest variety, and can be, and often is, very bad. On the other hand, there are plastics which are very good. As a class, plastics are not such efficient heat insulators as sectional coverings and mattresses, although many of the good plastics are better non-conducting coverings than poor sectionals and mattresses. For permanent work a plastic is often economical owing to its cheap first cost, but, as its removal entails the destruction of the covering, the economical consideration is governed by the permanency of the job. It is necessary, for the



correct application of the plastic form of covering, to have the metal surface to be lagged perfectly clean, and at a moderate temperature. I need hardly remind you that there is a lot of rubbish at present sold as such and such a plastic, and which, to apply, is absolutely false economy. Coverings composed of clay mixed with straw, hay, dung and other objectionable substances, are not worthy the cost of fixing.

The temperature of the outside of a covering is not an indication of the efficiency of the covering. Diagram No. 5 illustrates the fall in temperature through a covering, when the temperature of the pipe surface is at about 400° F. You will notice that the temperature falls to about 100° F. with the particular covering tested. If the temperature of the pipe surface were some other figure, the gradient of the curve would alter, but the surface temperature of the covering would be little altered. The only correct method for ascertaining the outside surface temperature of a covering, is to take the temperature at various known depths, and plot a curve. The general shape of the curve will probably be the same for all coverings of equal efficiency, although the end of the curve for temperature near the outside of the covering will vary according to whether the surface is rough or smooth. A thermometer applied to the outside gives quite an erroneous result as a guide to the efficiency of the covering. The rougher the outside surface, the quicker will the heat disperse. It is therefore advantageous to have all surfaces finished smoothly, although they may then feel hotter to the hand. Mr. Darling states that a coating of metallic paint, such as aluminium, reduces the heat escaping from an ordinary surface of lagging by as much as 7 per cent. I have heard it stated that a certain engineer judged of the efficiency of his boiler lagging by the degree of comfort or discomfort he sustained by sitting on the covering. This, of course, is not exactly a scientific method, and gives no indication of the efficiency. On diagram No. 6, I have had plotted curves illustrating the variation in weight of some typical coverings for different thicknesses. It is always desirable to have a light covering, as heavy coverings often put strains on pipes, altogether unallowed for by the designer of the plant.

Summarized, the properties of a desirable covering may be as follows :—

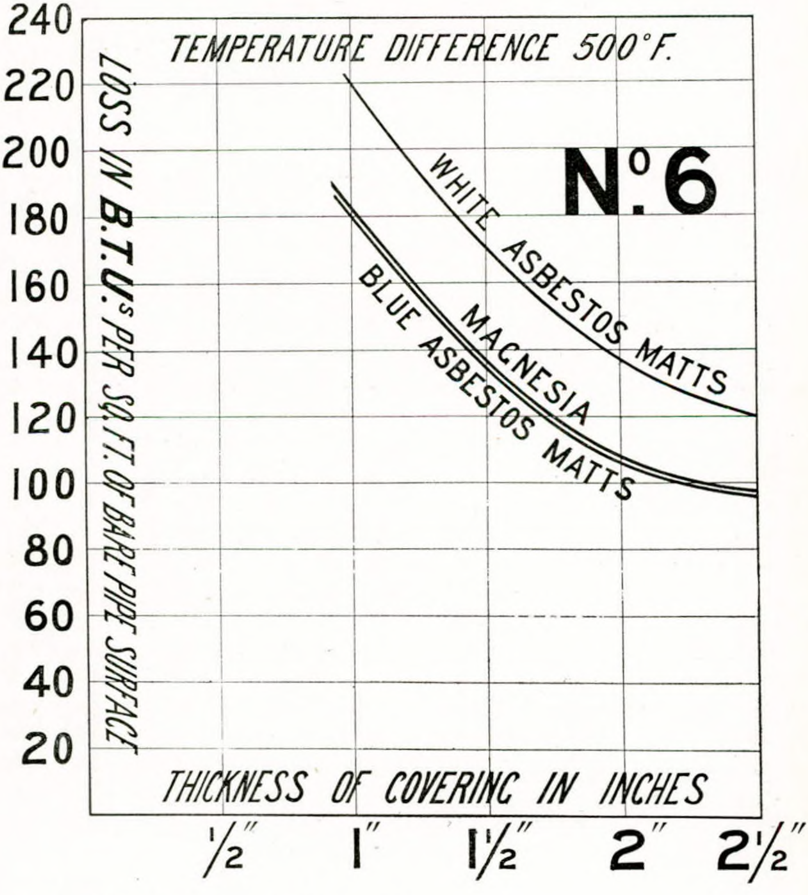
It should offer a high resistance to the passage of heat.

It should be capable of being easily removed.

Its efficiency should not be impaired by variations of temperature, the action of steam or water, vibration, rough handling, or physical and chemical changes over a term of years.

Its specific weight should not be so high as to place an undue strain on the steam pipes.

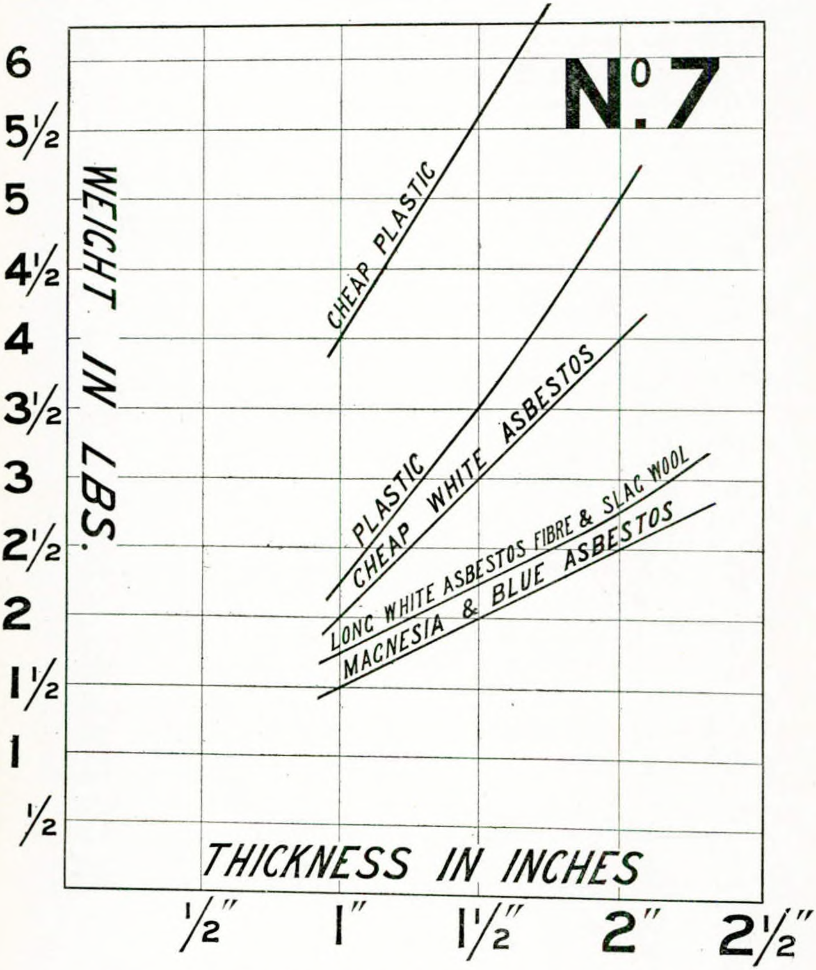
It should have no action on the metal surface lagged, even with the presence of steam and water.



It should be non-inflammable.

Its specific heat should be as low as possible, so that the covering may arrive at its full efficiency as soon as possible after starting cold, and absorb the minimum amount of heat.

A lagging possessing all these qualifications to a maximum degree, if such were possible, would, of course, be desirable. I will not venture to suggest that any covering is perfect, and think I should serve no useful purpose in dwelling further on the subject. If I have in any way kindled a spark in a new channel of thought, however improbable it may be deemed,



I shall have succeeded in my endeavour to call the attention of engineers to the fact that there really are B.T.U.'s to be saved, and economically saved, by the adoption of more efficient coverings, for boilers and steam pipes. Once this is realized, I feel certain that some of the ridiculous specifications of to-day will soon be a thing of the past.

CHAIRMAN: We have all ideas of our own on boiler coverings, and as there are some experienced men amongst us I think we ought to have a good discussion on the subject. I am sorry we have not been able to have copies of the lecture printed, but there is plenty to be said on the subject, and I have now much pleasure in throwing the meeting open for the discussion.

Mr. F. M. TIMPSON: Regarding the blue asbestos referred to in the lecture. Do I understand Mr. Strohmenger to say that it is a more porous material than the white?

Mr. STROHMENGER: It is more resilient. It does not necessarily follow that it is more porous.

Mr. TIMPSON: You spoke of it giving more resistance due to the path of resistance being longer; in that case there would seem to be more cells than in the white asbestos.

Mr. STROHMENGER: That may possibly be the case.

Mr. TIMPSON: Therefore, generally speaking, it would be a more porous material?

Mr. STROHMENGER: Yes, although it does not follow. I may say that the specific weight of the material in the blue might be lower, and thus there might be a bigger bulk for the same weight, so that you would possibly decrease the air cells.

Mr. TIMPSON: But you spoke of there being a longer path of resistance owing to using blue asbestos, so therefore I took it you meant it was a more porous material.

Mr. STROHMENGER: Yes, that is true.

Mr. TIMPSON: I suppose blue asbestos is, generally speaking, particularly adapted for that class of work, boiler covering?

Mr. STROHMENGER: Yes; of course slag wool has a good efficiency when new, owing to its resilient nature.

Mr. TIMPSON: For plastic lagging, would you favour rope lagging?

Mr. STROHMENGER: It appears to be more convenient.

Mr. Timpson: It is the general practice, and it is very convenient because one can unwind the rope and put the lagging back again, whereas with the plastic material it is broken up. With magnesia, in my own experience, one could hardly feel the heat through the covering; with some laggings radiation of heat was more apparent. All through the United States and Canada they have much greater experience with lagging than in this country. There is hardly a house in North America in which it is not used to keep the frost out of water heating pipes. It is very surprising, however, when you speak of the suitability of blue asbestos, that its use there is very small. Perhaps it is owing to the white being cheaper.

Mr. Strohmenger: Of course a mattress filled with blue asbestos will always weigh lighter than one filled with white.

Mr. Jas. Adamson: We are very much indebted to Mr. Strohmenger for his paper, and I should like to disabuse his mind entirely of the idea that his view of testing the non-conductivity of material will not commend itself to us. To my mind it seems to be very much better than the old style of measuring the condensation of water, and it is similar, I think, to the apparatus which was recommended by Mr. Bost in connexion with the Congress of the Refrigerating Industries at Paris, with a view to obtaining an improved efficient means of testing the conductivity of materials, and I think he is working very much in the direction indicated, and it commends itself to me as being much better than the older method. Of course Mr. Bost's experiments have been in the direction of keeping in the cold rather than heat, still, what is a good non-conductor in the one case ought to be an equally good non-conductor in the other. Reference has been made to a material which will not in any way eat into the metal of steel or copper pipes. In the past we have had experiences where it was said the non-conducting material on the pipe mixed with sea-water acted upon the pipes very detrimentally. There was one case not very long ago where disastrous consequences were said to have resulted almost entirely through that cause. One of the greatest troubles in marine work is to get a good non-conducting material applied to deck steam pipes. The pipes are washed all over with the hose religiously every morning, and if we could get a non-conducting covering which would resist such treatment from the water hose and seas it would be a great advantage to us. Trials have been made with cork covering. I do not know the factor for cork in terms to compare it with the blue and white asbestos, magnesia and plastic coverings, as given in the lecture, but we were driven to cork for deck steam pipes and for other purposes, chiefly in connexion with the insulation of the brine system for refrigeration, owing to the trouble of getting a good plastic material to stand the rough usage. Diatomite is another substance which has been used, perhaps Mr. Strohmenger can give us the factor of diatomite as compared with the other substances, for I know of several sets of boilers where it was put on, and it was on good for over twenty years. In two cases the diatomite was stripped off one entire plate where it was exposed to the action of the weather and the water coming down through the grating, to test whether it had any detrimental effect upon the steel, the steel was found quite sound and good underneath, only a thin rust scale.

CHAIRMAN: Was this plate covered with diatomite?

Mr. ADAMSON: It was a plastic covering of diatomite. I could not say what it was mixed with to give it cohesion.

Mr. STROHMENGER: Possibly it was fossil meal. There would have to be some binding material, and directly you use a binding material you lower the efficiency due to the increased cross-sectional area for the path of heat. It will always be found that directly a binding material is used you get a more solid condition, and the binding material itself then functions as the conductor of the heat, although you may decrease this low co-efficient by the presence of the diatomous earth which is very porous. The material which is acting as the true conductor of heat is your binding material. It is so in plastics which are mixed up with all sorts of things, most of the heat being conducted by the binding material. Cork is generally used for cooling and refrigerating plants, I think the reason being that it is very little acted upon at low temperatures, but at high temperatures cork shrinks tremendously and also is more or less oxidized in time and so becomes a fairly good conductor. The co-efficient of cork when new lies between that of slag wool and asbestos; therefore it is good to start with, but it will drop after after a term of years. With regard to the composition eating into the surface of the pipe, I think it will be found that pipe surfaces are always more or less attacked unless they are coated before the lagging is applied. It seems to be the best practice to give the pipe surfaces a coating of black lead so that there is a layer of carbon on the pipe, and if this is done the pipe will be found to stand very much better. I think this would prevent the corrosion you sometimes find as it is really due to the action of the chlorine in the sea-water.

Mr. T. HORSNELL: What happens, when a boiler is covered with mats, if one of the seams of the boiler is leaking? Does the mat absorb all the water, and would the engineer have any difficulty in finding where the leak occurred?

Mr. STROHMENGER: It would act like blotting paper. The water would run to the outside as soon as anywhere else and you would see the leak very quickly. Being so absorbent there would be no difficulty in tracing the leak.

Mr. W. WALKER: I should like to ask a question respecting diagram No. 4. It gives the temperature difference on the base line and the pounds in B.T.U. per hour on the vertical. What is the temperature difference taken from; is it the difference between the temperature of the atmosphere and the temperature of the steam? Mr. STROHMENGER: Yes.

Mr. WALKER: Then I take it you must have a certain average temperature to plot your curves from.

Mr. STROHMENGER: No, it is always the difference between the inside temperature and the outside temperature.

Mr. WALKER: But in this diagram what was the temperature difference to give you these results? what was the temperature difference that they were taken from? Say you have 350° F. temperature of steam, what was the temperature of the atmosphere to give 100 lb. in B.T.U.?

Mr. STROHMENGER: A fairly normal temperature of the atmosphere; you would find very little difference whatever in the temperature. The temperature difference is the correct thing to work upon. If you plotted the temperature of steam you would find that the results would vary; but in working upon temperature differences you are working upon an actual figure which will not vary the results.

Mr. Walker: The reason I am asking is because in some tests the result is plotted out per degree of difference, and in that case it shows up clearly, I think, a little more clearly than in your diagram, because when you get the curves per degree of difference it is quite clear, no matter what may be the difference between the atmosphere and the steam; we know that in that covering there is that certain loss.

Mr. Strohmenger: You will find the shape of the curve is identical in each case, no matter what the outside temperature may be. You could easily make it yourself.

Mr. Walker: There are several points in your lecture upon which, it seems to me, although you seem to be giving an opinion yet you also seem to ask an opinion yourself. For example, you say the carbonate of magnesia is in all probability mixed with some other compound. As far as my experience goes we have not less than 70 per cent. carbonate of magnesia, and the rest is long fibre asbestos used as binding material. I think the same remark applies to diatomite. That substance is still in use with at least one well-known firm. I am surprised that Mr. Strohmenger did not show us the different coverings, but perhaps it would be too much to expect to see samples of them all. Diatomite, however, has this advantage, it is a British substance, being produced in the Isle of Skye. Then there is Keiselgür, which comes from Germany, which is of the same nature, viz. fossil meal. In one test made by our Company at the Isle of Thanet the figures for plastic covering appear very much the same as those shown on figure 4 for blue asbestos. In that case, working at our difference per degree of temperature, we found that the heat lost per hour per sq. ft. of radiating surface when the plate was bare was 2·88 B.T.U., whereas when the plate was covered the loss was only ·348 B.T.U. Working that out with the actual difference of temperature, to bring it to compare with diagram 4, it was the difference between 366° F. steam and 69° F. atmosphere; that brings it out at about 4 B.T.U.'s per sq. ft. We see, therefore, that it works out at about the same with fossil meal as for magnesia. With regard to the question of plastic materials versus mattress, there is always this point to be considered: is the boiler or steam pipe to be covered exposed to the weather or not? If it is exposed we must make the covering rainproof and are consequently debarred from using the ordinary mattress. The mattress, if exposed, would quickly absorb the rain and moisture and would cause deterioration of the plates. Consequently where it is necessary to withstand exposure a hard substance should be used. Cork has been used in a great many instances, but, as Mr. Strohmenger pointed out, when used with steam it quickly carbonizes, and therefore has to be replaced in a very short space of time, There is one material that has been before the engineering world for some time which has for its object the prevention of wasting of steel pipes. Some firms recently have stipulated that before the pipes leave the makers' works they should be put in a bath of Dr. Augus Smith's solution. This soaks into the metal and gives a coating to prevent waste due to rusting or corrosion. I would ask the lecturer if he could give us any idea as to whether it is now possible to spin blue asbestos satisfactorily. That is one of the troubles in connection with this material. It has been recognized for some time that it is a good non-conductor, but there has always been a difficulty in getting it to spin into yarn for mattress making. I believe it is the percentage of iron it contains that prevents it from making a good yarn, but whether it is due to this or some other substance perhaps the lecturer can inform us.

Mr. Strohmenger : Oh, no ; it is perfectly pure. I imagine that the reason there was difficulty in spinning, was because of an endeavour to spin it with a plant that had been used for spinning a softer material. When special plant is used there is no difficulty in spinning it, as you can see by the specimens of cloth.

Mr. T. Horsnell : With regard to this test with the mats and the magnesia. I take it that these magnesia crystals disperse and get smaller as years go by, thus the lagging has a tendency to leave the pipes. Have you ever had a test with the non-conducting material in position, similar to Keenan's test, which has shown after four years the covering adhering to the boilers and the mats leaving the casing ?

Mr. Strohmenger : Oh, yes ; any material which is not absolutely tight will depreciate.

Mr. Horsnell : There is a certain amount of draught flowing through the casing, causing loss of temperature.

Mr. Strohmenger: Undoubtedly, if convection currents are set up the efficiency of the covering will be decreased. There is that disadvantage with fibrous materials that its value is depreciated by vibration. In that respect the plastic covering has the advantage, provided it has no other disadvantage to counterbalance it.

Mr. Horsnell: It has one good point, at any rate?

Mr. Strohmenger: Undoubtedly, it has many good points

Chairman: I do not quite agree with Mr. Strohmenger with regard to the corrosion and the action going on with all insulating materials for boilers, because I have seen, just recently, material taken off a main pipe, and that pipe appeared to be as good as when it came out of the coppersmith's shop fifteen years ago. I have seen boilers opened up and not showing a vestige of deterioration, the metal being quite bright. I have also had some experience with fossil meal and found the effects most disastrous, especially when it works loose owing to the movement of the ship. It wears holes in the bulkheads, for instance, where the bulkheads are covered with it. I do not agree with the lecturer, however, with regard to corrosion being caused by all materials.

A Member: Were the conditions the same?

Chairman: Yes, exactly the same; they were sister ships of the same build and the covering was in the same position in each case.

Mr. Timpson: Might I ask if it is not the case that all asbestos has a tendency to cause corrosion if it gets wet. I know it has a corrosive effect upon glass—water gauge glasses, for instance—for the glass rapidly corrodes away, I suppose, in a similar manner to iron or steel. In fact, many engineers are greatly opposed to the use of asbestos at all, especially to the use of asbestos for iron or steel surfaces where there is any moisture about. It is stated authoritatively that a number of engineers of high standing have a great objection to it, as it seems to set up a chemical action.

Mr. Strohmenger: From the chemical point of view I see absolutely no reason why this should be the case, unless it is due to the presence of some adulterant which may have been used in the process of manufacture, but I do not see how any such action could come from the silicate of magnesia in white asbestos or the silicate of iron in blue asbestos.

Mr. TIMPSON : It may be due to it not being a water-proof material and the water acting upon it, but I think, with regard to gauge glasses, any one can see the effect.

Mr. STROHMENGER : That is due, possibly, to a small percentage of alkali in it.

Mr. W. LAWRIE : I have had very little to do with boiler covering for many years, and in my time we did not get the asbestos up to the perfection they have it at now for boiler covering. I quite agree with the lecturer's opening remarks as to the haphazard way in which the boilers in a great many ships are covered. No doubt, in some of the better lines they do not mind spending money and doing the work in a proper manner, but in the majority of steamers the condition with regard to boiler coverings is not what it ought to be. A good many come through my hands nowadays in which the boiler covering is in very bad condition indeed, and it is amusing to hear some of the engineers tell one that all this has happened within the space of about 12 to 14 hours while the ship was ashore. When I had something more to do with steam-pipe covering than I have now, cork was introduced, and I had some experience with it. We covered a steam pipe, and it was to last a considerable number of years. We stripped the cork off in about twelve months' time, but found it to be so badly carbonized that we could not put the same cork back again. We have many different varieties of boiler covering, and I think the lecturer is to be congratulated in putting the subject before us in such a very clear manner. Personally, I am not in a position to contradict anything he has said, and I feel very pleased to have been here to get the information I have received. I am sure we are all pleased to have had such an instructive lecture ; the lecturer knows his subject very well and has given us a considerable amount of valuable information.

CHAIRMAN : As Mr. Lawrie had just remarked about the various kinds of coverings, could the lecturer say how they stand in regard to cost ?

Mr. STROHMENGER : I am not in a position to say.

Mr. Lawrie: One thing I might mention. Where there is a long fibre there is no difficulty in the spinning. The longer the fibre the better it is for spinning; that used to be the experience when I was in the cotton business.

Mr. Walker: The question of cost is the whole secret of boiler covering. If people are prepared to give the money they can get a good covering, but against that, under all surveys the boilers must be bared at certain periods, therefore it is not always wise to put the best covering on if it is expensive. Of course it does not follow that the best covering can be put back after it is once taken off. Consequently, the first outlay would be a loss if the boiler were to be bared frequently. The cost of blue asbestos is considerably more than any on the market; for one reason, the supply is limited. It comes from the Cape, and there was only one mine from which it was obtained up till last year. According to Mr. Strohmenger it is certainly the best covering, but the cost is high.

Mr. Bales: Might I ask the last speaker whether it is not possible to return the covering. Say, for instance, it is necessary to uncover a pipe for inspection periodically, is it not possible to return that covering to the suppliers and get a credit note for it? is there no value in the covering that has been taken off? It would appear that, if coverings have a life such as the Chairman mentioned, lasting for a period of fifteen years, and it is necessary for certain reasons to take it off after four years, there seems to be some value in the material.

Chairman: I see no reason why it should not be put back.

Mr. Strohmenger: If you use a plastic material there is considerable loss. But supposing a boiler is standing in the open it is necessary to have it covered. One will read in specifications that it is necessary to cover it with iron.

Mr. Horsnell: If the boilers are to be covered with a non-conducting composition, why should we have to put iron on to collect the heat again, especially in a boiler house? If you can get a good solid plastic material that should be enough.

Mr. Strohmenger: Exactly, you must ask your consulting engineers why they specify.

Mr. HORSNELL: I understand that it is generally in the open that sheet iron is required?

Mr. STROHMENGER: Yes, using a material other than plastic.

Mr. HORSNELL: Which would last fifteen years?

Mr. STROHMENGER: Provided it is not taken off for inspection.

Mr. WALKER: It all depends on the circumstances. If it is in the open the rule is five years, but if under cover it will last fifteen years. It depends on the situation entirely. But the question of putting the iron cover on is simply a case of wear and tear. The hardest plastic, if there is a considerable amount of traffic, must have some covering to protect it from being torn to pieces. That is the sole reason why iron is put on over the plastic covering.

Mr. LAWRIE: It seems to me that a man who keeps his boiler out in the open must be prepared to pay considerably for his covering. If he will not pay to put a structure over it, or if it is impossible to do so, I think it stands to reason that there can be no comparison between the case of that boiler and one on a steamship. I think, as far as the steamship is concerned, it is very seldom the boiler has to be stripped. The steam pipes have to be stripped every four years or so for inspection by the Board of Trade, but if the boiler shell is good and there is no indication of a leak, there need not be an inspection for a period of fifteen years, and if it lasts that long it has paid for itself.

Mr. BALES: The point I had in my mind is this. There are various coverings, some rather costly and some rather cheap. We are told that the objection to getting a good covering is its price. If the material can be sent back and a credit note obtained for it a good deal of that objection disappears, because if people know they are getting a certain life out of it and something back on the returned material, they are then prepared to pay more on the original outlay than if they got no return.

Mr. STROHMENGER: I should think you would find there are many who would be prepared to do so.

Mr. WALKER : In most ships they put it on again if it is a good plastic covering.

Mr. STROHMENGER : It is done in a great many instances, but if a test is made of the new material it will be found that the efficiency is materially lowered.

Mr. HORSNELL : In fifteen years, of course, the life would be gone, but in three to four years the deterioration would be very little. With reference again to these asbestos mats. When you apply them to the boilers, where the joints occur, is there not draught coming through those joints ? Unless they are covered over with asbestos cloth afterwards you are bound to get air spaces in between the joints of the mats. You may place them where you like, but there must be these air spaces, and therefore there is unequal expansion on the boilers.

Mr. STROHMENGER : I have often tried to find out if there is a greater leak at those points by taking the temperature along the joint, but I cannot find that there is any increased radiation or convection at that point if the mats are properly placed on. It will generally be found that the temperature is the same there as at any other part.

Mr. HORSNELL : Will it have a tendency to make the joints leak ?

Mr. STROHMENGER : No, if you have the same temperature at that point, you cannot get extra expansion or contraction there.

Mr. HORSNELL : But the joint will run in a parallel direction.

Mr. STROHMENGER : They will have to be mitred ; all that I have seen applied have been mitred.

Mr. HORSNELL : I have one here which is not mitred.

Mr. STROHMENGER : All that I have seen made for actual use have been mitred. That one has just been made for the purpose of this lecture.

Mr. TIMPSON : I think it is more usual in marine practice to put plastic material over the top, and then apply mats on the bottom so that they can be easily removed ; in fact, in some instances the bottom is entirely uncovered.

Mr. STROHMENGER : That is a wrong practice because there you would get unequal expansion.

Mr. TIMPSON : Up to a few years ago most boilers were left quite bare on the bottom, and I believe they are still in use in that condition.

Mr. WALKER : I take it there is no possible way of calculating the loss unless it is by actual measurement If the temperature is 500° F. in the steam pipe and 70° F. in the atmosphere and, say, a new covering is put on, is there any possible means, except by actual measurement of the water condensed, of saying what the loss per sq. ft. would be ? Say the temperature was 500° F. in the pipe and 120° F. in the outside of the covering.

Mr. STROHMENGER : I think it might be possible to have an approximate test by means of a curve. If you take the temperature at various depths and get the gradient you might approximate the efficiency of the covering.

Mr. WALKER : But it would not be a reliable test ?

Mr. STROHMENGER : No.

Mr. WALKER : There is no actual test except by the measurement of the water ? Mr. STROHMENGER : I have never heard of any.

Mr. WALKER : What I wish to arrive at is that you must thicken up the covering.

Mr. STROHMENGER : Yes, certainly. If you take a curve at varying depths, and you see the curve has a good way to fall, undoubtedly the conclusion would be that you would require to thicken the covering.

Mr. TIMPSON : I think the question Mr. Adamson raised regarding deck steam pipes is a very important one, and we should be interested if Mr. Strohmenger could give us some idea of a covering which would stand washing with the hose and sea.

Mr STROHMENGER : I really think the problem is a mechanical one and one which can hardly be dealt with from a heat engineer's point of view. The engineers must design a way out of the difficulty and suggest it to the coverers.

Mr. A. E. ROWE: I might give an experience I had with white rope covering three-quarters of an inch thick. It was on a winch steam pipe, four and a half inch pipe. We had to take the winch pipe out to use for a feed pipe in the engine room, and in annealing the pipe, on putting it in the forge to get a heat on it, I found it to be absolutely useless. That was a copper pipe after 4½ years' use.

Mr. STROHMENGER: I think any covering would have the same effect if the water was there. You have the sea-water in contact, and that would attack the pipe; it might possibly be due to electrical or chemical action, especially as it was a copper pipe.

Mr. ROWE: I have no doubt that was the cause, but if the covering had not been on there would have been nothing to hold the water.

Mr. STROHMENGER: I think the remedy in that case would have been to coat the pipe before putting it in.

Mr. ROWE: There was a certain composition put on it.

Mr. STROHMENGER: Perhaps the composition was bad.

Mr. Timpson: The lecturer speaks of coating pipes with composition; I think those metallic paints containing aluminium stand corrosion very well. I would like to ask the last speaker whether there was any visible sign of wear on the pipe.

Mr. ROWE: Of course, the covering being on the pipe, we did not expect to find any signs of corrosion, and it was only after it was on the forge on deck that we found the trouble It was due to oxidation, the metal was wasted away. It occurred to me that it might possibly be an advantage to have the rope bound tighter round the pipe and another thickness of it.

Mr. STROHMENGER: I could hardly think it would make any difference.

Mr. TIMPSON: I should think, in a case like that, it would be better to preserve it with coated canvas. It would keep it waterproof.

Mr. Rowe : We tried covering it with canvas, but in a cargo boat canvas will hardly stand the rough usage.

Mr. Strohmenger : It seems to me that it would require to be covered with iron. If canvas would not stand it the plastic covering certainly would not. If it is properly treated canvas will stand for twenty years.

Chairman : Not on the deck of a ship.

Mr. Adamson : I have tried the cork covering on one or two deck steam pipes after trying, with very poor results, almost every composition, and I can say that the cork stood on two pipes in an exposed position for about two years. The vessel was then sold to other owners, and I do not know whether it is still on or not. I know of one or two new steamers where, within twelve months, every vestige of composition put on the deck steam-pipes was gone. Of course it was only canvas and felt underneath, but the canvas was utterly perished. I know many boilers over twenty years old on which the original covering still remains untouched except where removed in places for examination of plating.

Mr. Rowe : Could the lecturer give us an idea of the loss which takes place if we had a good covering and the air space between the covering and the pipe was, say, $\frac{1}{4}$ in., taking pipes of $2\frac{1}{2}$ in. to 3 in.

Mr. Strohmenger : The loss would be enormously increased because of the convection currents which would be set up. It would possibly amount to 50 per cent. lower efficiency if the air space was anything over microscopical dimensions.

Mr. Adamson : I think it would be very interesting if we could get the views of some of the members present on the subject of deterioration. My experience of deterioration in steam pipes due to the covering has been almost nil ; I have seen very little of it. One long length of pipe was uncovered last year, which had not been uncovered to my knowledge for fourteen years, and there was no deterioration whatever underneath the covering. It was a main steam pipe.

Mr. Walker : I might also say that in an experience of fifteen to twenty years I have seen nothing more than surface wasting. We know that at a recent Board of Trade inquiry it was said that the trouble was due to wasting from some covering put on the pipe, but that was no doubt due to some composition put into the covering. There will not be any bad effect at all, neither with mats nor plastic, if it is a pure material and does not contain chemicals. Of course one firm recently went into the covering market with a covering made out of chemical refuse, and I would not like to say whether or not there would be any deterioration with that, but pure asbestos or fossil meal has no effect whatever on pipes or boilers in any shape or form. In fact, I know of a boiler which was bared during the last fortnight after being covered for seventeen years and there was absolutely no sign of wasting. A question has been asked whether a covering will show any leakages which may occur in the boiler. With both classes leakage as a rule works to the outside. The advantage of having mats is that you can unloose them if necessary ; with the plastic you have to cut it away and replace it in the best way you can. It is a question of appearance after all.

Mr. A. Robertson : I should like to propose a very hearty vote of thanks to Mr. Strohmenger for having placed this subject before us in such a lucid manner. I am sure we all feel very much indebted to him. The subject of the lecture is "Boiler Covering" and I should certainly have liked to have had some figures, if possible, showing the efficiency of a boiler lagged and unlagged. There seems to be a great difference in this respect, and it would be exceedingly interesting if we could get some figures to show us the added efficiency where there is a system of lagging right throughout as compared with a plant without lagging. The point referred to by Mr. Walker as to lagging not causing deterioration when it is pure is a very important point and goes to show that one need have no fear of any deterioration as long as he uses proper materials and materials absolutely pure. There is no doubt that if there is foreign matter in any material in contact with metal, either copper or steel, it is bound, in course of time, to affect the metal and cause corrosion. I have much pleasure in proposing that we accord to Mr. Strohmenger a very hearty vote of thanks.

The motion was seconded by Mr. K. C. Bales and carried with acclamation.

Mr. Walker : In reply to Mr. Robertson the actual difference per sq. ft. of heating surface is as follows: 2·88 B.T.U. uncovered, and ·348 B.T.U. covered. Taking the radiation of heat per sq. ft. of uncovered surface at 100 per cent. the radiation of heat per sq. ft. of covered surface showed 12·1 per cent., or, in other words, there is 87·9 per cent. less condensation per sq. ft. of covered surface than with a similar amount of bare surface.

The meeting closed with a vote of thanks to the Chairman.