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Lecture on "Electric Distance Thermometers,"

By Mr. G. A. H. BINZ,

February 20, 1911.

Chairman: Mr. A. COOKE (Member).

Mr. Binz: A little more than two years ago I had the honour of delivering before this Institute a short lecture on "Scientific Boiler Control," dealing principally with one phase of this large subject, that coming under the head of Flue Gas Analysis. I had the pleasure of emphasizing the importance to the engineer in charge of power plant, of taking advantage of the appliances science has placed at his disposal, in order to raise the standard of efficiency and economy in the operation of his plant, be it on land or at sea, to the highest attainable pitch, and what is far more difficult and more rare —keep it there.

The work of drawing attention to these scientific helpmeets of the engineer, of developing and adapting them, though at times a very uphill task, to me has been full of very interesting and instructive experiences, and I am to-day more than ever convinced, that provided the instruments which are to help the practical man are designed by engineers in intimate touch with the needs of these very men, are simple to use and their reliability easy to demonstrate, there is an ever-widening field for scientific appliances in every phase of industrial life, and there can be no doubt that their use by operating engineers and men in charge of plant of every description will increase by leaps and bounds. Thus if I again venture to crave your attention for a brief space, in order to give you a few particulars of another scientific device which can be of help to engineers, my excuse must be that the time is probably not far distant when apparatus of the kind I am going to describe will be in very general use, so that the time you will spend to-night in becoming more familiar with the use of this apparatus will not be entirely wasted.

Although the subject as such must of necessity appear trivial and unimportant to many of you who, as Marine Engineers, are accustomed to the discussion of more momentous questions, I hope that what I have to say will not prove devoid of interest and may perhaps be of some value to one or other of those present, at some future date.

As will be gathered from the title of the lecturette, it is on the measurement of temperature by electrical means that I propose to speak, and perhaps the first thing I ought to say is that as I am not a marine engineer, I shall have to be content with a general survey of the subject, merely indicating those phases which should be of particular interest to you.

We are all familiar with thermometers, and no doubt are all agreed that the observation of temperatures forms an important part of the daily routine of the engineer, both on land and at sea, and I think, therefore, if I can show a means of making temperature measurements more convenient, and perhaps more scientific, that is, more efficient than at present, an apparatus of that kind should prove of some interest. Taking, first of all, the refrigerators and cold stores, all of you are aware that they are at times very difficult to get at to take temperature measurements and at the same time it is very important that they should be taken regularly. It is a question of economy. For every degree you force the temperature down you have to spend so much in hard cash, so it is necessary that a careful watch should be kept on the thermometer. On the other hand the shipper whose goods are in the store must be satisfied, and the temperature must be kept sufficiently low. Closely related is the subject of ventilation, particularly in large ships. Thermometers are placed at many points, and there is no doubt useful information is obtained by regular observation of the thermometers and regular logging. Where it is not done it is probably due to the fact that with the ordinary thermometer it takes so much time. Ventilation is of greater importance in the Government service in connexion with the ammunition stores, where the temperature must be watched carefully in order to guard the safety of the vessel and the crew. Judging by the increase in the demand recently for flue gas thermometers, there is increased activity in the direction of studying the conditions under which fuel is burnt. Those experiments can have but one result, and that is to prove that the regular observation of the flue gas temperatures is necessary if the best results are to be obtained. Some time ago there appeared an article in the American technical journal *Power and the Engineer*, by Mr. G. H. Diman. It is entitled "An Example of Self-education." He says: "I have some bright young men working for me, and the other day I walked into one of our engine rooms and asked one of our assistants if he could figure a problem, and gave him the following:—

"Two mills each burn 100 tons of coal per day; in one the stack temperature of the waste gases is 450°, in the other 200°. Find the saving in tons of coal per day in the second plant over that of the first. He submitted the following solutions which pleased me very much:

"Eighteen pounds of air are required per pound of coal for best combustion. 200,000 × 18 = 3,600,000 pounds of air required for 100 tons of coal.

Heat required to raise one pound of air one degree Fahrenheit is 0·23751 B.t.u.

Therefore 3,600,000 × 0·23751 × 250 = 213,759,000 B.t.u. going up the stack in plant No. 1 in excess of that in No. 2.

The B.t.u. in each pound of coal = 14,500,

Hence 213,759,000 ÷ 14,500 = 14,742 pounds of coal required to heat this air from 200° to 450°, and

14,742 ÷ 2,000 = 7·371 tons of coal per day wasted."

Mr. Diman concludes: "This young man after one year in the high school, on account of the death of his father, came to work for me. He has always been a student, and there is hardly a day that I do not catch him with a book and pencil in his hand figuring out some problem." This illustration shows that 7·371 tons out of 100 tons can be wasted by not watching the flue gas temperature, and in this example only the extra heat imparted to the air has been taken into consideration. If we want to be quite accurate we must add the extra heat imparted to the gases themselves. Assuming 10 per cent. ash in the coal, 90 per cent. would go up the stack as gases. If we assume these gases are one-nineteenth of the total mixture, you have 5·26 per cent. to add to the figure given, which brings the total of coal wasted to over 11 tons out of 100. Of course I should also mention that this assumes that the reduction in the flue gas temperature of the second mill was really due to increased absorption of the heat by the heating surface of the boiler. In practice that does not necessarily follow. The reduction may be due to one of several things. It may be due to too much excess air entering the furnace through the fire doors, or to leaky settings or flues. Of course flue gas analysis will take care of these points, but in furnace practice, as in everything else, it will not do to draw any conclusion from one factor of an equation without considering the others. But I think it is true, nevertheless, to say that if properly interpreted, measurements of the temperature of the waste gases are very valuable and important. First of all, the temperature shows whether the furnaces are in good working order. If the flue gas temperature goes up rapidly and unaccountably it is sometimes found to be due to part of the bridge coming down. Then again, too low a flue gas temperature is due to leaks in the settings. High temperature may be accounted for by soot adhering to the boiler shell or tubes, or to scale being present in the boiler. Other temperatures in the boiler room which require attention are those of the feed water and the steam, particularly when superheated. It would be too much to go into details of the value of superheating, but I might quote a statement made by Mr. Wood before the Electric Lighting Association of Brooklyn recently. In a paper he demonstrated that there was a gain of 1 per cent. for every 10° Centigrade that steam is superheated. In the engine-room too high superheat is often a source of trouble where turbines are in use, and you must resort to the thermometer to keep things going smoothly. There are other temperatures, such as those of condensed steam, cooling water, the large bearings, and in some plants, oil-cooled electrical transformers. These do not exhaust the diverse uses to which thermometers are put, but they go to show that temperature measurement forms quite an important part in the daily routine of the average engineer; so that if appliances can be brought out which can do this work more efficiently and conveniently, they should be worth investigating.

The Mercurial Thermometer is on the whole a reliable and, when properly made, accurate appliance for measuring temperatures. It is used in thousands in every department of industrial life, and I question whether we could at all do without it at the present day. But it has its defects and shortcomings, and just as we are no longer content to measure time with a sand glass, just as to-day we prefer to use the telephone rather than a special courier to convey messages, so there has arisen a demand for a temperature indicator which could transmit its information over a distance so as

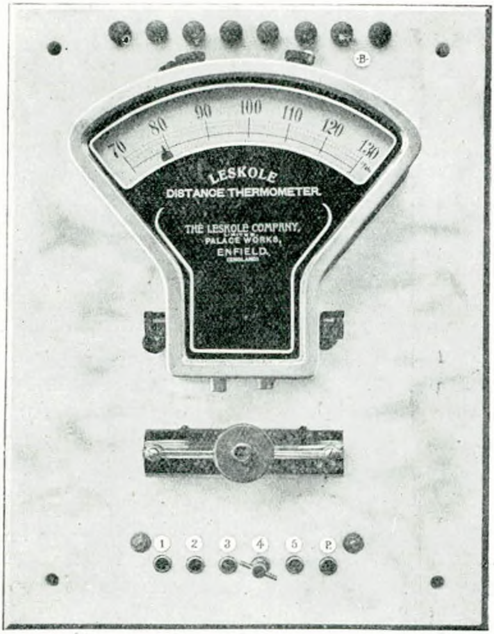

FIG. 1. SWITCHBOARD WITH LARGE INDICATOR AND CONTACTS FOR FIVE RESISTANCE THERMOMETERS.

to render possible a centralization of all important temperature readings at one point. The advantage of this concentration will be at once apparent. Good management, wherever it may be, depends very largely on organization. The degree of efficiency with which a man in charge succeeds in running a plant or establishment, will depend on his ability to unite all the reins in his hand, to keep in close and constant touch with all the threads of the entire fabric. Apply this to temperature and what do we find ? He has not the time or the inclination to go from thermometer to thermometer (often at considerable distances apart) and it is not always satisfactory to rely on information furnished by those over whose work he wishes to exercise a check and control. This is where the electrical thermometer comes to his aid. This system allows of readings being taken at any desired distance from the source of heat. Small switchboards, as the one before you, are erected at some central point, and any desired number of thermometers can be connected to them and their temperature observed alternately on the same indicator.

The thermometer elements, that is the part of the apparatus sensitive to temperature, are entirely of metal, strong and rigid and all but unbreakable. This is rather an important point to remember considering that the ordinary glass thermometer is quite the most fragile appliance found about a power plant, and the frequent breakages inseparable from its use are not its least objectionable feature. Then there is the question of accuracy, and here it is claimed that the electrical method stands head and shoulders above the mercurial thermometer. Indeed, frequent tests carried out in the Government laboratories have proved it to be almost absolute.

It may not be out of place here to mention a few factors which tend to imperil the accuracy of the mercurial thermometer. There is first of all the glass tube from which it is made. Unless very carefully selected and calibrated, the bore of the average tube used nearly always shows slight unevenness in different places, thus introducing the possibility of error. Where this tube is exposed to the higher temperatures the glass will be subjected to alternate expansion and contraction, influences which frequently cause permanent changes in its shape and size, unless the glass has previously undergone a process of careful annealing. Then there is the mercury.

This has to be boiled over a considerable period in order that all the air it contains may be removed. That this is often only partially accomplished in the ordinary commercial thermometer, is shown by the frequent severing of the mercury column found in practice, and the consequent inaccuracy of the thermometer.

But even when all these points have been carefully watched (and of course they are watched when it comes to producing a high class article), there is still the question of immersion. At the works the thermometer is calibrated with little more than the bulb immersed and the rest of the tube at "normal," that is to say, room temperature, about 60° F. Now it need hardly be pointed out that that thermometer cannot be equally accurate when those conditions of immersion are altered. At every point throughout the length of the tube, where the surrounding temperature is different from that under which the thermometer was calibrated, the factor of expansion of the mercury will be different, and in this way errors are introduced which are frequently much larger and more serious than those from all other sources I have mentioned combined. I have a table here which I obtained from the journal I mentioned a while ago, which shows the extent of this difference. Taking the difference between the bulb and stem at 240° F., and the number of graduations exposed at 200° F., there is an error on the thermometer of 4°. The biggest error shown on this table is for a difference between stem and bulb of 800° F. This difference might be found when taking the temperature of the flue gas, and assuming 500° exposed, the error is no less than 35° F. Now the electrical system, as will be apparent presently from a brief explanation of its principles and the construction of the instrument I propose to describe, has none of these defects, and in addition to offering the undoubted advantage of readings at a distance, in addition, further, to its strength and durability, it gives you an accuracy which will not only satisfy all requirements, but which is also permanent and quite unaffected by external changes. It may be of interest, while on the subject of accuracy, to mention that a modification of this system of measuring temperature by electrical resistance has been invented and is used by astronomers to measure the heat rays of the spectrum. With it one can measure the heat radiated from the human face at a distance of a mile and a half through space, and you can read one-millionth part of a degree Centigrade. In this instrument discs of platinum of infinite fineness are used as the resistance elements.

It has long been common knowledge that the resistance which different metals offer to the passage through them of an electric current varies with the temperature of the metal body in question, and this fact has been utilized to inversely determine the temperature of such bodies by measuring their electric resistance. Until quite recently, however, platinum was almost exclusively employed for this purpose, and its great cost was naturally a serious obstacle to a wide applica-

FIG. 2. RESISTANCE ELEMENT FOR MEASURING WATER UNDER PRESSURE, STEAM, ETC.

FIG. 3. RESISTANCE ELEMENT FOR TEMPERATURE OF ROOMS.

tion of this excellent means of temperature measurement. But during the last two years, other, non-precious, metals and alloys have been employed with complete success for temperatures to 900° F., and the resistance elements which I have here are composed of coils of very pure nickel wire. The resistance curve of this wire over the range of temperatures for which it is suitable, has been carefully determined in the Government laboratories and, as may be seen from the even divisions on the scale of this instrument, it rises almost in a straight line with the temperature. It may be claimed therefore that here we have for the first time a system of temperature measurement by electrical resistance, scientifically good, and at the same time so simple in construction and application and so moderate in cost, as to appeal directly to a very large body of industrial users.

To measure the resistance of the elements, sensitive to temperature, the principle of Wheatstone's bridge is resorted to. This principle is very well known and widely used for finding the value of unknown resistances, in telephone work, in the laboratory and elsewhere.

In the Wheatstone bridge, the value (in ohms) of an unknown

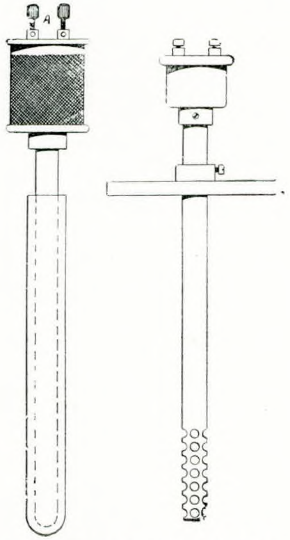

FIG. 4. A, THERMO-ELEMENT FOR ANNEALING FURNACES.
B, " " FLUE GASES.

resistance is ascertained by proportion. A grouping of several paths for the current is adopted, consisting mainly of four resistances, *a*, *b*, *c*, and *d*, arranged in the shape of a diamond. Thus the current from the battery finds two paths, either through *a* and *b*, or through *c* and *d*. Now the law is that if *a* is to *b*, as *c* is to *d*, no current will flow through a galvanometer bridged across the corners of the diamond, which would therefore remain at zero. But if the two sides are not in proportion, then the pointer of the galvanometer will show some current passing. If we now assume the value of *a* and

b to be known, and c to be the unknown resistance, a resistance box would be put in circuit in place of d, and resistances plugged in or out until the galvanometer were at zero, indicating that balance had been obtained.

As $a : b$ is as $c : d$, therefore c is equal to $\frac{a \times d}{b}$.

To adapt this system of resistance measurement to the Distance Thermometer, the three resistances a, b and c, are arranged inside the galvanometer, are all of known value and made of an alloy unchangeable with variations of temperature. The place of the fourth resistance is taken by the thermometer element proper (connected to the galvanometer by the wire leads) and in this case it is variable only in strict proportion with its temperature. Instead of altering the resistance to bring the galvanometer to zero, a scale is placed on the latter, and any increase in resistance of the thermometer element is then indicated by a deflection of the needle away from zero. The scales are directly calibrated in terms of temperature.

In order that a number of thermometer elements may be read on one indicator alternately, the galvanometer is mounted on a small marble panel carrying also a series of plug switches. These serve to connect the galvanometer with any desired thermometer element and at the same time place it in circuit with a 2-volt accumulator which provides all the current required to work the whole system.

As the accuracy of the measurements naturally depends on the E.M.F. of the battery being maintained at a definite level, a little regulating resistance is also fitted to the switchboard. To ascertain whether any adjustment is required the plug is inserted in a special contact provided, which places the galvanometer in contact with a fourth resistance, arranged inside the instrument, and so tuned as to cause the pointer to travel to a red line marked on the scale, when the battery is at the right strength. As the current consumed in working the thermometers is very small indeed, and the discharge usually intermittent, an adjustment of the rheostat is only necessary at very long intervals.

The sensitive elements used to place in the source of heat where it is desired to measure the temperature are small coils of nickel wire usually enclosed in a tube provided with a couple of terminals and connected to the temperature indicator by means of two copper wires. The terminals are insulated by a vulcanite plate. These tubes are made of various metals, copper, brass or steel, according to the temperature to be measured and the place where the element is to be inserted. Needless to say they can be of any length. Where the temperature exceeds 900° F. platinum resistances are used, and placed in fire-proof porcelain tubes. For cold stores, the nickel coil is placed inside a sheath with a little bracket at the bottom to attach to the wall or ceiling. It is not absolutely necessary to mount the nickel wire in the form of a cylindrical coil. For measuring surfaces it can be wound flat like a disc and this type is used (to mention an instance) for taking the temperature of a revolving calender roller used by dyers for finishing cloth. In many cases there is trouble because the heat will not evenly distribute over the surface of the calender, and it is possible for the first time, by this method, to actually determine which part of the surface is getting the most heat. The galvanometer most suitable for this class of work is the moving coil instrument, that is the kind in which a coil of fine wire closely wound is suspended in bearings in the field of a powerful magnet. The current enters the coil through spiral springs and the deflections are indicated on the scale by a pointer attached to the coil.

One of the great advantages of this system of temperature measurement is that the scales may commence and finish at any desired temperature within the limits I mentioned. For example, if a wide range is desired, the scale can commence at the lowest temperature and finish at the highest. If this range is so wide that the readings are not sufficiently close, two or three scales can be placed on the same dial and the thermometer arranged in groups so that they can be read on the different scales according to their temperature. Another interesting feature is that differential measurements can be made direct. For example, in a plant using jet condensers, they have been used for directly determining the temperature rise of the cooling water. For this purpose the instrument is connected to two groups of sensitive elements, the one measuring before and the other after the steam has entered. This instrument is calibrated to one-tenth of a degree and so shows the temperature in a more accurate form than with the mercurial thermometer. This is, in a few words, the system of measuring temperature by electrical means, which I will now demonstrate with the instrument before us.

Mr. Binz then proceeded with a number of demonstrations showing the working of the instrument.

CHAIRMAN: We are all indebted very much to Mr. Binz for his lecture and for the clear way in which he has explained to us the action of this apparatus. I daresay to a good many of us it will be entirely unfamiliar, as regards sea-going engineers, but if it acts as Mr. Binz has told us with such great accuracy, no doubt it must be a valuable appliance on board ship, where accuracy of temperature is in many cases very important. Mr. Binz alluded to refrigerating plant, where, there is no doubt, accuracy of temperature is practically everything, and where there is great difficulty in obtaining such accuracy in the refrigerating chambers, especially in hot weather. There are other cases in which I should think it would be very useful, say in the North Atlantic on the ice track in foggy weather. As we all know, under such conditions ice is often met with, especially on the Canadian route, and a knowledge of the temperature of the water and the atmosphere is very useful in determining whether there is any ice in the immediate vicinity. In a case like that I should think the apparatus would be extremely useful. I do not know whether the cost would be at all prohibitive to its adoption. Could Mr. Binz give us any idea of the cost ?

Mr. BINZ: The cost largely depends on the size of the installation. It becomes the smaller in comparison with mercurial thermometers the larger the installation. For a switchboard with six points, the cost is from £2 per point. There is no glass and therefore no cost for breakages, and there is no cost of upkeep ; the current used in the little 2-volt battery is but 0·01 amp. so that recharging is necessary but once in six months.

Mr. J. HOWIE: Does that £2 per point for six points include the indicator and everything ?

Mr. BINZ: Yes, assuming a plant with not less than that number of points.

Mr. HOWIE: I suppose the wiring would not come to much in an engine room ?

Mr. BINZ: The wire used is ordinary high-tension copper wire cotton insulated, which costs about 1*d.* per yard. It depends on the distance how much that adds to the cost. Of course it is only a first cost.

Mr. HOWIE: Has it been tried on shipboard?

Mr. BINZ: No, there are about fifty installations on land altogether.

Mr. ADAMSON: Similar instruments have been in use on shipboard.

Mr. BINZ: Oh, yes, but not of this particular make.

Mr. J. ROBERTSON: Does it affect these wires to bring them from the refrigerator through the hot engine room?

Mr. BINZ: No; the wire used is only slightly sensitive to temperature and the fluctuation in temperature will never make more than two ohms difference to its resistance. The sensitive wire in the refrigerator is tuned two ohms in advance of the proper temperature, so that if the switchboard is away the maximum distance allowed for and the fluctuation is the maximum expected, the difference will be allowed for and there will be no inaccuracy. There is an instrument fitted in a works down in Kent where the fluctuations in temperature are very great between the hot boiler house and the outside atmosphere, but the fluctuations there only cause a difference of a very slight fraction of an ohm in resistance, so that they hardly feel it.

Mr. JAS. BELL, R.N.R.: What is the maximum distance from the sensitive point to the switchboard?

Mr. BINZ: There is no limit except the cost of wiring. The longer the distance, the heavier the wire to be used to keep down the resistance. The largest distance I know of is 1,000 yards, and there is no difference whatever in taking the temperature at that distance.

Mr. ADAMSON: Have you any arrangement by which you could connect an alarm bell to this in the event of a fire in the bunker? The engineer may not always be near the instrument.

Mr. BINZ: A contact can be fitted on the instrument in such a way that, by setting it to any desired temperature, when that temperature is reached a bell is rung.

Mr. Howie: Would there be any difficulty if the wiring is in a moist place?

Mr. Binz: There would be the usual difficulty with electrical work. The wiring must be well insulated, and if the place is very wet, it must be run through tubing.

Mr. Hardy: Would the connexions be in any way affected by the production of electricity in the vicinity?

Mr. Binz: No.

Mr. Howie: Would there be any difficulty in having a lead inside the boiler?

Mr. Binz: You could make the tube sufficiently long to reach the farthest point in the boiler and place the terminals outside.

Mr. Bell: Could you apply the same arrangement to the hot well feed pipes and discharge?

Mr. Binz: Yes; that is one of its standard uses, particularly in land installations. Frequently we have switchboards for the feed arrangements alone. In that case the temperature of the cold feed is taken, then after passing through the economizer, and again of course the condensed steam returned.

Mr. Howie: I certainly think it is an advance on the ordinary arrangements.

Mr. Adamson: Has it been tried in connexion with the carriage of chilled meat?

Mr. Binz: I am not aware of any installation on board ship, but of course there are very similar uses on land. There is a large installation in London, of 25 points, in the Central Meat Market at Smithfield. That would, I take it, be exactly the same purpose, and there the elements are provided with a specially strong shield to prevent damage when the meat is stacked up against them.

Mr. J. Robertson: The trouble is near the side of the ship; the thermometers are too near the brine pipes.

Mr. Binz : You could put them exactly where you want to measure the temperature. I presume you mean you would take the temperature near the middle of the space ? That can be done by hanging them down or fixing them on a standard. So long as you get the sensitive element at the exact point where you want to record the temperature, it will act all right.

Mr. Adamson : I apprehend Mr. Robertson was referring to the difficulty there is in fixing the instruments exactly at the point required owing to the rolling of the ship. The usual method is to lower the thermometer down and then pull it up again. You simply lower it and raise it, whereas this would be a fixed point.

Mr. Binz : Yes ; it would be fixed. Why should it not be screwed down ?

Mr. Adamson : That is just the difficulty Mr. Robertson pointed out ; you cannot fix it up because it would be too near the brine pipes, which is not the critical part of the chamber. The usual tubes could be used, however.

Mr. Robertson : The meat swings about also.

Mr. Binz : If the meat swings, let it swing with the meat, or fix it to the meat. The actual element of measurement is not larger than my little finger. It could be fixed up in a thousand places where it would be impossible to put the ordinary mercurial thermometer.

Mr. Bell : In a large chamber you would require a number of different points.

Mr. Binz : That would depend upon whether the temperature was maintained evenly, or whether there are differences of temperature. If you had doubts you could fix up more than one and find out ; and if there was no difference, then you would be sure and be satisfied with one. Or you might find one place throughout the large chamber where you could rely on the average or relative reading.

Mr. Bell : In holds on board ship you would require a number.

Mr. Binz : Yes ; I should think so.

Mr. Howie: Supposing you left them in some foul place where there were thick gases and the tube got coated?

Mr. Binz: There again you will adopt the outer casing to fit particular circumstances. If acid, you could encase it in glass; or if sulphuric acid you would use cast iron. It is being employed for taking the temperature of concentrated sulphuric acid with iron sheets and is working very well.

Mr. Howie: I think when it is installed something too much might be expected of the instrument, whereas in the old system you know exactly what to expect.

Mr. Binz: One always finds in introducing a new thing that it is expected to do more than is claimed for it. Of course you can always test if you are keeping the right temperature, by inserting the plug in the special contact, and showing that the pointer goes to the correct point.

Mr. Robertson: Would it be affected by the rolling of the ship?

Mr. Binz: In a violent storm I do not know whether it would be so accurate; but in ordinary rough weather it would not be affected.

Mr. Robertson: I have seen thermometers put in meat boxes, where they registered themselves, and the weather affected them very much, even breaking the pencil.

Mr. Binz: The galvanometers are largely used on ships in connexion with electrical installations, and I think they give satisfaction.

Mr. Bell: Would the vibration have any effect?

Mr. Binz: No, the ordinary vibration is met with on land.

Mr. Bell: There is more on the ship. It depends on the condition of the ship; they may be running light ship and there is more vibration caused then than when loaded.

Mr. Binz: I do not think the vibration would have any effect. It might shorten the life of the galvanometer if the vibration is serious; but the galvanometer is not expensive.

Mr. B. H. Budding: Would it be affected by the compass?

Mr. Binz: No, the current is very much stronger than the effect of the magnetic action of the compass.

Mr. Adamson: For a large ship you would require probably about 50 points to make the whole efficient.

Mr. Binz: Fifty points could be placed on one switchboard.

Mr. Adamson: How much would the cost be?

Mr. Binz: It would cost between £90 and £100 approximately.

Mr. Adamson: Of course it would be particularly well adapted for the critical temperature holds such as where fruit is carried, and where the temperature should not vary even a degree.

Mr. Binz: The scale for that work could be made to cover only a few degrees so that you could read very small fractions of a degree quite plainly.

Mr. Cooke: What range of temperature would there be?

Mr. Binz: It could be made in anything from −200 to 2,900° F. From the temperature of liquid air to the highest temperature ever found inside boilers. That is a point that must not be forgotten. It measures the flue and furnace temperatures of boilers where ordinary thermometers cannot be employed at all.

Mr. A. G. Rainey: In case of a very high temperature, say of about 2,000°, what would the construction of the instrument be?

Mr. Binz: The element would be platinum and the sheath refractory porcelain.

Mr. Rainey: Would it stand the heat a considerable time?

Mr. Binz: The porcelain tubes are in constant use and last 9 to 12 months. They cost from 8*s*. 6*d*. to 13*s*. according to the quality.

A Member: Is it worked by the expansion of the metal in the sheath?

Mr. Binz: No, by the resistance. There is a small coil of wire, and the resistance the coil offers to the current is measured on the galvanometer. There is no expansion or contraction, no physical action at all, so that nothing deteriorates in the process.

Mr. Cooke : As long as the batteries are in order the temperature is absolutely reliable ?

Mr. Binz : Yes ; and whether it is in order or not can always be ascertained by the adjusting apparatus of the board ; whereas in the mercurial thermometer you have nothing to show and can never tell unless it is sent out to be tested.

Mr. Adamson : It seems to me it is particularly useful in connexion with coal bunkers, when so much is heard and experienced of the coal catching fire and there is a difficulty in locating the exact spot. In fact, a few years ago there was a very elaborate system got up by which the temperatures of the bunkers on a ship were indicated on an instrument, so that the least warning of heating would be given to the engine room by a bell. The price was considerable but no doubt its utility is great.

Mr. Binz : That would be the case in this also if platinum were used for the resistances ; but nickel is used which makes it much less expensive.

Mr. Howie : I do not know whether Mr. Adamson is thinking about a similar thing on exhibition at Shepherd's Bush, the Fournier system.

Mr. Binz : The Fournier system is worked by the expansion of saturated vapour. You cannot group them on one switchboard ; you must have a separate indicator for each sensitive element. A tube leads to the indicator and there a pressure gauge measures the expansion or contraction of the saturated vapour. There is a great difference between the two systems.

Mr. Howie : That was not carried the whole distance.

Mr. Binz : The connexion is made by a capillary tube containing some inert liquid. The great difference is that in one case the ordinary copper wire at 1*d*. per yard is used, while in the other there is a tube filled with some liquid. The tube costs more, and, of course, the farther you take it the more risk of breakage or leakage in the tube.

Mr. ADAMSON : I think it was about four years ago since Mr. Bain of the Cunard Co. spoke to me about this and said he had tried it on a ship running out of Liverpool. The last time Mr. Binz was here, I think he advocated that the chief engineer's cabin should be turned into an instrument room.

Mr. BINZ : I think it was a gentleman in the audience who made that suggestion.

Mr. ADAMSON : There is a cabin of one of our members illustrated in THE MARINE ENGINEERS, where he has instruments for indicating the engine revolutions, air pressure, the steam pressure, the voltage and amperes on electric lighting system, the temperatures of meat chambers and holds and other appliances, all desirable, but better suited for an anteroom or office than a private cabin, for health reasons.

Mr. J. BLELLOCH, Jr. : This fluid system is in use for refrigerated holds ; the system with a capillary tube. It is very successful.

Mr. BINZ : Yes ; I heard of that. I believe it is a very good system.

Mr. BLELLOCH : Yes ; it is quite satisfactory. It can be led into the chief engineer's cabin if desired.

Mr. BELL : How would you apply your system to the coal bunker ? You cannot get it into the centre ; you would require a special instrument to bore into the centre of the coal.

Mr. BINZ : You could make a strong steel tube with the coil on one end and force it into the coal, or place it there and lay the coal around it.

Mr. BELL : In a large bunker it would not be practicable.

Mr. BINZ : You could bring it up from the bottom in the centre.

Mr. BELL : Say the bunker is on fire ; you would require to seek out the points before finding the position. The fire may be in the centre ; it may be at the very bottom or it may be 12 or 14 ft. away from the instrument; how would you be able to tell?

Mr. Binz: What is done at the present time?

Mr. Bell: At the present time we just have to work out the bunker till we get at the place where the fire is located. Of course when a bunker takes fire, we sometimes may be working in the opposite direction.

Mr. Binz: I should think engineers of lifelong experience would have their ideas as to the most likely place to put in a thermometer.

Mr. Bell: You would have to have certain arrangements for that, which would mean more expense.

Mr. Binz: It would cost something to empty the bunker, so that a considerable amount of time might be saved.

Mr. Adamson: You cannot always forecast which bunker the certain classes of coal that give the trouble would be placed in, although generally this can be done.

Mr. Binz: I should say have one thermometer in each bunker, and if a fire occurs you would find out exactly the spot.

Mr. A. Robertson: I think we have listened to a very interesting lecture this evening, and one that is of scientific interest to us all, and although this particular instrument has not been applied on board ship up to the present time, I cannot but think that some shipowners will see the immense advantage there is to be gained by having such an instrument installed, and that before long some vessel will be fitted with it. From the explanation we have had this evening it appears that on one board we can connect up every temperature that we require to know on board ship, and as you are all aware, and as the lecturer is aware, they are considerable in number. When you consider the question of the freezing apparatus, and that every hold practically on board a steamer of any decent size has at least four thermometers in one deck, four below that and four again in the lower hold, and that you can place all those on one board it must be an immense advantage, and I think refrigerating engineers here this evening will realize that probably more than any one else. It would save an immense amount of time and trouble. One point that has not been brought out is the question of the insulation of the wires. Leaky wires give considerable trouble on board ship at times in corroding due to the salt water and atmosphere. and I suppose we have the same danger to contend with here. It would be a question of careful investigation of the installation from time to time.

Mr. Binz: That is so.

Mr. Robertson: I have great pleasure in proposing a hearty vote of thanks to Mr. Binz for this second lecture. Mr. Binz's previous one was very interesting and led to a good discussion, and I have no doubt you will all join with me in according him this vote of thanks.

The motion was carried with applause, and the meeting concluded.