THE MINING, MANUFACTURE, AND USES OF ASBESTOS.

It would be impossible to give, within the limits of a paper of this description, more than a brief outline of the history of the mining and manufacture of asbestos. Moreover, the time at my disposal—since I had the honour of receiving an invitation to read to you a paper on this subject—has not been sufficient to enable me to collect and arrange the materials on which it is based in the order I could have desired; nevertheless, I hope to lay before you some particulars which may be found interesting.

Much has been already written on the subject of asbestos, but I have been astonished to notice the great similarity in descriptive articles which have appeared from time to time in newspapers—even including scientific and technical papers and magazines. The writers seem, with amusing unanimity, to refer to some old encyclopædia, and reproduce, with various comments, certain hackneyed statements about the use of asbestos cloth by the ancients of Greece and Rome, who, thousands of years ago, wrapped the bodies of their dead in this material, and who made dinner napkins of asbestos, cleansing them after use by throwing them into a fire, and then exhibiting them to their amazed guests.

I should like to see the valuable space of our technical papers, when devoted to the subject of asbestos, occupied with information brought down to a later date and of a more practical nature, and I think this is a matter to which the publishers of encyclopædias might also pay a little more attention with advantage.

Asbestos has been found in all quarters of the globe, and there is, at the offices of the Company with which I am connected, a large collection of interesting specimens, which I should be pleased to show to any gentleman who cares to call and see them. They come from Italy, Canada, Newfoundland, the United States, Southern and Central America, China, Japan, Australia, Spain, Portugal, Hungary, Ger-

many, Russia, The Cape, and Central Africa. Scarcely a week passes without some new specimen arriving or an opinion being sought on some new discovery of this mineral substance.

Nearly all the discoveries made up to the present time have proved of little value, although we frequently see in the newspapers announcements of new sources of supply of so-called fine qualities of asbestos fibre, which, on investigation, prove to be worthless to the manufacturer. The important difference between good and bad asbestos will be at once perceived by an examination of the few specimens here, and I may say that the only kinds hitherto found suitable for commercial purposes are the "Italian" and "Canadian" varieties. These possess the properties of infusibility, tensile strength, fineness and elasticity which are so essential to manufacturers and the users of asbestos. It will be observed that this specimen of Australian asbestos, about the discovery of which a great deal was made in the papers some time ago, is very brittle and quite worthless for spinning or weaving purposes.

I have here, also, a specimen of African asbestos. It is dark blue in colour, and while the length of the fibre is about the same as the Canadian, it is altogether wanting in fire resisting power. Whilst Italian asbestos contains nearly 80 per cent. silicate of magnesium and only about 3 per cent. oxide of iron, this specimen of African asbestos only contains about 50 per cent. silica and no less than 40 per cent. oxide of iron. We experimented with this fibre two years ago with the idea of making some use of it, but the results were so unsatisfactory that we abandoned the idea, having proved its unsuitability for engineering purposes. It would not stand much heat without disintegrating and becoming quite rotten, this effect being probably due to the fact that a portion of the iron disclosed on analysis is in the form of a ferrous salt. By exposure to the air and heat this salt oxidises and alters the composition of the asbestos to such an extent that it is easily charred.

Last year a considerable quantity of asbestos somewhat resembling the Canadian in character and formation was imported into this country from beyond the Ural mountains in East Russia. This fibre, although darker in colour than the Canadian asbestos, is certainly superior to the African fibre, and we thought it would be worth while to make somewhat extensive experiments with it. As the result was not satisfactory I need not say anything more about it, but confine my further observations to the mining and manufacture of the two kinds of proved value, viz., ITALIAN and CANADIAN.

Specimens of these in the raw state, just as received from the mines, also after being cleaned and carded, are before me. The Italian variety may be distinguished by its longer fibre, saponaceous nature (an important quality when used in contact with moving parts of machinery), and its brown or greyish tint, while the Canadian is shorter, less saponaceous and white in colour. Each kind has special merits, and is used for the purposes which experience has proved it to be best adapted. I will refer first to

THE MINING OF ITALIAN ASBESTOS.

The modern history of Italian asbestos mining may be considered to commence with the present century. We find that about ninety years ago two enterprising citizens of North Italy conceived the idea that what had been done in ancient times might be undertaken for modern requirements, and that a cloth made of this material would answer well for various purposes. They carried out some experiments in Lombardy, which were consided to be, to a certain extent, satisfactory, and which earned for them some honorific distinctions from Napoleon I. who was always ready to encourage sciences, arts and industries. The numerous crises which kept this part of Europe in a perpetual state of disquietude prevented the development of the trials I have mentioned, and for a further space of years asbestos seems to have been looked upon as a substance of some interest to the mineralogist and geologist, but of little or no practical and commercial value.

It was not until the year 1866 that Signor Albonico, having given some attention to this product of the mountains of his native province, got into communication with a highly cultured and intelligent Florentine cleric, Canon Del Corona, and they were subsequently joined by a distinguished Roman nobleman, the Marquis di Baviera. The result of their endeavours was that they produced some asbestos cloth and paper, and were in hopes of obtaining a contract from the Italian Government for the supply of the latter for bank notes and other securities, but failed in this, and whatever prospects they may have had of better success in other directions were spoiled by the outbreak of the Franco-German war of 1870.

Signor Albonico had, however, obtained concessions from several communes of the right to work this material on their respective properties, and having transferred his rights to the Priest Corona and the Marquis di Baviera, he thenceforward acted as their agent until the mines and mining rights were transferred to other parties as mentioned farther on. The valleys and mountains amongst which asbestos is

found, although little known to the average tourist, are amongst the most beautiful of those which form the Alpine region, and the scientific man could not desire to explore ground of greater interest.

As I am only concerned at present in describing those districts in Italy in which asbestos of commercial value is obtained, my remarks will be confined to those under the control of the Company already referred to as that I am connected with, which holds all the mines of any real value, it may therefore be taken that my description will leave none unnoticed.

The first district in which asbestos of commercial value is obtained to which I desire to call your attention is the Susa valley, which is approached from France, through the famous Mont Cenis tunnel. On emerging from the tunnel on the Italian side, the line follows the southern mountain slope, with a gradual descent, overlooking the town of Susa, which gives its name to the valley, and which is placed at the head of the plain, which at times widening, and at times narrowing, for a distance of about 40 miles, finally opens out on the great plain of Piedmont. At a point in the centre of the valley, and on the northern mountain slope, are the places from which the floss asbestos fibre, the appearance of which in gas stoves is familiar to us all, is obtained. In the same locality is also found a fine white powder of asbestos, used in asbestos paint, and for other purposes. The ground from which these materials are got is about ten square miles in extent, and the works are carried on at a height of from 6,000 to 10,000 feet above sea level. The temperature is, of course, low at such an elevation, but the inhabitants are hardy and robust, and make willing miners. The works are reached by mule-paths for some distance, but the remainder of the way has to be done on foot, and from four to five hours are required for the journey from the plain, on which are the railway and high road. The first work done here in recent times dates from 1876. The mode in which the material is brought down the mountain side is by loading it on a sort of toboggan or sledge, which slides as easily over the rocks as over snow, and so expert are the inhabitants at this work, that two men can bring down 8 cwt. of asbestos in three hours.

Continuing down the valley there is hardly a spot that is not replete with historic interest. A ruined castle marks the epoch at which the peasantry revolted against the exercise of the infamous "seignorial right," and having stormed the walls, led by a brave, youthful bridegroom, overthrew the brutal tyrant, who from this stronghold domineered over his enslaved vassals. A narrow gorge

through which there hardly appears to be space enough for the railway line, is the scene of many a hard fight between invaders of one nationality or another and the Piedmontese, or between rival nobles; and a stupendous building on a lofty eminence is the ancient burial place of the war-like and illustrious Dukes of Savoy and Princes of Piedmont. Nor are places of modern interest wanting, for, on emerging from the valley into the broad and fertile plain, one of the most important dynamite factories in Europe is passed, and then pastures and vineyards alternate, until nearly straight ahead the white dome of the Superga, the burial place of the Kings of Sardinia, marks the close vicinity of the city of Turin.

The second of the districts to which I will refer is the Aosta valley, commencing at Ivrea, a town of some importance, about 40 miles, in a nearly northern direction, from Turin. From Ivrea to Chatillon, a distance of a little under 30 miles, the railway passes through the heart of the asbestos properties which flank it on either side, the direction being north-westerly, and at the latter town (Chatillon) the valley trends sharply to the west, until the city of Aosta, the ancient Augusta, is reached.

The history of the asbestos mining industry in this province is as follows:—In the year 1849 Signor Antonio Ré of Rome, finding himself implicated in certain political troubles, took refuge in this valley where he lived for many years. In 1873 he became aware of the proceedings of the Marquis di Baviera and the Priest Corona, and set to work to investigate the question of asbestos in the Aosta valley. He, like others, was aware of its existence, but until then, the mineral found in this district had been thought of inferior quality, and not serviceable for any industrial purpose, so that no trouble was taken about it. In the year named, however, Signor Ré undertook a search for some better qualities, and having assured himself that such could be found in abundance, he put himself in communication with the gentlemen I have mentioned, and they being satisfied with the material, started working on a pretty large scale.

It is impossible to give, with any degree of exactitude, the extent of the ground covering the asbestos mines in the Aosta valley, as it has not yet been all thoroughly surveyed; but as the valley is some 75 miles in length, and varies in width from 5 to 40 miles, some idea may be formed of it. Nothwithstanding the large quantity of asbestos that has been got, enormous deposits remain untouched, and the yield may almost be considered inexhaustible.

The quality of asbestos in the Aosta valley is not, however, similar to that in the Susa valley. It is of the kind

known as " Grey Fibre," long, strong and soapy to the touch, and is similar to that obtained in the third and perhaps most important of the vast areas which I will now describe.

This district is situated in that portion of Lombardy known as the Valtellina, and in order to reach it from the valley last described (Aosta) it is necessary to return to Turin. From thence a railway journey of about three hours and a half brings one to Milan, passing by the historical battle-fields of Novara and Magenta; the cathedral of St. Ambrose; the Victor Emmanuel Gallery, a noble arcade owing its execution to British enterprise; the Arch of the Simplon, erected by Napoleon I., in memory of his crossing the Alps, like Hannibal, at the head of an army, and the notable fresco of the last supper by Leonardo da Vinci, claim attention, as well as the celebrated public garden. Leaving the magnificent Milan railway station, a further journey by rail of about two hours brings one to Como, at the foot of the lake of that name. The route is then by steamer to Colico, situated at nearly the northern extremity of the lake. The clear waters of the lake reflect the surrounding mountains with remarkable distinctness, and as the steamers cross the narrow body of water from side to side, there is an ever changing variety of view. The Lake of Como is in shape like an inverted Y., the town from which it is named being at the western point, Lecco at the eastern, and Colico nearly at the northern extremity. Como and Lecco are connected with the general network of railways of the country, but the lines from Colico to Chiavenna to the north, and to Sondrio on the east, are still isolated. A line is, however, in course of construction from Colico to Lecco, which will bring the Valtellina into direct railway communication with the rest of the country, and which will greatly facilitate the transport of asbestos from the mines, obviating the necessity of putting it on broad barges to be taken from one end of the lake to the other. After arrival at Colico a railway journey of about two hours and a half brings us to Sondrio, the chief town of the district. The line follows the course of the river Adda. An affluent of the Adda, the Mallero, joins the former river at Sondrio, giving the name of Val Malenco to the valley in which it has its course, and in this valley and others branching out from it to the east are the asbestos mines. It was in this region that Signor Albonico commenced his researches.

The district is divided into five Communes, and the asbestos properties have an area of about 25,000 acres or nearly 40 square miles. The population numbers about 5,000, of whom a large proportion are engaged in asbestos mining. Throughout the whole of this extensive area the

mineral is found in abundance and of the finest quality. There is in the United Asbestos Company's exhibit at the Crystal Palace a specimen of the crude material in one piece which for quality was considered to be the finest in the world, and which weighs 45 pounds: but even this is far surpassed by a block from the same Company's mines at the present moment on its way to England of the weight of nearly 3½ cwt.

For a distance of 11 miles of the 20 which form the length of the Val Malenco there is a good carriage road, but beyond that the ascent to the mines is by following mere goat-tracks, and as the slope of the mountains is steep, the labour of bringing the mineral to the road in the bottom of the valley is very great.

The surface of the ground is, for about one third of its extent, pasture and woodland, the remainder being bare rock, which admits of easy examination and trial. A great portion of these mountains is as yet unexplored, but indications have been observed which lead to the conclusion that the supply of asbestos is practically inexhaustible.

The height above sea-level of the mines hitherto opened out varies from 3,600 feet to 7,200 feet. The climate is, for such an elevation, comparatively mild, there being some places at a height of 6,000 feet where work can be carried on during the whole year.

The inhabitants work willingly at the asbestos mines, in spite of its not being unattended by danger from landslips and avalanches.

The photographs which I have here imperfectly represent some of the United Asbestos Company's workings in this region. No. 1 is that of a mine which was first opened by Signor Albonico in 1870. No. 2 shows another mine in the neighbourhood of No. 1, where work was originated in 1872, and whence the large block, now on its way here, was extracted. No. 3 represents another one, and Nos. 4 and 5 show two different aspects of another excavation.

For a long time the opinion was held that at a certain depth, greater or less according to circumstances, the veins of asbestos gradually lost themselves in the serpentine rock, but recent experience has proved the fact that if the direction of the vein be followed it will be again met with. The work is carried on by means of shafts and galleries, dynamite being used for blasting purposes. We also find the fibre at the greater depths of better quality, being less indurated than that nearer the surface. I come now to

THE MINING OF CANADIAN ASBESTOS,

and in dealing with this part of my subject, although I have visited all the principal asbestos mines in Canada and studied

the subject of asbestos mining in that part of the world as well as in Italy, I shall avail myself in the few remarks I may have to make of the researches of Dr. Ells, of the Geological Survey of Canada, whom I have the pleasure of knowing.

Dr. Ells and other Canadian authorities state that the mineral asbestos proper—the Italian variety—belongs to the hornblende group of minerals, while that which is produced in Canada at the present day under the head of asbestos is in reality not asbestos proper but a serpentine rock called chrysotile. This occurs in veins in certain portions of the great belt of serpentine rocks of the Eastern Townships of Quebec, especially in portions of the Townships of Thetford, Ireland, Coleraine and Wolfetown. It is stated, in the *Mining Manual* for 1891, that although asbestos was known at many points in Eastern Quebec more than thirty years ago, and was exhibited at the International Exhibition in London in 1862, no attempt was made to work the mineral for some years. The credit of the discovery of the Thetford area is probably due to a French-Canadian named Fecteau, and following up his discovery certain areas were secured from the Government by private parties. The value of the mineral was not at first recognised, and in the first year of mining operations, 1878, only 50 tons were taken out, for which a ready sale was not at first obtained.

The publication of the prospectus of the United Asbestos Company in the year 1880, referred to further on, gave a great impetus to asbestos mining enterprises, and new companies obtained tracts of rocky land in the Townships of Thetford and Coleraine, and began the work of exploration and mining, the result being that from the year 1884 to the present time, large and increasing quantities of asbestos have been exported from Canada, a large proportion of which, however, would be of the qualities known as second and third grades, and used largely in the United States for covering steam boilers and pipes, roofing, building, and other purposes.

Although asbestos mining and prospecting in Canada has continued for fourteen years and the areas of serpentine are very extensive, the portions in which asbestos of good quality or in paying quantities is found, are in comparison so small that mining operations are practically confined to two centres only a short distance apart. These places may be reached in a few hours from the city of Quebec by train on the Quebec Central Railway, which runs through the heart of the asbestos mining district at Thetford and Black Lake Stations, about midway between Quebec and Sherbrook, at which point train may be taken to Montreal or the South.

The localities in which asbestos is found in Canada do not

so readily lend themselves to the imagination of lovers of nature as those in Italy to which I have referred; nor are they so full of historical romance as the latter. Yet the scenery on either side of the railway between Quebec and Sherbrook is at many points immeasurably rich in foliage, attractive, and fascinating.

Previous to the establishment of the headquarters of the British-American Land Company in Sherbrook in 1833, the Eastern Townships were aptly described as a " beautiful wilderness," and even fifteen years ago the whole of the lands in the asbestos region, and in which a large amount of British capital is now embarked, might have been acquired for a sum, the return on which would have astonished the fortunate investor, and probably added another name to our roll of millionaires.

Were I to dwell upon the many attractions of Sherbrook, paternally adopted by Sir John Sherbrook in 1833, with its Magog dashing wildly down an incline of nearly a hundred and twenty feet in half a mile, its cathedral, its college and spires picturesquely situated on the slopes of its beautiful hills and seen many miles away, the time at my disposal to-night would be exhausted.

Neither can I for the same reason descant on the glories of the City of Quebec—the Gibraltar of Canada—with its historic associations, its cliffs, its citadel, fortifications and " Heights of Abraham" where fell, in the year 1759, the Commander of the British forces, General Wolfe, in the moment of victory.

Reaching the summit of the wedge-shaped cliff through quaint narrow streets, clambering up " Break-neck Stairs," or availing oneself of the " Elevator" as an easier mode of ascent to Dufferin-terrace, we are struck with the grandeur of the scene before us. As we stand beside the flagstaff on the King's Bastion we have a view, which, for its magnificence, is said to be unsurpassed in North America. The contrasts of old and new in Quebec itself, the noble St. Lawrence at the foot, alive with ocean steamers and craft of every conceivable description, the winding St. Charles, the heights of Levis, with backgrounds of forest-covered mountains " shining green and gold," beyond and around—these and numerous other natural and artistic attractions lure one's thoughts from the subject of the "Mining, Manufacture and Uses of Asbestos," to which we must now return.

Dr. Ells points out, and this is confirmed by my own observations, that the rock carrying the marketable asbestos is generally a serpentine of some shade of green on fresh fracture, usually a greyish green, in which are contained numerous small particles of iron, both magnetic and chromic,

more usually the former. Serpentines that have a black, hard, chippy aspect do not promise well. In the asbestos-bearing rock proper the veins of asbestos are seen, without any special arrangement, intersecting the mass of the rock generally in every direction. In size they range from mere threads sometimes close together, as in the specimen here, to a thickness of one to two inches, and, very occasionally, three to four inches. The asbestos from these larger sized veins, provided it contains no serious impurities, is classed as grade No. 1, and is used for spinning and weaving; the shorter stuff and such as contains impurities is classed as No. 2 and No. 3 respectively. These latter grades, as I have already pointed out, are used principally in the United States for millboard, boiler and pipe covering and other purposes.

The character of the ground, and nature of the operation of mining, or more correctly quarrying, asbestos in Canada, may be ascertained from the plan and photographs I have here of our mines at Black Lake. Hand labour, which we are obliged to employ in Italy, owing to the difficult nature of the ground, has been largely superseded in Canada by the use of steam derricks, drills worked by compressed air, and other appliances.

When a block of asbestos-bearing rock has been displaced by the usual methods employed in blasting, the pieces are broken up, barren rock removed to "dumps" or waste heaps, and the remainder passed through the process of "cobbing," whereby the remaining rock is removed, and the asbestos exported in the form in which you see it here, and ready for the manufacturer. The third part of my subject deals with

THE MANUFACTURE AND USES OF ASBESTOS,

and here I suppose we must give our friends of the Encyclopædia—the ancient Greeks and Romans—the credit of having been the first to make asbestos cloth; but there is nothing on record to prove that it was made or used on what we should term a commercial scale.

There is in the Vatican an interesting specimen of asbestos cloth which is said to have been preserved from ancient times, and Marco Polo mentioned, in the account of his travels in China in the 13th century, a fire-resisting cloth, which he at first supposed to be made from the skin of the "Salamander," but which proved to be asbestos.

I have already referred to the part which the Italian priest, Corona, took in connection with the exploration and opening up of the Italian asbestos mines, in 1866. A Mr. Richard Lloyd took out a patent in the United States in the year 1857, for a packing in which he claimed the use of asbestos, but I am not aware that this packing ever came into

practical use, so that, so far as our information goes, the priest, Corona, has the credit of being the person who in modern times first explored for the raw Italian asbestos, and then successfully produced from it a millboard which has become such an important article of trade, though its composition and its manufacture have undergone many changes and improvements since Corona's time.

I believe that asbestos was used in the United States in the year 1868 or 1869, in connection with the manufacture of roofing felt and cement, but it was reserved for some enterprising Scotchmen to first bring asbestos to the notice of engineers in this country. In this connection I should not omit the names of Mr. H. R. Robson, of Glasgow, and the late Mr. Walter McLellan, of the well-known Glasgow Engineering firm. These gentlemen (with whom I was afterwards for several years associated in connection with the asbestos industry), having satisfied themselves as to the commercial value of asbestos, formed a Company in the year 1871, called "The Patent Asbestos Manufacture Company, Limited," established a works in Drummond Street, Glasgow, and commenced operations. I have already shown you how about this time the priest Corona, the Marquis di Baviera, Signor Albonico (the present manager of our Italian mines), and Messrs. Furse Brothers, of Rome, were actively engaged in securing properties and concessions to work asbestos from the Communal authorities in Italy, and when a few years later another company called "The Italo-English Pure Asbestos Company," of London, came into existence, backed by powerful influence, secured extensive mining rights and established a manufactory in Turin, keen competition for supremacy commenced.

The result was that all these Companies were amalgamated in the year 1880, by the formation of "The United Asbestos Company, Limited," under the presidency of Sir James Allport, of the Midland Railway.

I referred just now to some fire-resisting cloth which Marco Polo supposed to be made from the skin of the Salamander. As this reptile, pictured in a fire, was adopted as the trademark of the old Glasgow Company, and now constitutes the principal trademark of my Company, I may mention that the Salamander resembles the newt in form, but dwells on the land, taking refuge in the roots of trees. One quality universally ascribed to it was its supposed power of living in the fire. It was indeed said to be one of the "best proved facts" in natural history that the Salamander was the "lord of fire." This was, of course, a superstitious idea, and, we are told, possibly arose from the fact that the Salamander can emit a little watery fluid from its skin when

excited, and on some occasions this fluid may have damped for a moment the flame of the fire on which the animal may have been cast. However this may be, it is recorded that Francis I. of France adopted for his device a Salamander in the flames, thereby hinting to his foes that he, like that fearful reptile, was indestructible. It may therefore be allowed to be a suitable trademark for asbestos.

Competitors were soon in the field, and obtained a share of the trade opened up by the enterprise of the Pioneer Company. It was found desirable to concentrate the manufacture hitherto carried on at the old works in Glasgow, Turin, and Tivoli, near Rome, and extensive works were secured for this purpose at Harefield, near London, where asbestos goods, in all the forms in which they are offered to engineers to-day, are manufactured.

The machinery and plant for this purpose is of the most complete description and would occupy far more time to describe than is at my disposal.

I will briefly state the process of manufacture, and in doing this will refer mainly to the Canadian asbestos. The Italian fibre is more difficult to deal with and requires special machinery. As we have recently effected further improvements in our mode of treatment, you will understand my reasons for a little reserve on this part of my subject.

Our works are divided into several departments. First there is the Sorting and Opening Department, where the crude asbestos is dealt with. The blocks of fibre or "rock," as seen here, are crushed and opened up in special machines in such a way as not to destroy the fibre, and are passed thence to "shaking" machines, where the long fibre is separated from the short, and particles of rock removed. The long fibre suitable for spinning into thread is then taken into the Carding and Condensing Department, and the short to the Millboard and Boiler Covering Departments. The treatment of the long fibre in the Carding and Condensing Department is very similar to that in a textile factory, but its appearance would be scarcely encouraging to one who had been accustomed to wool or cotton. These latter staples, examined under the microscope, exhibit a notched or serrated appearance, which explains the ready way the material clings together when twisted. The peculiar nature of asbestos presents difficulties which are rendered more evident when its behaviour in the machines is watched, but these difficulties are overcome by special appliances attached to the condensing machines. As the fibre comes from the condensers in the form of sliver or condensed thread without any twist, it lightly folds itself in cans placed there to re-

ceive it, and is then taken to the Spinning and Doubling Department, where it is twisted into threads of every degree of fineness required. The thread then passes to the Weaving and Braiding Department, where it is made into various forms of yarn packings, also into tapes and cloth. The cloth is then taken to the India Rubber Department, where it is proofed and made into what is known as asbestos and India-rubber woven sheeting, tape and rings for steam and other joints, and also into rolled cloth and square block packings for glands.

This brings me to an important matter to which I should like to direct your particular attention. Recognising that in these days of fast steaming and high pressures it is of supreme importance to Marine Engineers that they should have jointing and packing materials upon which they might place reliance, we produced six or seven years ago a combination of asbestos and metallic wire which, with further improvements, recently effected, fully answers our expectations. Attempts had been previously made in this direction, but the results were not considered satisfactory, inasmuch as the asbestos-metallic cloth to which I refer was simply woven either with a wire warp and asbestos weft, or with alternate threads of asbestos and wire. We enclose, by an improved method recently adopted, a fine brass wire in the centre of every thread of asbestos in both warp and weft, thereby adding very largely to the strength of the cloth, while the wires are completely protected by the asbestos. This material is known as the "Victor" Metallic Cloth, and, being made into tapes and all sizes and shapes of joints as well as into round and square packings, is now largely used with satisfactory results by marine engineers and others.

So dense and close can we now make joints from this material that it is being largely supplied for hydraulic work, and I have here two small rings which have been tested up to pressures of 2,500 and 3,500 lbs. to the square inch respectively.

Another form of joint to which I should like to direct attention is the "SALAMANDER" JOINT recently patented. These joints have two concentric rings made from the metallic cloth to which I have just referred. The rings are sustained by a suitable metal ring, the vertical wall in the centre of which forms a partition between them, and absolutely prevents the possibility of displacement by either steam or moisture. By this arrangement, in fact, a *double* self-sustaining joint is made in place of the ordinary one.

There is great diversity of opinion as to the utility of India-rubber cores in gland packings. If the cores are

properly made, and are of the right quality of rubber, there may be a good deal to be said in their favour, but my opinion is that the use of inferior rubber is detrimental to the packing. Metallic cores are being tried, but I cannot see the use of a core at all unless it has some degree of elasticity. None of those I have seen contain this quality; some are practically solid and others collapse completely under pressure. I have been making experiments lately in this direction, and have so far succeeded as to lead me to hope that I may shortly be able to submit an elastic metallic core packing to the practical judgment of marine engineers.

I have just referred to the "Victor" metallic cloth, and may add that so far as its heat resisting properties are concerned, this is clearly demonstrated in the sample and photographs before me of a fire which entirely destroyed the auditorium of the Queen's Theatre at Manchester in 1890. The stage had been fitted with one of our patent metallic asbestos curtains, the fire originated in the auditorium and raged fiercely for several hours, but the whole of the stage and contents were saved by the curtain. The photographs of the walls of the theatre show the furnace heat to which they and the asbestos curtain had been subjected, and the piece of cloth I have here, which was detached from the curtain after the fire, shows very little injury.

Turning again to the processes of manufacture at Harefield, I said that in the sorting and opening department the long fibre suitable for spinning is separated from the shorter fibre suitable for millboard and boiler covering, and this brings me to the millboard department.

The manufacture of asbestos millboard is somewhat similar to that of ordinary cardboard. After some preliminary treatment, the asbestos fibre is run with water into the tanks of beating engines. Each of these tanks is provided with a rotating beater, which maintains a thorough circulation, taking up the fibre, opening and drawing it out, and then sending it forward to be soaked for a time until it comes round again to the beater. The binding ingredients are here added and thoroughly mixed with the fibre, when the pulp is passed into the vat of the millboard or paper machine, where it is kept in a state of agitation until gradually drawn off. The water passes through a fine wire gauze on a revolving cylinder, leaving a thin coating of pulp on the cylinder. This is then transferred by means of an endless band to a second rotating cylinder, where it gradually accumulates until the desired thickness has been reached. It is finally cut across and removed in the form of a square sheet of millboard. As the sheets contain a large percentage of moisture, they are next placed between

sheets of zinc and passed under hydraulic pressure and then hung in drying rooms. They are then again pressed and their edges trimmed, when their manufacture is complete.

In this process the chemical composition of the asbestos undergoes little if any change, and excepting the binding materials which have been added, chemical analysis shows the composition of the best millboards to be practically the same as the fibre from which they are made. It will be observed that nothing would be easier than to adulterate millboard pulp while in the beating engines, and large quantities of china clay and other ingredients are used by some manufacturers in this process. It has the effect not only of increasing the weight but also reducing the cost, to the detriment, however, of the finished material. I should not like to say how far the practice prevails in this country, but of one thing I am certain, it is not done at the works of the United Asbestos Company. I have here a specimen of our special A 1 quality of Italian asbestos millboard.

I now come to the boiler covering department, where the short fibre and powdery asbestos is worked up with other suitable ingredients into a non-conducting composition for covering steam boilers and pipes. Great improvements have been effected in this composition in recent years. The use of asbestos for this purpose has been criticised in some quarters lately, where it was desired to supersede it with other materials, and an attempt was made to show that asbestos was after all a bad non-conductor of heat. Now, after years of study of this subject, I may perhaps be allowed to say that much depends, firstly, upon the kind of asbestos used, and, secondly, upon the composition of the ingredients used with it for lightening it and for binding purposes. I venture to assert that with proper manipulation and application, asbestos composition will compare favourably with any other known material as regards its power as a non-conductor of heat, while its indestructible nature is certainly a point worth consideration.

The subject of covering steam boilers and pipes has, however, been brought into special prominence by the rule of the Board of Trade that all steam pipes and boilers of marine engines shall be tested by hydraulic pressure to double the working pressure at certain intervals. Before testing the pipes the lagging must be removed, but it is, I believe, in the discretion of the Board of Trade Surveyor whether or not the lagging of the boilers shall also be removed before testing.

This rule points to the desirability of producing a satisfactory removable boiler and pipe covering. The idea of making quilts or mattresses composed of asbestos cloth filled

or stuffed with non-conducting material is not new, for this was done by us years ago for non-conducting purposes. But the way in which these quilts or mattresses were prepared was somewhat defective, as the fibre or other material with which they were filled shifted its position, the result being that some parts of the mattress became choked and other parts empty.

This defect has now been removed by a simple arrangement which we have protected, and I have pleasure in showing you samples of this covering, which I hope will satisfactorily meet the requirements.

The weight of the covering is only 1½ lbs. to the square foot; it is easily applied, and may be removed and replaced without trouble. It has been carefully tested as a non-conductor, and found to give excellent results. We have already supplied several mattresses of this class to ship-builders in this country. The surface can either be painted like the specimens submitted, or they can be covered with sheets of zinc. The latter has been done in some of the cases to which I have referred.

I may here allude to asbestos paint, in which a considerable quantity of asbestos powder is used. These paints were patented by us and introduced in November, 1881, and are of two principal kinds.

First, Asbestos Fireproof Paint, suitable for rough woodwork such as joists, rafters, beams, stairs, warehouses, and wooden structures of all kinds. Numerous public experiments have been carried out from time to time, proving the remarkable fire-resisting qualities of this paint, the first being conducted under the patronage of the Lord Mayor and a distinguished Company at the Crystal Palace in January, 1882. I had the honour, two or three years later, of carrying out experiments at South Kensington in the presence of H.R.H. the Prince of Wales, the Executive President of the Colonial and Indian Exhibition, which were pronounced satisfactory, and nearly 150 tons of the material were used on the buildings of that and the Fisheries, Health and Inventions Exhibitions held in 1883-4-5-6.

At each of these exhibitions several small fires broke out at exhibition stalls, which might have proved very serious but for the protection afforded by the paint. I well remember one in which the fire occurred at a stall in a remote part of the buildings at four o'clock in the morning. The stall and contents were destroyed, and the wooden floor of the building burnt through; but the wooden partitions against which the stall stood, as well as the roof, both of which were painted, were scarcely injured. The paint was badly blistered, but the painted wood had not taken fire, as it

doubtless would have done under ordinary conditions and probably with disastrous results.

I might, if time permitted, mention many other instances where the spread of fire has been prevented, but will now briefly allude to the Asbestos Oil Paints. These are fire and acid resisting, but not quite fire-proof. One special kind, however, will be of interest to Marine Engineers, viz., asbestos funnel paint. It resists great heat, as well as the action of sea water. When first introduced in an experimental stage, it proved less satisfactory than could have been desired, but the difficulties have now been overcome, and its use is steadily increasing.

Will you bear with me while I refer to one other matter which I think will interest you. I refer to bunker fires. You may remember that Professor Lewes read a paper before the British Association in August last on the "Spontaneous Ignition of Coal." In the course of his remarks he said that bunker fires, which were becoming very frequent on some of the fast Liners, were due entirely to rise of temperature from the bunker bulkheads being too close to the hot-air upcast shafts from the boilers and furnaces, and he said that he thought the necessary safety could be obtained by having a thin water jacket between the smoke-shaft and the bunkers.

Now, it happens that a day or two before I was invited to prepare this paper, I had written a letter to the Editor of *Engineering* (which appeared on Saturday last) and the *Marine Engineer* on this subject (see Appendix), venturing to express an opinion that many practical difficulties would arise in connection with the fitting of efficient water jackets, and pointing out that the necessary safety might be economically obtained by a proper application of asbestos to the uptakes, funnels, and bunkers. I pointed out that this would not occupy more space than is usually occupied by the air casings or baffle plates which are generally fitted to these parts, and that it could be applied to any existing steamer (as it has in fact been already applied for the purposes of my experiments) without any alterations being made or room being specially provided.

With asbestos on the uptakes and funnels to keep the heat in, and on the bunkers to keep it out, and with ordinary ventilation of the space between the two, all risk of fire would be removed.

I shall be pleased to go more fully into this matter with any gentlemen who takes an interest in the subject.

If I were to refer to the numerous other articles into which asbestos is manufactured, I should only weary you. Twelve years ago only three or four distinct kinds of goods

were made; now we turn out over a hundred varieties. Asbestos twenty-five years ago was practically only known in the laboratory of the chemist or mineralogist. It now finds its way in one form or another into almost every workshop where steam is employed. I am being constantly asked to advise as to its suitability for a variety of operations, and it seems likely that its use will continue to extend.

APPENDIX.

FIRES IN BUNKERS.

The following correspondence on this subject appeared in *Engineering* for April 8th and 15th, 1892, and was read at the discussions following the reading of Mr. Fisher's Paper, on April 12th and April 26th :—

TO THE EDITOR OF "ENGINEERING."

SIR,—At the meeting of the British Association at Cardiff, in August last, a paper was read by Professor Vivian B. Lewes, on the "Spontaneous Ignition of Coal," and the following is an extract from the report of what took place.

"With regard to the bunker fires which are now becoming perilously frequent on some of the fast liners, Professor Lewes attributed them entirely to rise of temperature from the bunker bulkheads being too close to the hot air upcast shafts from the boilers and furnaces. In the course of a discussion which followed, pretty general agreement was expressed with the views of the reader of the paper. In reply to a question by Sir Frederick Bramwell, Professor Lewes pointed out that, in the case of coal bunkers in ships, the necessary safety could be obtained by having a thin water jacket between the smoke shaft and the bunkers."

The question of how to prevent fires in bunkers has engaged the attention of this company for a considerable time, and I venture to submit that the plan suggested by Professor Lewes is not the best—perhaps it may be the least practical—method of dealing with the difficulty. A far better result is conveniently and economically obtained by covering the uptakes, funnels, and bunkers with asbestos.

We have supplied a considerable quantity of specially prepared material to the Admiralty and mercantile navy for bunkers, &c., from time to time, and very good results have been obtained.

The lagging on the uptakes and funnels does not take up any more space than that usually occupied by the air casings or baffle plates which are usually fitted to these parts. Moreover, the lagging, being applied directly to the funnel, keeps the heat *in* the funnel (where it is of use) and prevents it from getting to the bunkers and other parts, where the excessive heat is not only useless, but generally of great inconvenience, and always a source of danger.

As the asbestos lagging occupies very little space, it can be

applied to any existing steamer without any alterations being made, or room being specially provided.

With lagging on the uptakes and funnels to keep the heat in, and lagging on the bunkers to keep the heat out, and with ordinary ventilation of the space between the two, all risk of fire would be removed.

We are of opinion that many practical difficulties would arise in connection with the fitting of efficient water jackets, and that they would require constant attention to maintain their efficiency, incurring a large expenditure, both in first cost and subsequent maintenance, besides which, we think that such an arrangement would, for various reasons, be very objectionable.

The method recommended is very easily applied, and when once fitted, requires absolutely no attention, unless subjected to unusual treatment.

Yours faithfully,
J. Alfred Fisher.

To the Editor of "Engineering."

Sir,—The United Asbestos Company's letter, in your last issue, is a very important one, and well deserving special attention.

If it be true that Professor Lewes suggested fitting water jackets to protect steamers' bunkers in order to prevent the coal from catching fire, it clearly shows that he has not had the experience which is required to deal with this very important and dangerous risk. It is not stated where he would fit the water jackets, but I presume, owing to the very irregular form of the uptakes, and the enormous expense and difficulty there would be in fitting water jackets round them, that the jackets would have to be fitted to the bunkers themselves. Unless the water jackets are applied direct to the funnel and uptake, the heat would not be confined, and the inconvenience of the heat would not be removed. In most steamers there certainly would not be room to fit water jackets independently of the bunker plates. If the bunker plates were not used to form part of the jackets there would have to be an additional thickness of plating, incurring additional weight. If the bunker plates were used to form part of the jackets, they would have to be made water-tight, and the first time the bunkers were filled the joints would be started and the water would leak out, because, unless the bunker plating were increased considerably in thickness, or even closely stayed, it would never stand the violent shocks to which it is subjected when coaling. It is not stated what water it is proposed to use for this purpose; if salt, the jackets would soon be filled up solid; if fresh, then evaporators, &c., would be required to supply it. The cost of the water jackets would be so great that it would not bear comparison with the plan suggested by the United Asbestos Company.

Any experienced man would see at a glance that water jackets are impracticable, and I feel assured that if this matter was clearly put before Sir Frederick Bramwell he would repudiate the impression given, viz., that he approved of the idea of fitting water jackets as being either economical or practicable. Fires

in bunkers are easily avoided by the simple means suggested by the United Asbestos Company; but there is another important advantage in the suggeston, which that Company has probably not realised. The heat from the boilers, and particularly the uptake and funnel on the one side of the bunker plates and the dampness of the coal on the other, lead to very rapid corrosion of the bunker plates. All experienced marine engineers know that unless these parts are preserved by frequent cleaning and coating they corrode very rapidly; to add a water jacket would be increasing the mischief enormously. Any reasonable steps which can be taken to reduce the rate of corrosion and the present necessary amount of chipping and coating of the bunker plates must be an advantage.

Lagging the uptake and the funnel with asbestos must prevent a large quantity of the heat from getting at the bunkers, and consequently tend to reduce the rate of corrosion; this I consider the best method of dealing with the difficulty, and I have obtained very good results from it.

The chief engineer of one of the steamers under my care frequently reported that his bunkers had been on fire, and though the fires were comparatively small, a considerable amount of coal was wasted, and I had to make costly repairs. Owing to the donkey boiler being close to the main funnel, the heat of the latter rendered it almost impossible to clean the former at the proper time, viz., at sea, consequently I had the uptake and funnel lagged with asbestos, and up to the present have received very satisfactory reports from the chief engineer. He states that no further fires have occurred, and that there is a great difference in the temperature, so much so that the captain has remarked the absence of the intense heat which previously escaped from the ventilators over the boilers, and the chief engineer also reports that the donkey boiler can now be cleaned without inconvenience. I think there is now a comparatively small chance of further trouble, and I expect there will be a reduction in the rate of deterioration of the bunker plates opposite these parts.

The space round the funnel referred to is not very confined, but in high-class passenger steamers, where the bunkers and funnel are very near together, I am satisfied the United Asbestos Company's suggestion of lagging the bunkers, as well as the uptake and funnel, would still further reduce the risk of fire and rate of corrosion. Asbestos is admirably adapted for this purpose, as it will bend to the form of the bunker plates without injury.

As fires are frequently occurring in bunkers, this is becoming a very important subject, and should receive careful attention. Apart from the great damage which is sometimes done by the fire, it is no small matter to have to combat with a bunker fire and drive a large steamer full speed at the same time; still I believe it has been done more than once, and without the passengers on board having the slightest idea of what was going on.

I am, Sir, your obedient servant,

FRED. EDWARDS.

62, Bishopsgate Street Within, E.C., April 11, 1892.

REMARKS ON ASBESTOS.

MR. JAMES WING.

(*Member.*)

A few months since I had six boilers and their main steam pipes covered with Bell's asbestos covering, two inches in thickness, resulting in a considerable saving in fuel, also a better command of steam, and there is no sign of the composition cracking; in the matter of four of these boilers, the stokehold temperatures showed as high as 140° previous to the application of the asbestos covering; since then it has ranged about and rather less than 100°, a material difference in point of temperature. Some years since I experienced the evil effects of the sheet asbestos on the shells of boilers, causing a rapid corrosion; this, I believe, is now obviated by a more careful process of manufacture, and for boiler covering I now appreciate it very much.

MR. R. DUNCAN.

(*Member.*)

I have listened to the paper and examined the specimens of asbestos now before us with great pleasure; but while agreeing with the writer that asbestos jointing, such as shown, is a good material for general purposes, I do not think it the most suitable under certain circumstances. I admit it makes a reliable joint in such as main steam pipes, where there is a regular pressure and flow of steam passing through, thus maintaining a fairly constant temperature. But in the case of steam winch pipes on deck, which are exposed to varying temperatures and are often full of water, caused by condensation, my experience is that an asbestos joint is very unsatisfactory, and does not last for any length of time. For such a joint I find that red lead and Taylor's patent corrugated metallic jointing is the most reliable.

MR. C. McEACHRAN.

(*Member.*)

The application of asbestos to the covering of boilers having been referred to, both in this paper and by a previous speaker, I should like to ask what effect it has on the shell plates of boilers so treated, also what would likely take place in the event of the composition getting wet, when exposed

to the weather, such as in donkey boilers placed on deck, or on unprotected boilers on shore. I am led to make these inquiries from observations I made some time ago in the Colonies, in which a boiler so exposed was found to be almost wasted right through when the covering was removed, and the greater part of the corrosion had taken place on the outside, beneath the covering. I have seen older boilers, when bared, not nearly so much corroded, and therefore I conclude there must have been something deleterious in the covering.

There is another point on which I should like to have some information, viz., as to the possibility of using asbestos as a protective agent for saddle corners, and other portions of the furnaces of boilers, which give trouble by leaking, owing to their exposure to the fierce heat when furnace doors are closed, and inrush of cold air when they are opened. I have seen a brick arch used for this purpose, but I think if asbestos could be utilized it would be a much better material, and might assist in removing the source of what causes considerable trouble to the marine engineer.

MR. W. W. WILSON.

(*Member of Council.*)

In continuation of the previous speaker's remarks, I would ask if it is not the case that asbestos of itself cannot be applied as a boiler covering, but that when used as such, it is mixed with some other material to enable it to be so used. In that case, even presuming that asbestos does not injure the plates, will not the other material have this effect? I have found that where millboard is used, it has a very bad effect on the bolts, and when these are removed I have seen them wasted about half through in many instances.

MR. W. BIRKETT.

(*Member.*)

In the paper and discussion we have been told that asbestos, for boiler covering, is a very good material; but there is one point, that regarding cost, which has not as yet been mentioned. I should like to know the price of asbestos as compared with other coverings in competition with it in the market, as at the present time first cost is specially considered. In view of recent regulations issued by the Board of Trade enforcing the removal of the covering every four years for the purpose of testing steam pipes, it is very important to know how asbestos stands in relation to other covering material, seeing that the expenditure involved has to be gone into so frequently.

Regarding steam pipe joints, my experience has been, that with anything like fair faces, asbestos will stand as well as

anything else. The rule I adopt is to steep the asbestos ring in boiled linseed oil and coat each side with black lead.

So far as efficiency goes, I certainly think asbestos good, but I should like to have more information as to its cost.

THE HONORARY SECRETARY.

The subject before us to-night has been brought forward in a very interesting manner, and its natural interest to us has been enhanced by the excellent samples and specimens which have been exhibited.

Asbestos, with the more recent developments in machinery, has become a necessity, and its introduction to the market in its various forms justifies the proverb that to everthing there is a time.

Some nine to ten years ago, when possibly the process of manufacture was much less nearer perfection than it is now, when also probably an inferior class of material was used, I had experience of some asbestos jointing, which, in a few voyages, had eaten almost through the bolts in the flanges of main steam pipes; this was not an isolated experience at that time. The experience of later years has been happier, and more confidence in asbestos, in respect to its action on iron and steel, has been the result, until now it is very largely used for steam joints.

In the presence of water or moist steam, the asbestos does not suit so well as where it is exposed to a dry heat, although that heat be very great.

I have noticed several cases of soft steel piston rods worn a good deal after using asbestos packing; in other cases again it appeared to do its duty without doing damage to the rods. It is difficult sometimes to account for the peculiar individualities of engines and portions of engines.

With reference to the covering of boilers, the usual practice is to cover only to the line of the fire bars. I consider it better to cover the entire shell, bottom included; it may be well to postpone doing so however, till a voyage has been made, so that the condition of the bottom seams and landings may be seen and caulked as necessary. If there is no leakage, well and good; if there is, the caulking can be done and tested before putting on the non-conducting covering. The covering of the bottoms of the shells is good for the boilers and good for the framework of the ship below them.

It is surprising to hear what a large percentage of rock has to be dislodged in comparison to the amount of asbestos gained; this fact accounts for the expense of working and delivering the crude material to the manufactory.

The asbestos-packed cocks are valuable additions to the older styles, and have come greatly into use of late years,

Dewrance's water gauge cocks for the boilers being great improvements over the ordinary brass cocks.

The asbestos boiler covering lasts longer than most of the other coverings in common use, but my impression is that the outer surface is not cooler, but otherwise, when put on to the ordinary thickness; the first cost is also somewhat greater.

THE CHAIRMAN (Mr. F. W. Wymer).
(*Vice-President.*)

I am very pleased to be here to-night to listen to this paper, and am much interested with the specimens of asbestos in its various forms, but especially so in those joints which we are told have been subjected to pressures of 2,500 and 3,500 lbs. per square inch. I would ask Mr. Fisher if these rings are suitable for steam joints; if so, it is very important to marine engineers.

With regard to the packing of glands, to which reference was made in the paper I think difficulties often arise owing to the shape of the neckbush, which is a point to which special attention should be given.

Another very important subject alluded to in the paper was that of bunker fires, and I am afraid the suggested water jacket will not be found a practical remedy. If asbestos will accomplish what is required in this respect there is a great future before it. I remember years ago being on board a steamer in which the boiler was put into the bunker, the sides of the boiler closely adjoining the sides of the bunker. As an inevitable result, the coals took fire, and in the end, spaces had to be blocked off around the boiler.

Before asking Mr. Fisher to reply to the various speakers, I would congratulate him on the paper which he has read before us to-night, and which, I think, we have all enjoyed.

MR. FISHER'S REPLY.

I thank you, Mr. Chairman and gentlemen, for the manner in which you have received the paper which I have had the pleasure of placing before you. I am also glad to notice the very kind interest you have taken in the subject, as evinced by the discussion.

With regard to the enquiries made by those who have spoken, I would first say that the rings referred to by the Chairman, which have been subjected to such high pressures as 2,500 and 3,500 lbs. per square inch, are perfectly suitable for steam joints.

Mr. Wing bears testimony to the success of the asbestos covering of which he has had experience, which I think is very satisfactory.

Mr. Duncan questions the suitability of asbestos jointing for all places, but he admits it is a reliable joint in the

generality of places. The pipes to which he refers, viz., winch pipes, exposed to varying temperatures, are possibly found to be difficult to keep tight with any joint, but the difficulty may be overcome by using "Victor Asbestos *Expansion* Joints."

In answer to Mr. McEachran, and Mr. Wilson, I would say that, wherever asbestos covering is intended to be used out of doors, we always recommend that it should have a good coating of paint or tar, so as to make it weather proof. With regard to the injury to boiler plates in the event of it being wet, this is not caused by the asbestos, but by moisture. Some time ago silicate of soda was used in the manufacture of some kinds of asbestos covering compositions, which under certain conditions would injure the iron plates. I am afraid I could not recommend asbestos for lining the furnaces of boilers as suggested by Mr. McEachran.

Mr. Birkett asks as to the cost compared with other boiler coverings. I can say that the cost of asbestos per square foot is only about the same as other well-known coverings. It is found, however, that owing to its more incombustible nature it lasts much longer, as remarked upon by the honorary secretary.

With regard to Professor Lewes's suggested water jacket for preventing bunker fires which I have mentioned in the paper, and to which the Chairman has also alluded, I would further add that some of the difficulties attending such an arrangement are the irregular form of the uptakes and the difficulty of fitting. In most steamers there is no room for water jackets independently of the bunker plates, and if the bunker plates are used the water will leak out when the bunkers are filled. Then, again, if salt water is used the jackets will become choked with salt, and if fresh water is employed evaporators will be required, which I do not think, on the score of economy, shipowners would care about.

ADJOURNED DISCUSSION, TUESDAY, APRIL 26TH.

THE CHAIRMAN (MR. J. H. THOMSON).

We have met this evening to discuss the paper read at the previous meeting by Mr. J. Alfred Fisher, on "Asbestos, with special reference to its uses in connection with Marine Engineering." Mr. Fisher is unable to be present, but Mr. Joseph Hawkridge is here to represent him, for the purpose of answering questions, or affording any further information that may be desired.

MR. HAWKRIDGE.

I may explain that Mr. Fisher's absence is owing to the death of Sir James Allport. It was often said that

the asbestos millboard joint would not stand moisture, which caused it to become a pulp; but a very singular experience has been reported with regard to a mill board joint that was supplied by one of the companies now amalgamated with the United Asbestos Company. A year or two before the amalgamation this company supplied a joint made from millboard, for the purposes of a water joint. It was a tremendous affair, several feet in diameter, and, strange to say, that millboard joint is still in use. It is a very remarkable circumstance, and they could not account for it, except on the supposition that this joint was made very tight, and so became waterproof. To obviate the difficulty due to the millboard not proving in all cases a watertight joint, an asbestos cloth has been made, and proofed with rubber. Afterwards there was made what is called the Victor metallic cloth, in which a fine brass wire is enclosed in the centre of every thread of asbestos, and joints made from this cloth have been tested up to pressures of 2,500 and 3,500 lb. to the square inch. In the course of his paper, Mr. Fisher alluded to the proposal of Professor Lewes, that bunker fires might be prevented by having a thin water jacket between the smoke shaft and the bunkers, and suggested that the necessary safety might be better secured by a proper application of asbestos to the uptakes, funnels and bunkers. This is a matter of special interest to marine engineers, and I would like to refer to the communications on the subject that have appeared in the *Engineer*, which have probably been read by many present. When this matter was under consideration a fortnight ago, a question was raised as to whether the asbestos covering for boilers, when, through exposure to the weather, it became wet, would injure the boiler plates. The answer to that is that the asbestos would not injure the plates. It was the water that did the injury, and the obvious way of preventing the injury is to see that the asbestos did not get wet: in other words, make the asbestos waterproof. Provided no moisture got to the asbestos, there could be no possible injury to iron or metal plates.

THE CHAIRMAN.

I may remark I first had experience of asbestos mill board some 18 years ago. At that time the price was 4s. 6d. per pound, and the manufacturers guaranteed 95 per cent. of pure asbestos, there being only sufficient pulp to make it into millboard. In the early days, therefore, they had this article as pure as it could possibly be got. With regard to Mr. Tait's remarks, I think it is expecting too much to look for asbestos to stick on the bottoms of boilers without bands or other means of support.

THE HONORARY SECRETARY.

It was a privilege to listen to the paper read by Mr. Fisher at our last meeting, and it appears to me that there has been great gain to those of our members who were present over those who were absent, in that the living words of the writer added a zest to the subject matter which is lost when the type has been set up.

The asbestos mines and the country around them, as described by the author, awakened both interest and a desire to visit the scenes depicted, and the poetic fervour with which Mr. Fisher introduced the subject at our last meeting made it most refreshing to listen to his description of the Italian asbestos fields, and it is hoped that he will deal in a similar spirit with the asbestos mines of Canada.

Some eight or nine years ago, asbestos had a very bad name for eating through steel and iron plates and bolts, but I believe that the asbestos covering and jointing material now supplied are of a different and better class. With regard to the packing of glands, and possibly the cutting up or scoring of rods of which complaint has been made, this arose, possibly, from the manner in which the packing was put into the stuffing boxes or the style of packing not being suitable for the rods. As asbestos packing expands by heat to a greater extent than ordinary packing, it is necessary to leave a good margin for expansion, leaving the gland easy and not tight. Recently it became necessary to take out of the recess the asbestos cord with which a cylinder liner had been packed; it hardly looked like the genuine article, and on being tested in the fire it burnt like cotton, that result confirmed the impression given by its appearance.

I have seen one or two main boilers partly stripped after having been coated with asbestos for five or six years, and cannot say that any abnormal corrosion has been noticed, that is to say, I have never observed that asbestos has eaten into the iron or steel plates any more than any other composition in the cases which I have examined.

A question was raised at the last meeting as to whether asbestos could be used for protecting the saddle plates and landings of furnaces; perhaps some members present might be able to give some information on that point. With regard to Professor Lewes's water jacket for preventing fires in bunkers, I am afraid there would be a great many difficulties in the way of carrying out the idea. It seems hardly a feasible scheme for practical working. There is a special arrangement with an asbestos mixture, in connection with side fire bars, to suit Fox's corrugated furnace tubes, which meets, to a certain extent, what was referred to, and the

principle can be applied to other portions of the heating surfaces with advantage; this remark has reference to Mr. McEachran's question.

MR. HAWKRIDGE'S REPLY.

Some years ago silicate of soda was used as a binding agent for asbestos coverings for boilers, and would not expand in the same proportion as the boiler plates, the result being that it cracked. But we have learned by experience, and I would undertake to say that the material now put on by the leading asbestos companies should stick, and will be found an economical and efficient boiler covering. Some two years ago we were asked to cover the under part of two main boilers on a steamer, and to put iron plates over the covering. We obtained an estimate for the iron plates, but the cost was found to be so heavy that the asbestos was put on without the plates, and the last time I inquired as to how the covering was going on I learned it was answering all right. With plenty of fibre in the material, and a good binding agent, we have had no difficulty for years past in making the covering stick. With regard to asbestos packing, we sometimes get complaints of the scoring of rods, but I think the reason has already been indicated. In eight or nine cases out of every ten it was due to the packing being too tightly screwed up. A question had been asked as to the possible use of asbestos for standing the impact of flame. We have given attention to that matter, and endeavoured to manufacture a brick, partly of asbestos and partly of clay, but it was found that the two materials were not homogeneous enough, and did not behave in the same way under the influence of heat. The result was that after a considerable outlay the company discontinued those experiments. On the question of the cost of asbestos covering, I can only remind you that there are many boiler coverings in the market, and that asbestos is constantly being ordered by engineers and others in preference to other materials. Of course, there is some difference between the cost of asbestos covering and cement, but I have no hesitation in saying that, in the long run, asbestos would be found the cheapest and the most efficient. An asbestos covering for boilers made in the form of removable blankets could be supplied at from 1s. 9d. to 2s. per square foot. It would last for years, and could be taken off the boiler and replaced quite easily.

In answer to Mr. Nicoll, an asbestos boiler covering could also be supplied at from 10d. to 1s. per square foot. This article would contain from 80 to 90 per cent. of pure asbestos.

ADDITIONAL REMARKS BY MR. FISHER.

Since attending the meeting of the Institute on April 12th, I have had, by the courtesy of the Hon. Secretary, an opportunity of perusing the reports of the discussions which have taken place, and desire again to express my thanks to the members for the way in which my paper, so hastily prepared, has been received by them.

It is gratifying to see that efforts made by manufacturers of asbestos, to meet the requirements of marine engineers, are appreciated, and that the nature of asbestos, as well as the advantages to be gained by its use, is so much better understood now than formerly. If the material had been better known fifteen years ago, prejudices against its use, still occasionally met with, would not exist. Packings were then introduced in a very imperfect state of manufacture, and in using them engineers did not make allowance for expansion caused by the steam. Consequently, the material was often condemned when a proper conception of its capabilities would have elicited praise. It is now generally admitted that, given a good make and quality of asbestos packing, excellent results may be, and are obtained by its use. The same remark applies to pipe jointing, referred to by Mr. Duncan. Expansion and contraction are provided for in some of the asbestos jointing materials now applied. Whilst nothing could be better than Italian asbestos millboard for dry steam joints, combinations of asbestos and India-rubber are largely employed for wet steam, and, as I have pointed out, for hydraulic joints under regular working pressures of 700 to 900 lbs.

Unfortunately, excessive competition has led to much adulteration. This was amusingly illustrated by the Hon. Secretary, to whom we are indebted foy valuable contributions to the discussion. I have referred to the adulteration of millboard, and might also mention boiler covering daily offered under the name of "asbestos," but which does not contain more than 10 to 15 per cent. of that material in the form of fibre, which often *shows* well, but is very misleading as to the real character of the composition.

It is absolutely impossible for much asbestos to be used, without a loss to the manufacturer, in compositions offered at from sixpence to ninepence per square foot super. The best qualities will cost from 1s. to 1s. 6d. per foot, according to steam pressure and thickness of the material, and if a really satisfactory and durable job is wanted, it will pay well to go to the higher prices.

With respect to the question of corrosion of boiler plates raised by Mr. McEachran, frequent inspections have been

made of boilers and pipes, which were covered with Italian asbestos composition by my Company, without the slightest trace of corrosion being found, and I see no reason to modify the opinions on this subject expressed by Mr. Hawkridge and myself in the course of the discussions.

On the question of the prevention of fires in coal bunkers, an interesting discussion took place at a meeting of the Society of Arts in March last. I had not the advantage of seeing a report of this discussion before preparing my paper for the Institute, and may now add that Professor Lewes pointed out that the temperature close to the outside of bulkheads is often as high as 200° F., whilst inside, the temperature would be about 120° F.

Although this is far below the igniting point of coal, Professor Lewes remarked that if coal, with a tendency to absorb oxygen next the bulkheads be kept at 120°, it would run a great chance of igniting within a few days ; and further, that all that is necessary to prevent spontaneous ignition under these circumstances is to reduce the temperature of the bulkhead in contact with the coal from 120°. to not exceeding 82° to 90° F.

Now, as it is a common thing for surface temperature to be reduced from 300° to 80° or 90° F. by the use of asbestos, my contention is that a thin covering of the same material, suitably prepared, on the uptakes, as well as on the outside of the bulkheads, would be a far simpler, less expensive, and more reliable safeguard than the water jackets recommended by Professor Lewes, and is based on reliable data.

I observe, also, that Sir Frederick Bramwell, who occupied the chair at the meeting of the Society of Arts, then expressed the opinion that double bulkheads would be very costly to make and keep water-tight, and would take up a great deal of space. It was admitted, he said, that no one would use them except under the pressure of legislature.

These objections certainly cannot be urged against asbestos. It has, as a matter of fact, been employed for the purpose named, and with very good results.

Plans have now been prepared showing the method of application, and I shall be happy to forward one to any member or friend of the Institute who desires further information.