air chamber consists of a number of capsules 9 in. in diameter, and ⅛ in. high, soldered together as shown, the knife-edge bearing stem S, vent V. Glycerine seal and other parts will be readily understood by the drawing.

Fig. 9 is another form of air chamber which occupies very little space above the eggs. It is made entirely of thin sheet tin plate or brass; the center is a box of 1½ in. square by 6 in. long. On the two sides are punched four 1 in. holes. Into these tubes are soldered, the outer ends of which are capped, or otherwise securely closed. These should be as long as the incubator space admits of. In the center of the top of the box is a hole, *s*, into which the tube, S, is soldered.

Other forms of air chambers may be used, but these here given are simple, have a very large metal surface, and occupy little space. In all cases where air chambers are used, the colder or more dense the air is when it is sealed in by the cup and glycerine seal, the greater will be the expansion when heated; but if in any case sufficient expansion, or power, cannot be had from air alone, the addition, when cold, of a few drops of any of the fluids before mentioned in connection with capsules will accomplish the purpose.

THE DISPOSAL AND UTILIZATION OF BLAST FURNACE SLAG.*

By Mr. WILLIAM HAWDON, of Middlesbrough.

Production of Slag.—While it is sometimes difficult to realize a profit in disposing of the pig iron produced from the blast furnace, it is almost always difficult to avoid a loss in getting rid of the slag made in conjunction with the iron. In other words, it is only under exceptional circumstances that the slag can be sold as a useful commodity and a profit be made from it. As a rule slag has at a certain cost for labor to be tipped over more or less valuable land, which is thereby covered up and wasted; or in some cases it has to be carried quite a way from the locality of the blast furnaces, at a further cost of carriage. Thus the disposal of slag from the blast furnace has almost always entailed a cost which has had to be reckoned in the manufacture of pig iron; and when it is borne in mind that about ten million tons of slag are made yearly in Great Britain, it wil at once be seen that the aggregate amount of this cost is enormous, and that the subject is well worthy of attentive consideration.

Uses of Slag.—In some few localities a profit is realized by selling slag as a material for road making. It is first of all run in its molten state into balls, formed in the usual boxes, and carried away on bogies, from which it is tipped; when cool it is broken into pieces of the requisite size and sold at whatever profit can be obtained. At a few blast furnaces bricks for paving are made, but only to a limited extent. Where the traffic is not too heavy they are found to stand fairly well, as in stables and stable yards, and in the back streets of towns; in Edinburgh indeed some of the better streets are paved with them, notwithstanding that granite can be obtained near at hand. Slag is also cast in various forms, such as channels for water courses, curbs for footpaths, etc. Glass has been made from it in small quantities, but the author believes not on a commercial scale. The whole, however, of the slag utilized for all other purposes than road metal amounts to only a very small percentage indeed of the total quantity of slag made in the country.

Previous Modes of Disposal.—In the Cleveland district, where probably some 3¾ million tons of slag are made per annum, the question of its disposal has received somewhat serious consideration, and has been solved in one of two ways; either land has been purchased at a high price, from £400 to £1,000 per acre; or the slag has been sent out to sea in hopper barges, and there deposited in deep water. In the early days of iron manufacture, slag used to be run into holes dug in the sand of the pig bed, into which a stake of iron had been fixed; and when the slag was set the lump was lifted out by a crane laying hold of the stake. Sometimes the slag was run into channels made in sand or ashes, and was afterward broken up by hand. But with the subsequent larger makes from the blast furnaces it was found impossible to clear it away by these means. Cast iron boxes were then placed to form moulds for the slag to run into, and iron bogies were run underneath them to carry them away; or the sides of the boxes were themselves mounted on bogies which formed the bottoms of the boxes. The slag is thus conveyed away in balls of 2 to 4 tons; when it is cool, the frame or sides of the box are lifted off the bottom by a crane, the bogie is drawn away to the tip, and manual labor is employed to bar the balls off, in order either to level up uneven ground, or to build up a mountain, which is carried to a great height, so as to cover as small a base as possible on the costly land.

When sent to sea, the slag had to be broken up by hand, and wheeled barrowful by barrowful into the hopper barge. But this was such costly work that means were devised for breaking up the slag balls by fixing in the center of the bogie a hollow casting; the idea being that, when the mass of slag cooled and contracted round this casting, the ball would break up into pieces small enough to be tipped into the barge without much injury to the vessel. The hollow core was cast about one-third the width of the ball, and was fixed firmly on the top of the bogie; and when the box or frame was placed on the bogie, the slag was run into the space surrounding the core. It was found in practice, however, that this also was too costly a procedure. The central castings soon became burnt and cracked and broken, and repairs were found to be heavy. Moreover, the slag balls did not break into small pieces, and occasionally into only two or three large heavy pieces, which wrought havoc to the plates of the barges, springing the joints so that the pumps had to be kept constantly going to keep the water out; and often a hole was smashed through the plates and the vessel disabled by a heavy mass of slag, falling as it did down a shoot placed at the height necessary for loading at high tide, and thus acquiring an additional fall of 14 or 16 feet when loading at low water. The idea of the central hollow core or casting for causing the slag to break up in cooling was no doubt a good one, and the plan was certainly an advance on the old method of breaking up the balls by hand.

In some few instances the American plan is adopted of running the slag in flushes into a "boat" or tank on wheels, lined throughout with fire brick; or simply into a ladle placed on a truck. In either case the slag is merely run or tipped out of the vessel containing it. If intended for further removal, it is run from the tank or ladle on to cast iron plates, so as to form layers of slag, which can afterward be removed by hand when cool. The cast iron core was first introduced by Mr. J. A. Birkbeck at the Acklam Iron Works, Middlesbrough. The hollow casting was made double pear-shaped in plan, and of the full height of the slag ball, with the finer ends or knife edges toward the front and back of the bogie, so that when the bogie was tilted up, the slag, which had already cooled and cracked through contraction round the core, was cleft in two or more pieces, and fell into the barge. But these pieces were too large and heavy to be thrown with safety into the vessel. A vast amount of thought and money was expended by Messrs. Cochrane & Co., at the Ormesby Iron Works, Middlesbrough, in their endeavors to bring to a successful issue this method of breaking up and loading the slag. They introduced as a central core what they called a "hog back" casting. By this plan the slag was broken up into much smaller pieces than by Mr. Birkbeck's. After the slag had been run and had solidified, the bogies were placed under a series of perforated pipes, from which sprays of water played on the top of the still hot mass; the sudden cooling assisted in cracking the balls, which contracted round the hog backs. But although not so costly as the old plan of breaking the balls by hand labor and wheeling the slag into the barges, it was not satisfactory, the wear and tear, especially of the hog back core, being very great. This method has now been abandoned, and replaced by the apparatus about to be described.

At the Normanby Iron Works, Middlesbrough, where also the slag is sent to sea, Mr. Edwin Jones has built iron bogies with wrought iron sides about 15 inches high, and widening outward from the bottom. These are filled with slag, and when it is sufficiently cooled are run up to the slag shoot, and tipped up bodily so as to shoot the block of slag out, and let it fall upon knife-edged iron castings, by which it is broken up into somewhat large pieces; these then roll into the barge, or into a large hopper shoot fixed so as to store about 100 tons of slag. Still, however, the pieces are too large for the safety and wear of the barge. Several mechanical contrivances have been designed to deal with molten slag, the earliest probably being that of Mr. Thomas Bell, at the Walker Iron Works, near Newcastle-on-Tyne. As there was little land adjoining the works, he designed about 1871 or 1872 a machine for running the slag into such small pieces as could be readily handled and tipped into barges at the wharf adjoining the works, and thence sent to sea. The slag was run into a series of cast iron trays, each about 3 feet wide, which were fixed on an endless horizontal belt traveling a distance of about 12 feet. When the slag was sufficiently set or cooled, water was played on it to cool it further, and it was then tipped into trucks. For some reason unknown to the writer this apparatus was abandoned.

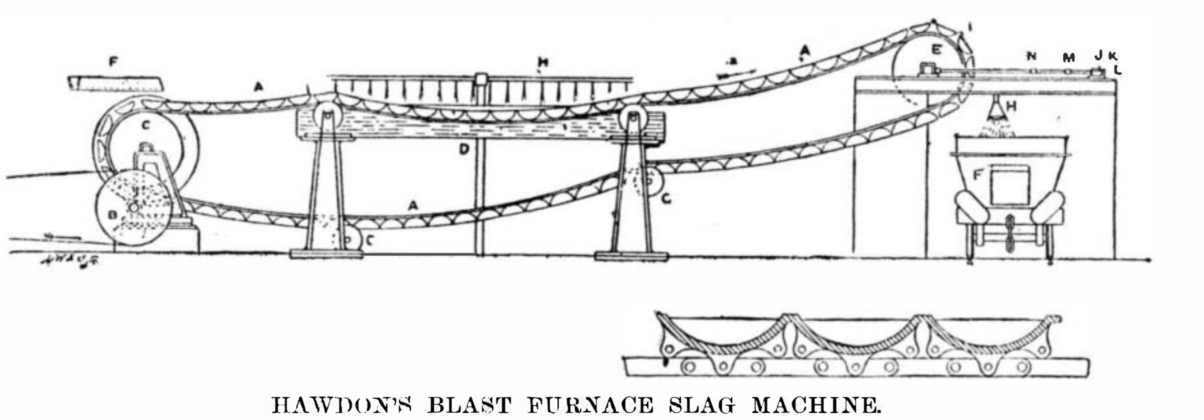
In 1873 designs were submitted to the Cleveland ironmasters by Mr. David Joy, who read a paper to the Cleveland Institute of Engineers, describing his plans, none of which, however, so far as the writer is aware, were put into practice. One idea was to have long endless belts running from the furnaces to the river for shipment. The belts were to consist of iron plates one-fourth inch thick, fixed on iron ropes; it is needless to say that those would have been too light to resist the action of molten slag run upon them. Another design was for disintegrating the slag by running it into water, out of which it was to be dredged by an arrangement of buckets. Other designs were also drawn out for running the slag into moulds fixed on the inner side of a horizontal wrought iron drum, which revolved on small rollers: the idea was to assist the cooling of the slag by means of water jets, and to carry it in the moulds nearly up to the top of the circle described by the revolution of the drum, and then to tilt it out into a trough shooting it into trucks. An experimental machine constructed on this plan could not deal with such a large flow of slag as was discharged from the furnaces of that date, and it does not appear to have been put into practical use.

Utilization of Slag.—To the utilization of slag a good deal of attention has been given by Mr. Charles Wood, of Middlesbrough, by whom several machines have been designed for dealing with it in this direction. In a paper read before the Society of Arts in London in May, 1880, Mr. Wood described several appliances which he had designed with this object. The first is a machine for making "slag shingle," and consists of a horizontal annular table about 16 ft. diameter, which is formed of segments or cooling plates about 2 ft. wide, made of cast iron, and having wrought iron pipes cast in them, through which water flows. While the table is revolving slowly, the molten slag is run upon it, and spreads out to a thickness of from three-fourths to 1 in. When it has traveled about 10 ft. and has consolidated, water is run upon it to cool it further; and then a set of scrapers push the slag off into iron wagons, into which it falls in small pieces. This machine is largely used for making concrete.

Another machine is for making slag sand, and consists of a wheel or short drum, the outer rim of which is trough-shaped and about 14 ft. diameter, revolving on a horizontal axle. Into the lower part of the trough-shaped rim, of which the opening faces inward or toward the center, water is run to a depth of 18 or 24 in., and into this water the molten slag is run, where it forms into a spongy sort of sand. Perforated shelves or elevators are fixed radially across the trough at intervals all round the wheel, and in passing through the water carry away the sand and lift it to the top of the machine, where it drops into a spout and is shot out into wagons. This sand has been extensively used for making concrete bricks which are useful for structural purposes; some millions have been sent from the Tees to London for house building, and have sometimes been sold at a profit at as low a price as 10s. or 11s. per thousand. In many parts of the country cement mortar is made from slag in this condition, and is very tough and durable.

Another form in which blast furnace slag has been usefully applied by Mr. Wood is that of slag wool or silicate cotton; and he appears to have been the first to manufacture it in this country on a commercial scale. The process is interesting and extremely simple. According to his own description in the paper already referred to, a jet of steam is made to strike upon the stream of molten slag, as it flows from the usual spout from the furnace. The steam scatters it into shot, and as each shot leaves the molten stream it draws out a fine thread; just in the same way as when treacle is touched lightly with the finger, it is drawn out into a fine thread. On losing its heat the fine thread of slag drawn out by each shot becomes set like glass. The shot itself being heavy drops to the ground, but the light thread is sucked into a large tube by an induced current of air. The finer qualities float about and settle near the outside of the chamber, while the heavier or larger fibers lie chiefly in the center. The wool is then ready for use, and is packed in bags for sending away. It is principally used for covering boilers or steam pipes, for which purpose it is peculiarly adapted, being a splendid non-conductor of heat and incombustible. As only one-quarter of a cwt. is made from each ton of molten slag operated upon, it will be seen that the process is not a very rapid one.

Endless-chain Slag Machine.—The disposal of slag by mechanical means engaged the writer's attention more particularly in the year 1885, when all the land available for slag tipping at the Newport Ironworks of Sir B. Samuelson & Co., at Middlesbrough, had been pretty well filled up. He then designed the apparatus illustrated above. A A are two endless chains, made of long steel or iron links, which are fastened together by pins or rivets. B is the primary driving shaft, driven by a small engine, or if more convenient by a belt. The endless chains pass over a pair of pulleys at C; they are driven from the shaft, B, by geared wheels, and cause the chains to travel in the direction shown by the arrow. The pans which carry the slag are fixed on the chains. They are shown in cross section in the smaller illustration. They are ninety in number, and are each made in three pieces, and are bolted on the chains, A, by means of two lugs cast on the bottom. The slag is conveyed from the furnace by means of the trough, F, from which it flows in a molten state into the pans as they travel beneath it. The pans then pass through the water trough, D, after which the slag is still further cooled by being sprinkled with water from the perforated pipe, H. Finally, in passing over the pulleys, E, the slag is tipped out of the pans into a shoot discharging into wagons beneath. For taking up any wear on the chains, a worm wheel and screw fixed at J are connected by links, K, to the pulley shaft, E, whereby the chain can at any time be tightened as required.



HAWDON'S BLAST FURNACE SLAG MACHINE.

At the Newport works the eight machines are each driven by a steam engine with single 5 inch cylinder; but only about half its power is really necessary for driving them. The chains are run at slightly varying speeds, according to the output of slag, the average rate being about 13 ft. per minute. The eight machines together deal with 1,000 tons of slag per twenty-four hours. In the water trough, D, into which the pans dip down with the chains after passing the bearing pulley, G, the water is kept at a level reaching about two-thirds up the sides of the pans, and being kept boiling by the heat, a certain portion of it usually splashes over into the pans and assists in cooling the slag; but this is not essential to the process. Two or three trucks are kept in reserve on a slight incline, so that when one truck is full another is lowered into its place without stopping the machine. The trucks are made with bottom doors, or with side or end tip, to suit the particular requirements of the works where they are employed.

At casting time the slag which may follow the iron at the end of the cast is run into cast iron troughs, and when cooled is broken up by the slagger and thrown into the trucks, so that bogies and boxes are dispensed with in the general working of the blast furnace when these machines are employed. There is thus a considerable saving in labor, and in wear and tear of machinery and material employed in the disposal of slag from ordinary blast furnaces. Burst balls of slag,

* Paper read before the Institution of Mechanical Engineers, February 5, 1892, with discussion thereon.—*Iron.*

which might burn up the sleepers and roads and cause labor, are unknown. It is now no longer necessary to bar the balls off the trucks at the tip; and the constant repair, renewal, and shifting of rails and sleepers on the tip are now unnecessary. Two men per shift do the whole of the work required for the disposal of 6,000 to 7,000 tons of slag per week at the Newport works, with one locomotive per shift, which is assisted on the day shift only for one half the time by a second locomotive, thus averaging 1¼ locomotives per shift, in place of three locomotives when tipping on a mountain of slag. The enormous wear and tear of bogies and boxes due to hot slag is now done away with; and the wear on locomotives is reduced to a minimum, the dust and dirt due to the old method being dispensed with.

The slag is run into the pans about 1 to 2 inches thick, and breaks up into pieces from the size of a nut to a few pounds weight. It is largely used for road making, especially for the foundation of new roads. For concrete, being already small in size, it requires little further breaking to render it suitable, and for this purpose it has been found to be particularly adapted, some thousands of tons having been used for the walls of piers, wharves, etc., and also for the walls of buildings.

Experiments are now being made on a large scale with the view of using it extensively in the manufacture of cement, and it would appear likely to be largely used in future for the purpose. Not that it is a new idea to use slag for cement making, but the form and consistency into which it is run and manipulated in this apparatus adapt it in a special manner for cement manufacture. The slag is annealed or tempered in passing through the water, and that made from hematite iron, for instance, which contains a high percentage of lime, does not fall away into dust, as it otherwise does when run into balls and exposed for a short time to the atmosphere. In some districts vast quantities of ballast are brought for miles, and obtained in the first instance at some cost, for packing the sleepers of railways, which actually run past the very furnaces where the slag can so easily be made useful for the purpose. On the Northeastern Railway, which forms a network throughout the Cleveland and Durham districts, ashes from the ironworks and coke ovens are universally used. This ballast retains a lot of rain and surface water, and tends to rot the sleepers, and where steel sleepers are used, nothing is more injurious and wasting. Were this slag used wholly or in part as ballast, a drier and more lasting road would be the result. On many railways the larger class of ballast is used entirely, and in some cases slag is the material chosen. There appears therefore to be a wide opening for the use of this material, which in most localities is at present a nuisance and a source of expense.

The apparatus now described is a simple contrivance having probably no great merit as a mechanical device; but few things are more difficult to deal with than the force of expansion and contraction in metals, especially when brought about rapidly and with continuous alternations. This is the case at blast furnaces in any mode of dealing with the slag, and particularly so when artificial cooling is resorted to, and though at last simplicity has now been arrived at, a good deal of time has been occupied and many devices tried, before the desired result has been reached. Wear and tear, consequent on the rough usage which such apparatus is necessarily subjected to, require to be met by special consideration in the design of the different parts. Cheapness of manipulation being a matter of vital importance in iron manufacture, any apparatus or any method of treating the materials which realizes this object lays claim to the best attention not only of the makers of iron, but also of engineers generally, by whom this metal is so largely employed in all their works.

DISCUSSION.

Mr. Joy produced some drawings, which he said he had placed before the ironmasters of Middlesbrough in 1871, in reference to the removal of slag. He said he had spent most of the summer in that year in examining the various methods by which slag was treated, and coal and other materials manipulated, in Hartlepool, Liverpool, and elsewhere. The first proposal which he brought before the ironmasters was that of a couple of steel ropes carrying little buckets. Another plan was to take the slag into large wheels, as shown in one of Mr. Hawdon's diagrams. The wheel received the slag at the bottom, and when it was nearly at the top dropped it over into a hopper, from which it slipped into the wagon. So far as it went the machine was very efficient. There was another of the same construction, only horizontal. In both machines the slag was treated with water, which made it boil into a sort of scum, so that it broke very readily. Another plan was a sort of ejector. Something of the same kind had been used by Mons. Boulanger in France to carry away the slag in the form of sand. He (Mr. Joy) thought that by blowing a current of air in the slag spout the slag would be carried away while fluid and dropped into spheres and practically thrown away as sand. It did so; but it left a residuum which was the terror of every one about the place—a little tail that was afterward found to be the right thing for making silicate of cotton, which was a very valuable product. Messrs. Wilsons, Pease & Co. took up the other wheel and paid him a royalty. The ironmasters formed a committee to decide which was the best plan to adopt. Several plans were tried, but the Tees Conservancy, wanting slag for their breakwater, offered to take an enormous quantity. The ironmasters then declined to put their capital into the concern and it dropped to the ground. The labor, however, was not wasted, because a great deal had been learned. For himself he came to the conclusion that one of the wheels was better for each furnace, because if a wheel was wrong it could be taken away and another put in.

Mr. Jeremiah Head said that the greatest consumption of slag for any useful purpose in the Cleveland district had been for the making of breakwaters, especially by the Tees Conservancy. Large blocks had been made artificially, and floated out, weighing, he believed, about 250 tons each; but even these in a heavy sea were sometimes found to have been slightly shifted. The breakwater had been once or twice damaged, but the interstices had been filled up, and he believed it was now in a good condition. Another was being made in the same way. At Hull also embankments and other structures were being made of slag. With regard to the heaps of slag taken some miles out to sea, although the heaps might rise to a great height, it was found that they quickly spread about as soon as a heavy gale occurred. He had been one of the unfortunate directors of a company formed for making bricks of slag sand by mixing it with lime and pressing it into moulds. But although from an engineering point of view the bricks seemed to be very successful, getting harder as they grow older, the affair was not a financial success, and it was finally wound up. He believed that the manufacture of slag wool was still carried on by Wilsons, Pease & Co. It was composed of very fine threads, and was very good as long as it was new. It was silicious, and had good non-conducting properties. He had seen some taken off the tops of marine boilers after some time, and a curious effect was produced. The heat of the boiler seemed to anneal the little films, and they settled down into a very close, compact mass, looking like a lump of glass. He should doubt whether it fully retained its non-conducting qualities. The annealed bricks were an important industry. They were formed by running molten slag into iron moulds, and then, before they got cooled, running them into a kiln and allowing them to cool about ten or eleven hours. The effect was to make them exceedingly hard. If the moulds were allowed to cool quickly in the open air they would fly to pieces. The bricks were very useful where a road crossed a footpath, or in some by-streets in towns where there was not a great deal of traffic, and where they could be used for paving right across, making a nice, clean finish. He believed that some of them had been sent to London, although he had never seen any laid down in the streets. Several attempts had been made to make slag into Portland cement, and apparently with good results. The late Mr. John Fowler, the Tees Conservancy engineer, had a strong belief in cement made in that way. A Swedish gentleman named Larsson had proposed to grind the slag to an exceedingly fine impalpable powder, to make a hard-setting cement. His method was to put it into an iron cylinder with a number of spherical balls inside, which, tumbling over and over among the material, ground it very fine. That, however, was not a commercial manufacture at the present time. He thought that Mr. Hawdon's apparatus had been brought to a great state of perfection, and was doing its work perfectly well, taking the stuff away as fast as it was made, and putting it into trucks in a form in which it could be removed at once. There were hardly any men about it, and there did not seem to be any great wear and tear, or any considerable quantity of water used. The method only wanted to be better known to get into almost universal use.

Mr. Marten said that there was a great quantity of slag in the district of South Staffordshire. The great use made of it was in the pitching of streams. Almost a hundred miles of pitching had been done entirely with broken slag, in whatever pieces they could get it, using it as mere surface pitching, and they were surprised to find how exceedingly well it stood. It was a great deal better than bricks, which often perished in a frost. There were places which had been done ten or twelve years, and were in the same condition as at first, although they had looked very unpromising at the time. In some of the older ironworks a number of walls had been built with the slag, and so long as it was not disturbed they remained very well, but if one block fell out, it generally tumbled into small pieces. For the purpose of foundations it was nearly useless, because it fell to pieces so easily. He had been surprised that the Northwestern and Great Western Railway Companies had put up large shops for breaking slag into small pieces for ballast, which was done at great cost. He was also surprised to see the enormous heaps of very fine slag which it was said were useless, but it was certainly useful in road making or path making. If it was worth while to use slag of such fine material for ballast, it would surely be worth while not to let it get into large lumps to be broken up again, but to treat it as described in the paper. He was one of those who thought that, although the paving bricks might be very sound and lasting, they would make a very rough road for horses and pedestrians.

Mr. Perry F. Nursey said he had seen many of the methods in use for the utilization of slag. The most obvious method, he supposed, was that of breaking it into small lumps and using it for road metal. He had seen slag applied in that way at Middlesbrough some years ago, but it was not successful, and it was very damaging both to horses and vehicles. He had also seen walls built from slag balls, which were very beautiful and solid, but beyond that he believed the erection of walls did not go. With reference to the use of slag for ballast on railways, he had seen in Germany and France a simple method of disintegrating the slag by simply running it into a stream of water, after which it was shoveled aside and put into trucks and used for ballast purposes, for which he imagined it would be very useful. Some thought that it might become too rigid in the course of time. It might be too solid for the high speeds in England, but probably it would not affect the lower speeds in vogue on the Continent. He had been interested in seeing slag wool made. It had a very beautiful appearance, the whole of the shed in which it was made and the screens on which it was blown appearing as if covered with fresh snow. At Barrow a large addition to the steel works had been formed by tipping slag into the sea. The same thing was also going on at the new Dowlais works at Cardiff. It was not tipped into the water there, but the land was being raised to a high level by the use of the slag obtained from the furnaces. In the same way it had been very judiciously utilized at the Clarence works, where a very large area had been added to the property. It was interesting to watch the development of anything that would prevent the increase of slag heaps, and the apparatus described in the paper appeared to be one that was working satisfactorily in that direction.

Mr. Tomlinson said that nearly all the large railways were now coming to use slag. All the railways in Wales near the ironworks were entirely ballasted with it. Unfortunately, however, it lasted so long that the railways did not get rid of all that was made.

Mr. Bauerman said that the system of making large blocks was a great mistake. The true principle undoubtedly was that of the older system of furnaces, running the slag into small masses, and getting it away as quickly as possible—a plan that seemed to be carried out in a very perfect manner in the machine described. It was wonderful to see the large furnaces in the enormous works in Cleveland making such great quantities of cinder and disposing of it. The best plan was the American one of heaping, running it over the ground. The great thing was not to have too much cinder. He was very much pleased to see the system adopted in South Wales, where they took a very small quantity in an ordinary ladle, such as that used in taking metal to a Bessemer converter; then running it over the ground it could be run out in small quantities of more than half an inch or three-quarters of an inch, so that it would set very quickly. It could then be broken up and handled as conveniently as gravel or ballast. The machine described by the author appeared to be based on a thoroughly good principle.

Mr. Hawdon, in reply, said he could not help thinking that the thin plates of the machine referred to by Mr. Joy would soon be burned through. With reference to Mr. Head's remarks as to the "unfortunate" company that made slag bricks, he had understood from Mr. Wood that it was a great success, and that the reason why it was abandoned was that the Northeastern Railway Company bought the land. With regard to the pier built at Mr. Hutchinson's works, it had been stated in a paper read before the Society of Arts that 85 or 90 per cent. of the Cleveland slag was used in the cement. It was made into a sort of sand, and not in the manner described in the paper. He had been told by some manufacturers that they greatly preferred it made in the form of the specimen he had exhibited, which was much more easily dealt with. Instead of being in fine sand and filled with water, it was perfectly dry and very easily ground. There was no doubt an enormous waste in throwing slag away. There were twelve million tons of slag made per annum, and the great bulk of it, in many parts of the world, was entirely wasted. The machines at Newport made about 1,300 tons of slag per week with one of the furnaces, and the machine described in the paper dealt with it. The cost of it was about £200 or £220, and the cost of producing the slag, without including the locomotive drivers, was about 2s. 8d. per ton of iron, or 1·3d. per ton of slag. As to the American method of using slag at the Dowlais works, the objection to it was that the trucks were sculled very much, which required a great deal of labor and cost. They had also to break up the slag after it was run into fine layers.

Professor Kennedy said that it was obvious that Mr. Hawdon and his coadjutors and predecessors were anxious to do with iron what had been done with gas and one or two other matters, viz., to make a material which could be sold for nothing because so much profit was made out of the by-products. They had not quite reached that point, but in the meantime, to every one who made a practical step toward it, the whole engineering world was indebted.

CAST IRON.

ON February 11, Mr. Thomas Turner delivered the fourth of his course of lectures on the above subject in the chemistry lecture theater of the Mason College, Birmingham.

The lecturer remarked that castings were sometimes made from iron taken directly from the blast furnace in the fluid condition. But this method was only used to a very limited extent, and was becoming relatively of less and less importance, as irregular results were obtained, owing to the variations in the character of the iron made in a blast furnace from day to day, or even from hour to hour. So that even when founders are also ironmakers it is the custom to remelt the pig iron after its uniformity of character has been checked by fracture, or by analysis if necessary. On the small scale, for special purposes, gas furnaces are convenient for melting cast iron, but their use is limited, as the cost of gas is generally too high to allow of the application of gas on any considerable scale. Wind furnaces with fireclay crucibles and coke for fuel are in use in many cases were small castings are made; and where great uniformity is necessary a reverberatory or air furnace is employed. But in the vast majority of cases a small blast furnace, called a cupola, is used, as it is cheap, rapid, and easily managed. The coke should be hard and as free from sulphur and ash as possible. The amount of coke used will depend on the quantity of iron melted in a given time, and on the construction of the cupola. It may be reduced to as little as cwt. of coke per ton of iron melted. Usually, however, from 2 to 3 cwt. is employed. In addition to the simple form of cupola so long in favor a number of improved varieties have been introduced during the last few years. In Germany the Herbertz cupola has met with much favor, but has not succeeded in making its way in this country. It is worked with a steam exhaust, instead of with a forced blast, as is usual. Where large quantities of metal of uniform quality are needed, a cupola with a receiver or mixer is to be preferred, and Stewart's "Rapid" answers very well.

As the applications of cast iron are almost indefinitely numerous, and despite the competition of steel appear to increase rather than diminish, the difference in form and variety of moulds is very great. The most general material used for moulding is green sand, a black mixture to be found in every foundry, and which gets its name from the fact that it is used in the raw or unbaked condition. For special purposes dry sand, loam, or cast iron moulds are needed, but the Staffordshire district is famous for green sand moulding for brass, iron, and other metals, and for the improvements in details which have been introduced in order to allow of the production of a large number of the same class of patterns in the shortest time. Moulding machines are now being rapidly introduced into many branches of the trade where there is much repetition of simple forms, and it is stated that by this means the cost of moulding can, in some cases, be reduced to about one sixth of what it formerly cost. The effect of remelting cast iron varies with the character of the metal and with the method of melting. It has been frequently supposed that iron was improved by being melted and kept in the fluid condition, but Mr. Turner's analyses of the test pieces prepared by Sir W. Fairbairn have shown that the effects obtained can be fully explained by the chemical changes that took place, and that the