and conveying sand and similar material, and many have a capacity of over 30 tons per hour.

Belt or Band Conveyors were devised in their present form as the results of experiments conducted about the year 1868, to determine the most suitable type for the conveyance of grain. They consist simply of a continuous flat band of four or six-ply cotton duck, protected against wear by the application of various coatings, generally rubber and oil compounds, and running over a series of flat pulleys. For the conveyance of grain an entirely flat belt has proved successful provided the grain is fed on to it in a proper manner, but as a rule the top or carrying part of the belt is hollowed by being run over specially placed rollers, the lower or return hold being carried in a flat position. The arrangement of such conveyors is clearly shown in Plate XXI., Fig. 6, the one with the belt removed showing the carrying pulleys and driving gear, the other showing the conveyor in operation handling coke. (Plate XXI., Fig. 7). These belts travel at speeds between 400 and 600 feet per minute—the slower speed being required when light grains are to be handled. The capacity of the type and the small power required may be judged by the fact that an 18 inch band 100 feet in length, and, travelling at a speed of 500 feet per minute, would convey 50 tons of grain per hour, and would require power at the rate of 4.5 h.p. With care and attention a good conveyor belt should last from three to five years—depending upon the class of material to be handled. This type is in very general use for handling coal, grain, lime, cement, sand, ores, bagged material, and small boxes, etc.

The last type of conveyor that we can consider is that known as the Continuous or Travelling Through type, and primarily consists of a series of overlapping pans attached to the conveyor chain links, thus forming a continuous trough or channel. The whole is supported in the usual manner by wheels running on a suitable track. This type has one advantage over the push plate conveyor in that it causes less breakage to material, but it obviously can only be used for terminal delivery. The speed of travel is usually from 60 to 120 feet per minute, and inclines of 15 degrees with the horizontal are quite usual, and even up to 45 degrees, in which latter case the sections of the conveyor are each provided with projections to prevent the material from sliding back. In general, the cost of installation of conveyors lies between £1 10s. and £6 per foot run depending upon the type adopted and the conditions of service. The cost of repairs and renewals per 100 feet of traverse per ton handled lies between 1-20th of a penny and ¼th of a penny for coal and such materials, the cost increasing largely where hot or acid materials are dealt with; hot coke necessitating an expenditure of 1d. to 2d. on repairs and renewals per ton per 100 feet run, and such materials as sulphate of ammonia anything up to 4d. per ton.

Coming now to a consideration of those appliances in use for the intermittent handling of material, we shall first consider Cranes, which in their many and various forms comprise by far the greatest percentage of such appliances.

This general class "Cranes" may be subdivided into the following main types:—

(a) Overhead Travelling Cranes.
(b) Gantry Cranes of both Bridge and Cantilever type.
(c) Jib Cranes, both fixed and travelling.
(d) Locomotive Cranes.
(e) Derricks.

There are also numberless appliances which cannot be directly classed under any of the above headings, but which all belong to the general class of "Cranes."

Overhead Travelling Cranes.—One or more such cranes can nowadays always be found in any large foundry or machine shop, operated by either hand or power, usually electric, the latter being always preferred where quick handling is required. Such cranes have in the past generally been installed and operated by either direct applied steam engines or by power conveyed to the crane from a steam engine through the medium of a square revolving shaft, or a travelling cotton ropes.

But all these latter types have, wherever possible, been superseded by an electric drive, this latter being the more economical in power, very much simpler in operation, and costing less for maintenance and repairs; and it is safe to say that 90 per cent. of the power driven overhead cranes now built are operated electrically. Whatever the nature of the "power" may be, in general such cranes consist of a pair of bridge girders placed transversely to the span to be covered and carried on each end by suitable two-wheeled frames travelling upon a pair of elevated rails running one on either side of the length of the building or space over which the crane has to operate. Each bridge girder carries a rail usually upon its top flange, upon which runs a crab or "Travelling Winch," the lifting gear being usually located upon this winch. In the first replacement of direct steam square shaft or rope operated cranes by electrically driven machines, it was usual and natural to operate the whole of the motions from one electric motor through suitable friction or other clutches, but since it is these latter appliances that are the chief source of trouble in these cranes it has become the universal custom now in all modern well-designed electrical cranes to operate each of the three motions; that is, the travel, the traverse, and the lift, by an independent motor, and further, in the case of cranes of large power to equip them with an auxiliary and independent set of lifting gear operated by a fourth motor. In this way the use of all clutches, sliding gears, etc., is avoided, with a resultant reduction in running expenses and repairs, and a considerably increased simplicity and ease in operation. As a rule in such cranes the whole of the operations are electrically controlled by an operator who is carried in a cage located at and suspended from the main crane girders, at one end and to one side, so as to interfere as little as possible with the movement of the crab, and also so located that the operator has his load in full view at all times. Most of you are familiar with small cranes of this type, but he had a few illustrations of installations of a heavier character, which he thought would be of interest. The first, Plate XXI., Fig. 8, a 150 ton equipment, provided with two 75-ton crabs for together handling a length and heavy load, such as a locomotive. The operator's cage, independent motors and general arrangement could be all clearly seen, the whole crane being a typical example of up-to-date crane practice. Plate XXI., Fig. 9, shows a somewhat similar crane of 125 tons capacity handling a locomotive. Plate XXII., Fig. 1, shows two 30 tons four motor electric travelling cranes handling a 60-ton locomotive in the Government Workshops of Western Australia. These cranes were part of an equipment of twenty-four that were installed under his supervision in that State, and the method of conveying the electric power from the controllers in the operating cage to the travelling winches could be clearly seen in each case. The auxiliary hoists could also be seen, this appliance being invaluable in the rapid handling of the lighter portions of the locomotives. These cranes were operated by three phase motors, and it is to be noticed that two independent cranes are engaged in one lift. The completely synchronous operation of the two cranes was also very noticeable in the travelling of a load so suspended from one end of the shop to the other, it never being in the slightest degree necessary to adjust the speed of either crane whilst travelling.

Plate XXII., Fig. 2, shows a typical ship-building berth equipment, in which two overhead travelling cranes are in use with the operator's cage located in the middle of each. The extremely neat and efficient application of travelling jib cranes may also be seen upon either side and below the others. With such an equipment, the various lifting operations required in the building up of the ship's hull can be quickly and conveniently dealt with, it being possible in the case shown to operate six cranes simultaneously.

Of late years the extraordinary increase in the operating speeds of the various motions is very noticeable —American practice being very advanced in this respect. Where a few years ago a 10-ton overhead crane of good design had a lifting speed of 10 feet per minute, and trolley traverse of 60 feet per minute, the main bridge travelling at speeds not exceeding 120 feet per minute, a modern American crane of equal capacity has a lifting speed of 30 feet per minute, cross traverse at the rate of 100 feet per minute, and a bridge travelling speed of from 350 to 400 feet per minute. It is needless to point out the enormous increase in crane capacity with the latter equipment in all such cases as will allow of the use of the higher speeds.

Before leaving the consideration of overhead travelling cranes, he would like to illustrate one more example of a somewhat modified and very ingenious design. It consists of an overhead travelling crane of ordinary design (Plate XXII., Fig. 3), except that the load is handled from an "all-round cantilever jib" suspended from the ordinary traversing crab. By this arrangement the one crane can not only serve the whole area between the longitudinal crane rails but can also cover the ground for a distance of 20 feet on the outside of the main crane tracks, the combination of cantilever jib and cross traverse crab enabling any load to be projected between the main building columns on either side. As a last and rather instructive illustration of the capacity of modern overhead cranes he would point out the size of crane bottom block and hook as fitted to a 150-ton crane, an ordinary 3-ton hook being shown also for comparison (Plate XXII., Fig. 4). The overall length, 10 feet 3 inches, and the weight, over 5 tons, are to be noticed.

We come next to a brief consideration of the type known as Gantry Cranes, which are primarily designed for outdoor operation, and to travel when so required upon rails laid down at ground level, thus obviating the necessity for overhead crane tracks, and thereby reducing first cost, particularly when long "travel" is required, and also maintaining the space over which the crane is to be operated free from all permanent and fixed obstructions. Such cranes belong generally to one of two types —Bridge Cranes and Cantilever Cranes. Sometimes a combination of both is used. The first named type closely resembles the ordinary overhead travelling crane with the one main alteration, that the bridge and trolleys are extended down through suitable framing to travel upon a track at the ground level, thus doing away with the necessity for overhead crane ways. For many years past hand-operated cranes of this type have been in use, mostly with heavy timber frames, but during the past 10 or 15 years a great development of the type has taken place, such cranes now being built of steel, with a bridge span frequently exceeding 300 feet, the whole of the operations being electrically driven by independent motors. The type is clearly shown in Plate XXII., Fig. 5. The extremely neat steel construction in the machine is worthy of note. In the earlier machines of this class, the bridge and pieces were rigidly attached to the bridge, with the result that inequalities in the track or slight variations in the rate of speed of the two pieces produced severe racking strains throughout the structure. In the more modern designs the bridge is pivoted one end to one pier and suspended from a sheer at the other, with the result that neither faulty track alignment nor unequal rates of travel in any way strain the structure nor interfere with the satisfactory operation of the machine. Such cranes are frequently built having a capacity up to 10 tons, with a trolley speed of from 800 to 1200 feet per minute, and bridge speed of over 500 feet per minute. All the operations are under the control of one operator, located usually on one of the fixed piers, the even travel of both piers being maintained through cross shafts with universal joint connections and frequently with sprocket chain drive. Typical American Gantry Cranes are shown in outline in Plate XXII., Fig. 6. To suit certain sites, one leg of the gantry is frequently brought in from the end of the bridge, the traversing crab being arranged to travel to the extreme overhung end, through the specially designed pier, as shown in Plate XXII., Fig. 7, and from this type has been developed the cantilever gantry crane, in which both piers are brought within some 20 to 30 feet of one another, the bridge thus being practically replaced by two cantilevers. This is clearly shown in Plate XXII., Fig. 8 and 9, which represent typical British and American examples. Frequently the double cantilever of these cranes is arranged to swing round a centre pivot, thus greatly increasing the flexibility of the appliance. They are frequently built with a total overall length of 350 feet, and a load capacity of 10 to 15 tons, and to increase the stability of the structure the counterweight is generally arranged to automatically travel in the opposite cantilever to that from which the load is suspended. An interesting modification of the cantilever crane is shown in Plate XXIII., Fig. 1, illustration of an Electric Transport Roof Crane, which has been designed for travelling upon the outer face of the roof of wharf buildings, thus leaving the whole of the wharf below clear of obstuction. Of recent years the question of loading and unloading ships and particularly those carrying such materials as grain, coal, and ores, has demanded and received a vast amount of consideration and thought, and as a result a number of appliances have been devised for quickly and efficiently performing this work, the Temperley Company in England and the Brown Hoisting Company in the United States being particularly eminent in this class of work. For want of time he could only consider these appliances in the briefest manner, but no doubt from the diagrams those who were not familiar with these machines would readily realise their mode of operation. These special appliances, usually known as "Transporters" or "Unloaders," in general consist of a beam suspended from a suitable sheer, and upon which runs an automatic traveller operated by means of wire ropes from an engine or motor located in the sheer frame. From the traveller is suspended an automatic dumping skip or grab or bucket, depending upon the class of material to be handled. The machinery employed in their operation is extremely ingenious, and allows of the complete control of both the closing and opening of the grab bucket, as well as of their transport, thus enabling friable material such as coal to be handled in the gentlest possible manner from ship to dump or truck or vice versa. Each unit is frequently built to handle material up to a capacity of 250 tons per hour, groups of such units being arranged side by side where the quantity to be dealt with is very great. Usually they are so designed that one man controls the whole of the operation. A typical example is shown diagramatically in Plate XXIII., Fig. 2, from which the method of operation can clearly be realised. In this type the beam upon which the automatic traveller runs, is one of the fixed horizontal cantilever type, and such is also the arrangement in Plate XXIII., Fig. 3, which shows a similar plant in operation. It has been found, however, that a considerably greater flexibility of operation is obtained by suspending the beam upon which the traveller runs in such a manner that its inclination to the horizontal can be varied at will. In this way the shore end can be raised above the out end, as the shore dump grows, or vice versa. Such an arrangement is shown in Plate XXIII., Fig. 4, of a floating coal depot for coaling vessels in Portsmouth Harbour. The inclined beam can be clearly seen with a traveller at its outer end, and Plate XXIII., Fig. 5, shows this plant in actual operation, taking in coal, in which the equipment of four transporting towers may be seen. Such a vessel can coal two ships at once without occupying valuable wharf space, and has the further advantage that the coal is always stored under cover. In such a plant coal can be handled up to a capacity of 700 to 800 tons per hour. The particular equipment shown was built for coaling British war vessels in or around Portsmouth. Plate XXIII., Fig. 6 and 7, shows three typical illustrations of similar appliances by the Brown Hoisting Company. A somewhat modified type for handling miscellaneous material required in the construction of the Panama Canal is shown in Plate XXIII., Fig. 8. In this case also the elevation of the outer end of the cantilever can be varied at will. This has been specially designed to accommodate vessels lying at a port at which the tidal variation exceeds 20 feet. The boom is 80 feet in length, and in the position shown will deliver goods from the vessel's side at high-tide and land them within the warehouse door.

In dealing generally with bridge cranes, he desired to point out that in such structures it was advisable to attach the bridge to the piers in a flexible manner so as to avoid severe racking strains. Such an arrangement even further developed is shown in Plate XXIII., Fig. 9, of a grab bridge transporter. In this design the flexibility of the suspension has been so increased as to allow of the piers being moved along independently of one another until the bridge lies as much as 10 degrees out of square. In this way coal can be taken from one fixed position, such as a ship's hold, and distributed over a very large area of ground, or vice versa.

We come now to a consideration of another class of crane, the Revolving Jib type, which may be either fixed or travelling. This type must be familiar to all of you, but from want of time he could but briefly show various illustrations of typical modern examples, those selected representing cranes of a size and type rarely seen in this country. The first(Plate XXIV., Fig. 1) shows a 100-ton Hydraulic Crane with direct acting cylinders suspended from the jib end, also equipped with an auxiliary high lift gear of 30 tons capacity for masting ships, etc. This type is in use in British naval dockyards up to 150 tons capacity, both electrically and hydraulically operated. Plate XXIV., Fig. 2 shows a fixed revolving electrically operated crane of the Fairbairn type, of 20 tons capacity. Plate XXIV., Figs. 3, 4, and 5 show a type of Jib Crane known as the "Hammerhead" variety, which is very largely used for dockyard work, particularly in Germany. All these examples show cranes of 150 tons capacity, and each is electrically operated with an independent motor for each motion. Plate XXIV., Fig. 6, shows a somewhat similar type of hydraulically operated coal storing cranes as used by the Midland Railway Company of England. This crane commands an area of 17,500 square feet, giving a storage of approximately 400,000 cubic feet, the revolving jib having a maximum radius of 75 feet. The whole of the operations, for operating the crane and controlling the coal boxes, are commanded from the cabin on the crane pillar. Our next four diagrams show typical Jib Cranes, differing only from the first considered in that they are mounted upon wheels and can either propel themselves or be hauled from one part of the wharf or yard to another. Plate XXIV., Fig. 7, shows a typical steam driven self-propelling yard crane of 30 tons capacity. Plate XXIV., Fig. 8, a modern Hydraulic Coal Crane that can be hauled along the wharf as required. This crane is shown carrying a loaded railway coal truck, which can be turned upside down and its contents thus discharged, as shown in Plate XXIV., Fig. 9. This type, which has been installed in many depots, is now being largely replaced by special coal transporters and unloaders, sinces these latter, where they can be applied, are both more speedy and economical. Plate XXV., Fig. 1, shows a type of travelling Jib Crane known as the "Titan" class, and has been very largely installed for dockyard and jetty construction, in the setting of large concrete and masonry blocks. Our last two classes of cranes, namely, Locomotive Crane and Derricks, need only brief mention, since both are types of which we have numerous examples in this country. Of recent years many locomotive coaling stations have been equipped with Locomotive Cranes operating the Priestman or other similar type of grab for the unloading of coal from the railway waggons into the elevated bunkers from which it gravitates into the locomotive tenders. This system is now largely in use in the Government Railways of Western Australia, and has resulted in considerable economy in coaling operations. Plate XXV., Figs. 2 and 3, show plants of this character, the former being practically the same as that adopted in Western