beit travels. Thus the two horizontal shafts need not be parallel, the vertical shaft transmitting motion from the first horizontal shaft to the conveyor. This conveyor is usually about 25 ft. long in both 60 and 100 ton apparatus. Sometimes, as we have said, there is substituted a telescopic shoot constructed of steel plates, and about 30 ft. long, opening out in 10 ft. lengths. This, of course, can only be used when the vessel is lower than the top of the trestle of the conveyor.

Two 60 ton machines are not infrequently mounted upon one barge, in which case the power plant consists of a horizontal multitubular boiler, 7 ft. 6 in. in diameter by 7 ft. long, furnishing steam to two small horizontal steam engines, each with two cylinders, 7 in. bore by 12 in. stroke, the actual power required for both machines not being more than 20 indicated horse. The 100 ton machine is driven by a horizontal steam engine with two cylinders 9 in. bore by 15 in. stroke, steam being supplied by a horizontal multitubular boiler, 7 ft. in diameter by 7 ft. 6 in. long. The actual power required for driving a 100 ton machine is not more than 15 indicated horse. The engine drives a shaft with bearings on the deck of the barge, and extending the whole length of the railway on which the trestle is traversed. Power is transmitted from this shaft by wheels and detachable chain to a second shaft, fixed as shown on the traveling trestle. Similar chain gearing drives the shaft on the derrick arms, whence power is derived for the swiveling of the derricks, for driving the conveyor and the bucket chains of the elevator, as well as of the fixed elevator. Detachable chains are used in all cases, and where there are vertical drives tension wheels are introduced. For driving the fixed elevator power is taken from the same shaft to a shaft at the top of the trestle, which also drives the conveyor, extending over to the hatch of the ship. The sprocket wheels are all of steel. Inside the elevators the chain is of $2\frac{3}{4}$ in. pitch in the case of the 60 ton apparatus and 3 in. in the 100 ton plant. The drive chain is 3 in. pitch, but the main drive from the engine shaft is $3\frac{1}{2}$ in. pitch. The chains in the 60 ton elevator are constructed for a working strain of 850 lb., and in the 100 ton machine 1,500 lb.

On a platform of the trestle is a crab driven by two belts from the main shaft, so fitted as to give reversing motion, with one fast and two loose pulleys. All the wheels are of steel, the bearings of gun metal; sprocket gear is preferred, as it is unaffected by weather. All timber subject to the wearing action of the grain is steel-lined. The trestle wheels are driven by spur and pinion gear; the gauge is usually 10 ft., and there are four wheels. The barges themselves are from 60 ft. to 100 ft. long, from 15 ft. to 20 ft. wide and about 10 ft. deep.

A special feature is that the apparatus is bolted to the deck, and that the grain is conveyed from one barge to another or on shore; and thus, instead of the band conveyor from the movable elevator, there is a steel telescopic shoot delivering into a hopper under which there passes a band conveyor which is led to the barge or on shore. The distance the grain may thus be conveyed is not limited, as several belt conveyors can be laid one under the end of the other. The order carried out by Messrs. Stott in this case was for conveyors to traverse 95 ft. from the foot of the elevator.—Engineering.

PHOSPHOR BRONZE.*

By MAX H. WICKHORST.

BRONZE is an alloy of copper and tin. Phosphor bronze is bronze containing varying amounts of phosphorus, from a few hundredths of 1 per cent. to 1 or 2 per cent. Bronze containing simply copper and tin is very liable to be defective from the presence of oxygen, sulphur, or occluded gases. Oxygen causes the metal to be spongy and weak. Sulphur and occluded gases cause porosity. Oxygen gets into the metal by absorption from the air. It can be eliminated by adding to the metal something which combines with the oxygen and then fluxes off. Such deoxidizers are zinc, antimony, aluminum, manganese, silicon, and phosphorus. Sulphur and occluded gases can be eliminated by melting the metal, exposing it to the air and letting it thus absorb some oxygen, which then burns the sulphur and gas. The oxygen can then be removed by adding one of the above-mentioned deoxidizers. The important use of phosphorus in bronze is therefore to remove oxygen and also indirectly to destroy occluded gas and sulphur.

At the C., B. and Q. R.R. brass foundry, at Aurora, Ill., we make a bronze with an extra high percentage of phosphorus, namely, 6 per cent. We make this alloy so as to have phosphorus in convenient form for use, and the process of manufacture followed by us is as follows: 90 lb. of copper are melted under charcoal in a No. 70 crucible, which holds about 200 lb. of metal when full; 11 lb. of tin are added and the metal is allowed to become hot. The crucible is then removed from the furnace and 7 lb. of phosphorus are introduced in the following manner: A three-gallon stone jar, half full of dilute solution of blue vitriol, is weighed. Then the weights are increased 7 lb., and phosphorus in sticks about 4 in. long is added till the scales balance again. The phosphorus is left in this solution half an hour or longer, the phosphorus being given a coating of copper, so that it may be dried and exposed to the air without igniting. We have ready a pan about 30 in. square and 6 in. deep, containing about 2 in. of water. Over the water is a wire netting, which is laid loose on ledges or supports along the inner sides of the pan. On the netting is blotting paper, and on this the phosphorus is laid to dry when taken out of the blue vitriol solution. The pan also has a lid which can be put down in case of ignition of the phosphorus.

We now have the phosphorus ready for introduction into the metal. This is done by means of a cup-shaped instrument called a retort or phosphorizer. One man holds the retort on the rim of the crucible in a horizontal position. A second man takes about three pieces of phosphorus and throws them into the retort. The first man then immediately plunges the mouth of the retort below the surface of the metal before the phosphorus has a chance to fall or flow out. •

course the phosphorus immediately melts and also begins to volatilize. As the phosphorus comes in contact with the metal, it combines with it. This process is continued till all the 7 lb. of phosphorus has been put into the metal. The metal is then poured into slabs about 3 in. by 4 in. by 1 in. thick. The metal is so hard that a greater thickness would make it difficult to break it up. When finished, the metal contains, by analysis, 6 per cent. of phosphorus. When we wish ordinarily to add phosphorus to metal, we do it by adding a little of this hardener.

Copper is a soft, ductile metal, with its melting point at about 2,000 degrees Fahr., or 1,100 degrees Cen. Molten copper has the marked property of absorbing various gases. It is for this reason that it is so difficult to make sound castings of clear copper. Molten copper combines readily with the oxygen of the air, forming oxide of copper, which dissolves in the copper and mixes homogeneously with it.

A casting made from such metal would be very spongy. The bad effect of oxygen is intended to be overcome by adding zinc to the extent of 1 per cent. or more. This result can be much more effectively attained by the use of aluminum, manganese or phosphorus. The action of these substances is to combine with the oxygen, and as the product formed separates and goes to the surface, the metal is left in a sound condition. Aluminum and manganese deoxidize copper and bronze very effectively, and the oxide formed goes to the surface as a scum. When a casting is made from such metal, the oxide or scum, instead of freeing itself from the casting perfectly, generally remains in the top part of the casting mixed with the metal, as a fractured surface will show. Phosphorus deoxidizes copper, and the oxide formed leaves the metal in the form of a gas, so that a casting made from such metal shows a clean fracture throughout, although the metal is not as dense as when aluminum or manganese is used.

Copper also has the property of absorbing or occluding carbon monoxide. But the carbonic oxide thus absorbed is in a different condition from the oxygen absorbed. When oxygen is absorbed by copper, the oxygen combines chemically with the copper and loses its own identity as a gas. But when coal gas is absorbed by the copper, it keeps its own physical identity and simply exists in the copper in a state of solution. All natural waters, such as lake water, river water, spring water, etc., contain air in solution or occlusion. When such water is cooled and frozen, just at the time of changing from the liquid to the solid state, the dissolved gas separates and forms air bubbles, which remain entangled in the ice. The carbonic oxide which is dissolved or occluded in copper acts in exactly the same way.

Hydrogen acts in exactly the same manner as carbonic oxide. Sulphur also has a bad effect on copper and bronze. Sulphur combines with copper and other metals, forming sulphide of copper, etc. When molten copper or bronze containing sulphur comes in contact with air it absorbs some oxygen, and this in turn combines with the sulphur present, forming sulphur dioxide, which is a gas which remains occluded in the metal.

Tin is a soft white metal, melting at 440 degrees Fahr., or 230 degrees Cen. Toward gases it acts something like copper, but not in so marked a degree. Although copper and tin are both soft, yet when mixed they make a harder metal. When bronze cools from the molten state, the copper and the copper tin alloy tend to crystallize by themselves. The quicker the cooling occurs the less separation will there be, and also the fracture will be more homogeneous in appearance.

Gun bronze contains copper and tin in the proportion of 9 or 10 parts of copper to 1 of tin. This is the metal used where an ordinary bronze casting is wanted. A harder bronze is copper and tin in the ratio of 6 to 1. This is often used as a bearing metal. When either of these metals is to be turned in the machine shop, they should contain about 3 per cent. of lead, which will make them work very much better, but it also decreases their tensile strength. Bearing metal now generally contains about 10 per cent. of lead, with copper and tin in varying ratios. The large percentage of lead is put in that the metal may wear away slower. Lead, although a metal having properties similar to tin, acts entirely different toward copper. Copper and tin have a good deal of affinity for each other, but copper and lead show no attraction at all for each other. Copper and tin mix in all proportions, but copper and lead mix only to a very limited extent. About 3 per cent. of lead can be mixed with copper. With bronze about 15 per cent. to 20 per cent. of lead can be mixed. In bearing bronze the lead keeps its own physical properties, so that the constituent lead melts long before the metal attains a red heat. It sometimes happens when a bearing runs warm that the lead actually sweats out and forms pimples on the metal. Or sometimes in re-melting a bearing bronze casting the lead may be seen to drop out while the metal is warming up. All of these metals, however, should contain something to flux or deoxidize them, such as zinc, manganese, aluminum, silicon, antimony or phosphorus.

The phosphor bronze bearing metal in vogue at Aurora has the following composition: Copper, 79.7 per cent.; tin, 10 per cent.; lead, 10 per cent.; and phosphorus, 0.3 per cent.

Melt 140 lb. of copper in a No. 70 pot, covering with charcoal. When copper is all melted, add $17\frac{1}{2}$ lb. of tin to $17\frac{1}{2}$ lb. of lead, and allow the metal to become sufficiently warm, but not any hotter than is needed. Then add 10 lb. of "hardener" (made as previously described) and stir well. Remove from furnace, skim off the charcoal, cool the metal with gates to as low a temperature as is consistent with getting a good casting, stir well again, and pour. The moulds for this kind of work are faced with plumbago.

There are several firms that make phosphor bronze bearings with a composition similar to the above one, and most of them, or perhaps all, make it by melting the metals and then charging with phosphorus to the extent of 0.7 to 1.0 per cent. But I have found some metal from all brands that I have tried that contains occluded gas. So that after such metal is cast, in about two minutes or so, the metal will ooze or sweat out through the gate, and such a casting will be found to be porous. But I have not yet had one such experience with metal made as I have described above. My

explanation for the imperfections of metal made by adding phosphorus direct to the final mixture containing occluded gas would be this: The phosphorus as it is charged into the metal still contains a little moisture, and at the high temperature of the molten metal the phosphorus takes the oxygen from this water, leaving the hydrogen to be absorbed by the metal.

But this practical point should be heeded, viz., that pig phosphor bronze should be brought to the specifications that the metal should have shrunk in the ingot mould in cooling, as shown by the concave surface of the upper side, and that it should make a casting in a sand mould without rising in the gate after being poured.

In bearing metal, occluded gas is very objectionable, because the gas, in trying to free itself, shoves the very hard copper tin compound (which has a low melting point and remains liquid after the copper has begun to set) into spots, and thus causes hard spots in the metal.

Phosphorus is very dangerous to handle, and there is great risk from fire with it, so that many would not care to handle the phosphorus itself. But phosphor copper containing 5 per cent. of phosphorus, and phosphor tin containing 2 to 7 per cent. of phosphorus, and several other such alloys can be obtained in the market. I would suggest to those who wish to make phosphor bronze, but do not want to handle phosphorus itself, to make it by using the proper amount of one of these high phosphorus alloys. In using phosphorus it is only necessary to use enough to thoroughly deoxidize the metal, say 0.3 per cent. More than this will make the metal harder, but not any sounder.

In the course of the discussion Mr. Wickhorst stated that phosphor bronze shrinks very little. He expressed the belief that the pure copper castings used in electrical work are made with the aid of silicon copper.

THE FIRST ENGLISH ARMOR PLATE ROLLING.

In a sketch of the life work of Sir John Brown, the eminent English iron and steel manufacturer, The Engineer gives the following account of the first armor plate rolling in England:

"It is Mr. Brown's custom to go on the Continent every autumn. In 1860, on his way home, he returned by Toulon. There was no little commotion in the place that day. The French ship *La Gloire* had put into the harbor. This ship was a wooden 90 gun three decker. The French had cut her down into a sort of magnified corvette, armed her with forty heavy guns, and clothed her with hammered iron armor $4\frac{1}{2}$ inches thick; the plates were each five feet long and two feet wide. This 'new departure' in men-of-war put our admiralty in a fever. Ten 90 gun and 100 gun timber built ships were at once stopped in their construction, the intention being to make them so many British editions of the French craft. Sir John tried to get on board the ship. He was not allowed. Inspecting the vessel very closely through his glasses, his quick eye detected that the hammered armor had a cobbled look, rough, like a rubble wall. He felt sure he could do better than that. Convinced that he could roll a plate superior to anything that could be hammered, he went back to Sheffield and set to work. He put down a rolling mill, and experimented incessantly until he achieved his purpose. At a meeting of the Institution of Mechanical Engineers, Sir John read a paper, in which he gave a description of the method of rolling a five ton armor plate. As the first authoritative account of armor plate rolling in England, an extract is worth preserving. Here it is: Several bars of iron were rolled twelve inches broad by one inch thick and were cut thirty inches long. Five of these bars were piled and rolled down to another slab, and these two slabs were then welded and rolled down to a plate $1\frac{1}{2}$ inches thick, which was sheared to four feet square. Four plates like that one were then piled and rolled down to one plate, measuring eight by four feet and two inches thick. Lastly, four of these were piled and rolled to form the final and entire plate. There were thus welded together sixteen thicknesses of plate, each of which was originally one inch thick, to form one plate $4\frac{1}{2}$ inches thick, being a reduction of thirty five times in thickness, and in the operation from 3500 to 4000 square feet of surface had to be perfectly welded by the process of rolling. Even with the greatest care it was not surprising that blisters and imperfect welding should occur and render the plate defective. This was the chief difficulty to be overcome, and it increased with the magnitude and weight of the plate, the final operation of welding the four plates, measuring eight by four feet and $2\frac{1}{2}$ inches thick, being a very critical one. The intensity of the heat thrown off was almost unendurable, and the loss of a few moments in the conveyance of the pile from the furnace to the rolls would be fatal to success."

The Chicago Trade Bulletin says: "From present indications the United States will raise the largest yield of wheat in many years, and probably the finest crop harvested by any country in 1897. The yield, while liberal, will probably fall below the quantity reported in 1891, but the outlook now favors the second largest yield ever reported. The winter wheat crop is virtually out of danger, and the spring wheat crop, with a backward and unfavorable start, owing to unseasonable weather, is now reaching maturity in good condition, though it will not be out of danger of the changeable weather of the Northwest for four or five weeks. It is virtually safe, unless some damage should occur, to calculate that the aggregate yield will approximate about 550,000,000 bushels, about 310,000,000 bushels of winter and 240,000,000 bushels of spring. At the same time, it is doubtful if the Department of Agriculture will reach such conclusions. The grain trade is confident that the area reported by the Department of Agriculture is too small, possibly by 2,000,000 acres, and this is the weak feature in the returns to the department. The deficiency is largely in the new sections of the country which have been opened up through the agencies of railroads and the land disposed of to emigrants. These people, as a rule, are indifferent about making reports, and have a dread of a crop reporter, regarding him as an agent of the assessor in disguise."

* A paper read before the Western Foundrymen's Association, Chicago, March 17, 1897.