groove in the top of the box and are screwed down upon leather or rubber insertion so as to make a watertight joint. When not in use, the socket which receives the plug is protected by a strong cap gripping the cover by means of a bayonet joint, and making a watertight connection with it.

These boxes are let flush into the quay wherever required, and branches are taken to them underground from the quay mains, each branch being led inside the box to a terminal carried by a porcelain insulator and connected through a fuse to one of the contact clips which is carried by another porcelain insulator.

The speeds of the various motions are as follows: Hoisting full load at 120 feet per minute, lighter loads at proportionately greater speeds; slewing with full load, one complete turn of crane (380 feet travel of jib-head) in 40 seconds; slewing empty, two revolutions of crane per minute; derricking from maximum to minimum radius in one minute; traveling 100 feet per minute.

ALLOY STEELS.*

By WILLIAM METCALF.

THE term "alloy steels" is used chiefly to distinguish steels containing influencing quantities of metals other than iron from the ordinary steel of commerce known as carbon steel, in which iron and carbon are the influencing elements for use, other elements being considered more as impurities than as useful ingredients. There are three kinds of carbon steel of universal use—namely, crucible, Bessemer, and open-hearth. Their discussion does not belong properly to our subject, but it may be observed that they contain small quantities of phosphorus, sulphur, silicon, and manganese, as well as oxygen, nitrogen, and hydrogen. Copper and arsenic are present sometimes, but not so generally or in such quantity as to require the careful analyses that are necessary for other ingredients. Certain small percentages of silicon and of manganese are often regarded as useful for special purposes, but not in such quantities as to justify their giving any specific name to the steel.

From time to time we have put upon the market silicon steel, phosphorus steel, chrome steel, aluminium steel, none of which have won any permanent place in commerce. Of permanent alloy steels, we have nickel steel, manganese steel, self-hardening or air-hardening steel, and the latest, the new variety called high-speed steel.

Nickel steel, containing comparatively small percentages of nickel, is used chiefly for structural purposes, giving increased strength and toughness. It has been applied mostly to armor plates and gun parts, and lately it is being tested largely in rails to determine whether the increase in durability in difficult places will justify the greater cost over ordinary Bessemer or open-hearth rails.

Hadfield's manganese steel is unique. Hard, tough, non-magnetic, non-hardening by quenching, non-annealable by any known method, practically unmachinable, it stands by itself; there is nothing to compare it to nor to test it by. It is finding large use for a number of special purposes.

Self-hardening or air-hardening steel derives its name from the fact that when it is heated to an orange color and allowed to cool slowly in the air it becomes exceedingly hard. Some years ago it was known generally as Mushet steel, from the fact that its first development was due to the distinguished metallurgist whose name it bore. The usual composition of this steel is about 2 to 3 per cent manganese, 4 to 6 per cent tungsten, and carbon high.

The distinctive, persistent hardness of manganese steel indicates that it is manganese that gives this steel its so-called self-hardening property. This was confirmed many years ago by Langley, who found that steel high in carbon, containing about 4 per cent tungsten and minute quantities of manganese, had no self-hardening property, and that the same steel remelted so as to contain 3 per cent manganese became an excellent self-hardening steel. Langley next showed by his beautiful emery-wheel test that tungsten is the element that acts as a mordant to hold the carbon in solution at a high temperature, giving this steel its most valuable property, that of remaining hard at a comparatively high temperature, so that a tool made of it could be used for cutting metals at a high speed, the tool continuing to do its work at a temperature, caused by the enormous friction of the high speed, that would soften completely and render useless the best carbon steel tool that could be made. This very useful variety of steel has a large place in the markets, being used for many purposes where its peculiar properties give it great value. It is being rapidly overshadowed, however, by the latest and most surprising steel of all, known as high-speed steel.

Air-hardening steel, as a rule, is not tough—that is to say, if it is made tough it will not be very hard. The edge of a tool will flow, and when it is so hard that it will not flow then it is so brittle that it will crumble easily, and this limits its usefulness. A few years ago, at the Bethlehem Steel Works, some person—whether he was a blunderer or a genius, history does not say—revolutionized the whole machine business. Either by design or accident he heated a tool made of air-hardening steel until it was nearly melted, and according to the traditions and teachings of the ages, the tool was ruined utterly. Again, either by accident or design, this "ruined" tool was put into

service, and to the amazement of everybody it did an unheard-of amount of work. This led to further experiments and tests, and the Taylor-White process was developed.

This process consisted in heating a tool excessively hot and cooling it by successive stages, producing a tool that would cut at enormous speed for metal work, and take off chips that developed enough heat to blue them. The process was patented, and therefore it is not necessary to go into a long explanation here, especially as it has been superseded. The process seems to have been uncertain—that is to say, when a tool was handled just right it produced results that were wonderful, and when the manipulations were not exactly right the results were *nil*.

The potentialities were so great that nearly all of the leading steel makers in the world attacked the problem, with the result that the present high-speed steels are in no sense of the word air-hardening. Manganese has been reduced from 3 to 4 per cent to 0.30 per cent to traces; tungsten has been increased to 10 to 20 per cent, instead of the usual 4 to 6 per cent, and the carbon is generally less than 1 per cent.

There are about fifty different brands on the market, and of course each one is the best. Perhaps the analyses of two of the leading brands will be interesting, as follows:

	Per cent.	Per cent.
Tungsten	9.99	18.48
Chrome	2.83	2.90
Carbon	0.69	0.78
Phosphorus	0.010	Not determined
Sulphur	0.010	Not determined
Silicon	Trace	Not determined
Manganese	Trace	0.33

Another contains the following:

	Per cent.
Molybdenum	9.65
Chromium	
Carbon	0.66
Phosphorus	0.016
Silicon	0.046
Manganese	0.22

In one sense it is chaos. All traditions as to heating are completely reversed, and no one really knows what is the best. One brand is famous for its excellence in one kind of work, another in another kind, no one yet seeming to cover all of the ground.

One thing is certain, the machine business is revolutionized. These tools have crowded ordinary lathes, planers, drills, etc., away beyond their capacity; machine builders are remodeling their machines to meet the new conditions, and many of the users are throwing out their old machinery for the new, or else remodeling and strengthening what they have.

There are many records published of the work done by this steel, giving speed per minute, feed, depth of cut, etc., so that it is not necessary to repeat them here. A few illustrations of what can be done may be interesting.

In one case a couple of steel cast bed plates, about 4 feet wide and 9 feet long, were to be planed. There was nominally $\frac{1}{2}$ inch to come off, but the unevenness of the casting made the cut about 1 inch in places. The surface was hard and gritty from the sand of the mold. Several tools were tried, each one going about $\frac{1}{2}$ inch and then having to be reground. Next, one tool cut about 2 inches without grinding. Finally, a tool was tried that had turned up a large, rusty, gray iron pulley without grinding, and it cut clear across the bed plates and was still in good condition for further work. It is clear that the cost per pound of that tool cut no figure.

Another party had a great many castings to thread, with dies made of the very best carbon steel. He could at moderate speed thread from 2,000 to 3,000 pieces without grinding; with dies made of high-speed steel, and with his machine running as fast as he could drive it, he threads from 20,000 to 30,000 pieces without grinding. Another party turns many pieces of hard brasses. He found it difficult to get a tool that would cut them at all, until he tried the right high-speed steel, and made a tool that would cut all day without grinding, running his lathes at the highest speed he could get. The same party bores many cast-iron cylinders, and with tools made of steel that would not cut his brass he bores eight to ten cylinders without regrinding, and at a speed so great that the cylinders came out too hot to be handled with the naked hand. He tried in his cylinders the steel that cut his brass so well, and it would bore only two to four cylinders without grinding.

Another party drills $\frac{3}{8}$ -inch holes $\frac{7}{8}$ inches deep in soft steel forgings, drilling a hole in about three minutes; the same steel will not make a good threading die for the same forgings, and for this he uses another brand. Neither of these steels will make a good lathe tool for turning these forgings, and for this work he uses a third brand.

All of these brands, upon analysis, would come within the limits of the analyses given above. From all of this two things are clear: One is that there has been a marvelous, a revolutionary advance in the machining of metals; the other is that steel makers have met the demand remarkably.

It is also clear that we do not know yet where we are and there is much to be learned by everybody. The best methods of hardening may not have been found; it seems that for very high speed work it is necessary to fairly melt the point of a tool and quench it in a strong air blast, and then grind to shape. This

would not do for threading dies, milling cutters, etc., for the heat would destroy the tools.

Such tools are finished from annealed bars; this high-speed steel can be annealed as nicely as carbon steel, differing in this respect from air-hardening steel.

The finished tools are heated in a lead bath of 1,800 to 2,000 degrees, and are quenched quickly in ordinary tempering oil, which must be kept cool by a coil containing circulating cold water; they are then tempered in a bath of heavy oil heated to about 450 degrees. The tools come out bright and clean and do their work wonderfully well.

The steel maker has the most to learn. He must find out why there is such a great difference in the work the steel will do, when there is so little difference in composition. He must find the composition or mixture that will come nearest to meeting all the requirements. He has at his command now ferromanganese, ferrosilicon, ferrochromium, ferrotungsten, ferromolybdenum, ferrovanadium, and ferrotitanium. These alloys are all expensive, except the first two, costing from 60 cents to \$12 a pound; therefore the present prices of high-speed steel, which to some people seem to be of the fancy order, are really not excessive.

As far as we know at present, the steel users have not succeeded in making tools that are satisfactory for finishing, and for this purpose they resort to tools of carbon steel, after having done the rougher, heavier work with high-speed steel. This difficulty may be overcome by proper methods of hardening and tempering, or the steel makers may find a composition that will make a tool that is as good for finishing as for roughing.

The successful production of the above-named alloys marks a great advance in metallurgy, and, now that a demand has sprung up, it is certain that the supply will follow, with certainty and uniformity of composition and reductions of cost.

The making and the utilizing of steel containing practically only carbon and iron, with some modifications made by the use of small quantities of manganese, silicon, tungsten, and nickel, have occupied the best minds in the manufacturing and engineering world for many years. The last half of the nineteenth century saw most wonderful developments produced by the inventions of Bessemer and Siemens, aided by the skill and energy of the brightest engineering minds. At the close of the century it was customary to "point with pride," and to assume that so much had been done and so much was known that there was no room for more revolutionary changes, and the coming generation had only to tag along, utilizing these great advances with ease and comfort to themselves and with blessings upon their predecessors.

Now, in the first five years of the twentieth century, we older men find ourselves standing on our heads once more. A revolution has come already, and we can look forward to a splendid opening for the exercise of the best energy and thought of the succeeding generation.

We enjoyed the struggle and the gains of our time, and we can rejoice with the younger men in the prospects of the great triumphs that are to come for them. Clearly, there is still plenty to do and plenty to learn, and in the doing of them there will be great pleasure.

THE CATATYPE PRINTING PROCESS.

AMONG the results of the numerous investigations on catalysis which have been carried out in Ostwald's institute at Leipzig, the "catatype" process has recently been attracting more general attention. The following quotation from a paper read by Demeler before the "Rheinischer Bezirksverein," and published in the *Zeitschrift für Angewandte Chemie*, gives a good idea of the nature of the process and its different modes of application. The lecturer says:

The catatype process, unlike most other copying processes, does not involve the action of light. It was developed by Ostwald and Gross, and is based on the fact that finely divided metals or metallic oxides catalytically decompose hydrogen peroxide into water and oxygen. If a negative is treated with ethereal solution of hydrogen peroxide (a platinum negative gives the best results), the peroxide is decomposed to a varying extent according to the density of the platinum deposit in different parts of the plate, the undecomposed portion remaining behind on the plate after the ether has evaporated. In this way an invisible image consisting of H_2O_2 is produced on the plate. This image can be mechanically transferred to paper by simply pressing a sheet against the negative. If the paper has been previously prepared, a visible image can thus be obtained. If for instance the paper has been treated with potassium iodide and starch, and is passed through water after having the image impressed upon it, the latter will appear in the familiar blue color of starch-iodide. Such an image is not, however, permanent, as it fades on drying.

But the image can also be rendered visible by other means; for instance, by placing the paper for a short time in a solution of a ferrous salt (e. g., ferrous sulphate or ferrous ammonium sulphate) ferric oxide is deposited wherever there is any hydrogen peroxide. In this way a very faint yellow image is produced, which can be rendered plainly visible by dipping it into a solution of gallic acid, when a black "ink" print is obtained, or into a solution of potassium ferrocyanide, when a blue image of "Berlin blue" is produced.

Other reagents also which are capable of being oxidized by the hydrogen peroxide can be used for

*Presented at the meeting of the American Society for Testing Materials, Atlantic City, N. J., June, 1904.