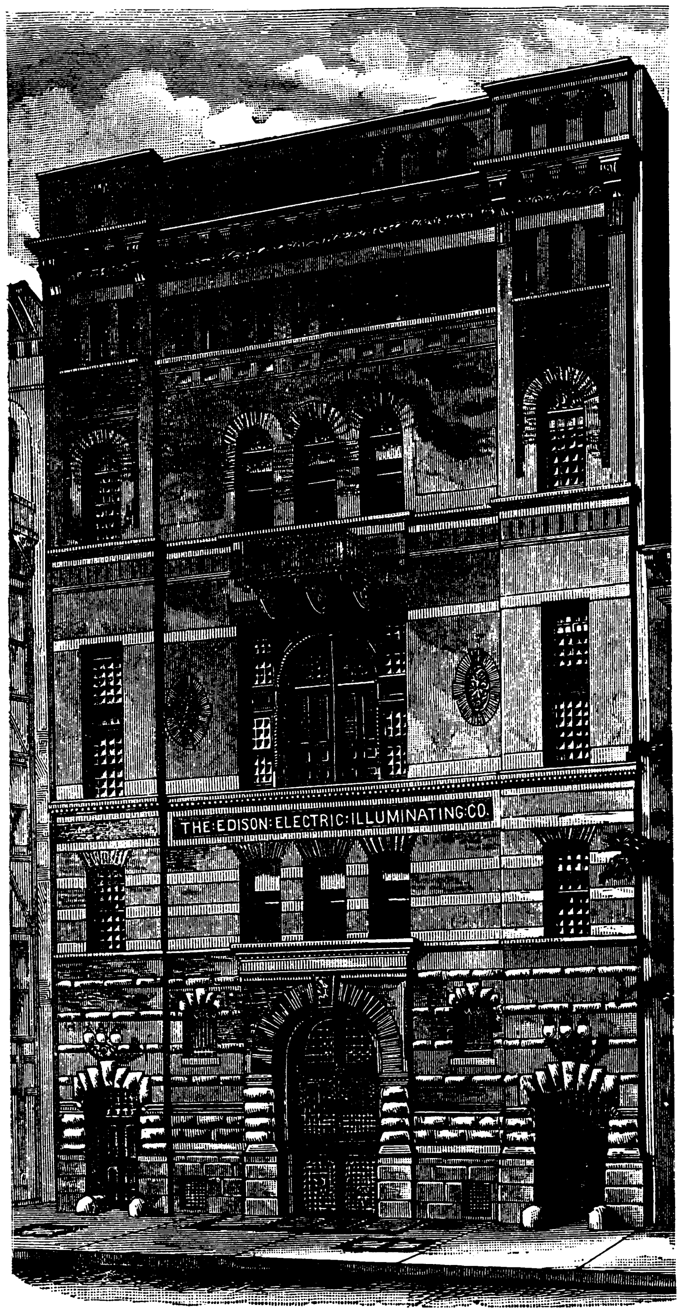
THE EDISON LIGHT FOR HOUSES, STORES, THEATRES, ETC.

THERE is probably no new industry of equal magnitude that is comparatively so little known to the general public, even in this city, as that of supplying the Edison incandescent light from central stations for interior illumination. Six years ago a small station was started at 255 and 257 Pearl Street. This station has been running continuously, night and day, since Sept. 4, 1882, and is now supplying some 15,000 lamps through a network of 56 miles



NEW EDISON CENTRAL STATION, W. 26TH STREET, NEW YORK.

of underground conductors. It was freely predicted that mechanical and electrical difficulties would constitute a barrier to its success; but, these apparently insurmountable obstacles having been overcome by the indomitable perseverance and peerless skill of Mr. Edison, the next prognostication was financial failure. In spite of these dire forebodings, the enterprise was long ago established upon a successful paying commercial basis, as a result of which the capitalists who were pioneers in the business have recently supplied the capital with which to construct two immense stations for supplying residences, stores, theatres, hotels, etc., in the upper portion of the city.

About 165 miles of conductors were laid under ground, covering a district from 18th to 59th Streets, and from Sixth to Fourth Avenues; and two substantial buildings were erected, — one on 39th Street, near Broadway; and one on 26th Street, near Sixth Avenue. These stations are about completed, and ready to furnish lights, and will have an ultimate capacity of 50,000 lamps each. This great luxury, so long enjoyed by many business-men in their down-town offices, will now be within reach of their uptown homes, and our citizens will welcome a light which does not heat or vitiate the atmosphere by burning up the oxygen; does not destroy or deteriorate decorations, pictures, books, etc.; obviates risk of fire; is as conducive to the preservation of eyesight as the natural light of the sun; and is capable of innumerable applications for ornamental and decorative purposes, as well as for the supplying of power for pumps, elevators, ventilating-fans, sewing-machines. For these and many other purposes the electric current will be ever present, night and day, and will be furnished and charged for by a meter the accuracy of which has been proved by six years of practical use, and at prices that will place one of the greatest luxuries of modern times within reach of all.

HADFIELD'S MANGANESE STEEL.[1]

THE most notable contribution to the metallurgy of manganese and its alloys made in recent years is the paper read before the Institution of Civil Engineers of Great Britain by Mr. Robert A. Hadfield, of Hadfield's Steel Foundry Company, Sheffield, on Manganese steel, the invention of his father, but which the author of the paper has done so much to perfect. This steel has been described in previous reports, but Mr. Hadfield's paper sets forth so clearly some of the very peculiar properties that manganese in large quantities imparts to steel, that, with his permission, we quote from it at considerable length.

The most noticeable characteristics of the Hadfield manganese steel are its peculiar hardness, combined with great toughness, the effect of water-quenching upon the steel, and its electrical properties.

Peculiar Hardness.

It is difficult to accurately describe its peculiar hardness, because all the specimens are exceedingly hard; in fact, it is scarcely possible to machine any of them on a practical scale, yet such hardness varies considerably in degree, being most intense in the cast material, containing 5 to 6 per cent manganese, which no tool will face or touch. A gradual decrease is noted then, and, when about 10 per cent is reached, the softest condition occurs. Then an increase again takes place, and at 22 per cent it is very hard, still not so much so as in the 5 per cent. After passing 22 per cent, the cause of hardness becomes more complicated, owing to the presence of more carbon, 2 per cent and upwards; in fact, the material begins to partake more of the nature of cast iron, though as to strength, when compared with the latter, specimen No. 225 (carbon, 2 per cent; manganese, 23.5 per cent) had a transverse strength of 34 tons against 10 tons for cast iron.

The 8 to 20 per cent material can be machined, although only with the utmost difficulty, as will be seen from the following example. The test-bar No. 22 B (manganese, 14 per cent), which elongated 44.5 per cent without fracture and had a tensile strength of 67 tons, was put under a double-geared 18-inch drill. Over an hour was occupied in drilling one hole one half-inch in diameter by three-fourths inch deep; and even to do this it was requisite to run at the lowest speed, or the edge of the drill would have given way. During this time fifteen to twenty holes of the same size could have been easily drilled in mild steel. Similar results from specimens sent to different engineering firms in Sheffield and elsewhere confirm this test, yet this specimen could be indented by an ordinary hand-hammer; so that, whilst so hard, it may be said to possess "a special kind of softness." Although, when being turned, it appears harder than chilled iron, its softness is particularly noticeable when testing the material for compression. Specimens of 10-per-cent manganese steel 1 inch long by .79 inch in diameter,

[1] Extract from a paper on 'Manganese,' by Joseph D. Weeks, to appear in the forthcoming volume of 'Mineral Resources of the United States,' published by the United States Geological Survey, edited by Dr. W. T. Day.

notwithstanding they require several days' preparation in the lathe, owing to their hardness, yet, under a compression load of 100 tons per square inch, shorten .25 inch, and the harder kind (manganese, 15 to 20 per cent) .1 inch to .13 inch. Chilled iron or hardened steel would stand this test without any alteration. A cast specimen, No. 24 B (manganese, 14.75 per cent), not forged, made into a standard Whitworth test-piece, took nearly a fortnight to tool and finish.

The test-bar of the specimen (12.75 per cent) tested by Mr. Wellman, of the Otis Iron and Steel Company, Cleveland, O., was a day and a half in the lathe, as against half an hour for ordinary mild steel.

Owing to this peculiar hardness, its general application to castings has been limited by the difficulty of machining them, no method having yet been perfected by which the heads or runners can be cut off, or the castings otherwise tooled to shape. Tool steels from the best makers have been tried, including self-hardening kinds and tools made of manganese steel, but without success. The tests and applications, therefore, have necessarily been confined to castings, where the runners could be broken off cold or pared off hot.

Water-Quenching, and the Effect of Heat upon Manganese Steel.

Naturally one of the questions asked, when examining a new material said to be steel, or possessing the properties of steel, is, 'What effect has water or other cooling medium on it when plunged therein in a heated condition; in other words, will it harden?' Again: the behavior was found to be quite different when compared with ordinary carbon steel, no hardening action taking place. Water certainly causes the material to become stiffer, but in an entirely different degree to hardened carbon steel; for a piece of manganese steel, after such treatment, is slightly more easily touched by a file: therefore, for the following reasons, the process now described is termed 'water-toughening.' The increase in stiffness is most marked, the tensile strength rising from 40 to 60, and in some cases over 70, tons per square inch; but this is not a mere stiffening or hardening effect in the ordinary sense of the term, for in all carbon steel such rise is invariably accompanied, when the cooling medium is water, by a considerable decrease in the ductility or elongation, whereas in this material just the opposite effect is produced. In specimens Nos. 22 B and D² the tensile strength of the bar as received from the forge was only 36 tons per square inch, with 1.56 per cent elongation. This latter is exceptionally low, usually being 6 to 8 per cent. After water-toughening, it rose to the extraordinary amount of 67 tons, with 44.44 per cent elongation; and even then the specimen was not fractured, as at this point it was considered worthy of being retained unbroken. The same result occurs if the piece under treatment be dipped when at a welding heat, though the carbon be as high as 1 per cent or more. With regard to those samples containing below about 7 per cent manganese, this treatment seems to exercise little or no influence, and the material is comparatively valueless where toughness is requisite. While touching upon this point, the results obtained by the Terre Noire Company of France with high manganese steel (1.75 to 2.25 per cent) should be referred to. It is stated that it was not possible to obtain test-bars when dipped in water or oil, as they either cracked or broke into pieces. Strange to say, not a single bar in these experiments has behaved so. Take, for example, No. 4 B, with 6.95 per cent of manganese, which may be termed comparatively low, and more approaching to the Terre Noire material: the test-bar, when heated to a white heat, could be safely plunged into either water or oil without being water-cracked.

After a large number of tests with regard to the action of heat and sudden cooling upon this material, generally speaking, it has been found that the higher the heat of the piece treated, and the more sudden and rapid the cooling, the higher will be the breaking load, and the greater the toughness or elongation. Six of the bars were heated as uniformly as possible to a yellow heat, and plunged into water of 72° F. These gave breaking loads varying from 57 to 63 tons per square inch, and elongations of 39.8 per cent to 50 per cent. As a comparative test, another test-bar of the same material, heated in precisely the same way and to the same degree, but plunged into water at a temperature of 202° F., gave only 53 tons and 32.8 per cent. The more rapid cooling of the other test-bars was evidently the cause of their superiority, the chemical composition of all being the same.

It was also thought that sulphuric acid, being a rapid conductor of heat, might give good results as a cooling medium. The experiment was therefore made with a bath consisting of equal volumes of water and of sulphuric acid, and on 8 inches the extraordinary elongation of 50.7 per cent was reached with a breaking load of 65 tons, the bar being thus drawn cold 4$\frac{1}{16}$ inches before fracture. Another specimen on a 4-inch length gave 56.75 per cent. The operation of merely heating the forged test-bar to a yellow heat and cooling it in air has a very beneficial effect, the elongation in most instances being increased to 15 and 20 per cent, the tensile strength also rising 8 or 10 tons per square inch.

As before pointed out, the temperature to which the bar is subjected has a marked influence. Although good tests result when the specimens are treated at lower temperatures, the best are obtained with as high a temperature as possible, the bars being thoroughly soaked, and plunged into cold water. Care, of course, must be taken that they are not burnt, or heated beyond a welding heat. In those specimens where the alloy is not so pure a mixture of iron and manganese, and the material cannot be heated so hot without crumbling, lower temperatures also give good results, viz., 40 to 46 per cent elongation. The best tests have been obtained with material containing 12 to 14 per cent of manganese, though those with 10.83 per cent are also good, considering their high breaking loads as compared with mild steel. However, special attention is drawn to the peculiar fact that an increase of 4 per cent in the manganese causes such a considerable rise, both in tenacity and elongation. The cause of this is very obscure, the only explanation offered being that the peculiar crystallization in the cast ingots seems to disappear gradually after passing about 11 per cent, and the fibre noticed is not so much a cause of weakness. This is only surmise, as to the eye the fibre in even the lower percentages entirely disappears in the hammered bar.

It is not easy to understand the action of the water-quenching process. As so ably explained by Chernoff, the effect of oil-tempering on ordinary steel is to produce a metal of fine grain, which possesses much greater strength than open, coarse-grained steel. If, however, forged manganese steel possesses any real difference of structure, after being heated and water-toughened, it is rather in the direction of a more open than a closer grain. But the most puzzling case in the author's experience is that of the cast-toughened 9-per-cent specimens, at which percentage, as before pointed out, the crystallization is very peculiar. An ingot 2½ inches square and 2 feet long was cast in an iron mould. When cold, a piece was broken off, requiring four blows under a steam-hammer. The fracture showed the usual peculiar form of the 9-per-cent material, — a form which, to outward appearance, is unchanged by any heats short of the actual melting-point. The other piece was reheated to a yellow heat, and water-quenched. In this the toughness was increased in a remarkable manner, ten blows of the steam-hammer being required to break the bar. The appearance of fracture was unchanged. What caused the increase of toughness? In this case, certainly, it was not owing to structural changes, the pronounced form of ingot not being to the eye in any way altered. It will therefore be understood how difficult it is to offer any satisfactory explanation of these peculiarities.

Considering the effects of water-toughening, special attention is drawn to a specimen containing, carbon, 1.85 per cent; manganese, 9.42 per cent. Ordinary steel with this amount of carbon would be excessively hard if water-quenched even at a dull-red heat; in fact, it is questionable whether it could be hardened at all without being water-cracked. Yet the above specimen was heated to a high heat, plunged into cold water, and the bar was not water-cracked, and, if changed at all, slightly softer. Carbon seems, therefore, entirely deprived of its usual hardening properties, and it is probable that manganese must be partly considered as the cause of the high tensile strength of this material, that is, unless iron itself possesses the property of taking some other form not hitherto suspected. Further, iron so combined with manganese is rendered capable of elongating 50 per cent on 8 inches, against about 30 per cent in the best brands of wrought iron, which contain about 99.5 per cent of iron, against 84 per cent in the manganese steel.

Electrical Properties.

This material possesses the peculiar property of being almost entirely non-magnetic. Rinman mentioned in 1773 that manganese diminishes, and in the end destroys, the magnetic properties of iron. This was also noticed in some specimens of manganese alloys made by Mr. David Mushet about 1830. This is especially curious, seeing that iron is present in amounts eight or nine times greater than the manganese itself. An approximate idea of the amount of manganese contained in the steel may be formed by passing a magnet over specimens. As the percentage of manganese increases, the magnet's power decreases. Upon reaching about 8 per cent, there is no attraction in the bulk, though fine drillings are influenced; but even this diminishes, as, when 20 per cent is reached, a magnet capable of lifting 30 pounds of ordinary steel or iron will only lift pieces weighing a few milligrams. On this point the material behaves in the same manner either in its forged or cast state, water or oil quenching making practically no difference.

Some interesting experiments with regard to the physical properties of manganese steel have been made by Sir William Thomson, Mr. Bottomley of Glasgow, and Professor Reinold of the Royal Naval College, Greenwich. Prof. W. F. Barrett, of the Royal College of Science, Dublin, has also experimented respecting its non-magnetic character and electrical properties. His experiments were carried out upon a sample containing, carbon, .85 per cent; manganese, 13.75 per cent; the wire being drawn to No. 19 British wire gauge. The author first attempted to draw direct from the rods, but with little progress; the wire, owing to its hardness, breaking into short lengths when being pulled through the wortles. Ordinary annealing was tried, but with no better results. As exceedingly good bending tests have been obtained with bars from the same steel, when heated to a yellow heat and plunged into cold water, the rods were treated in the same manner. These were coiled up, heated to whiteness, and plunged into cold water. The material was then easily drawn; but, after every reduction through two sizes, its ductility was again lost, and the operation of heating to whiteness and quenching in cold water was again necessary. A specimen has been subjected to white heat no less than five times, and is yet uninjured, as will be seen from the remarkable tensile tests obtained from it by Professor Barrett, viz., 110 tons per square inch, in its hard state. A similar result was obtained by the manager of the wire department at the Barrow Steel Works, the report being "that it would stand any tensile load up to 100 tons per square inch, according to the temper, and the elongation was extraordinary." The density, according to Professor Barrett, was 7.81, which is somewhat lower compared with the specific gravity obtained at the Hecla laboratory; viz., 7.83 on the same wire. The electric conductivity was found to be very low; No. 19 British wire gauge wire, .96 millimetre in diameter, having a resistance of 1.112 legal ohms per metre, or 75 microhms per cubic centimetre at 15° C. Ordinary iron wire is only 9,800, and German-silver 21,170; so that use might be made of the manganese steel for resistance-coils in electric-lighting. This has since been successfully applied by Dr. E. Hopkinson, in Messrs. Mather & Platt's electric department. Its high specific resistance, and capacity to stand heating, make it very useful for resistance-boxes. A length of 1,180 yards No. 8 British wire gauge (No. 634, manganese 13.95 per cent) was cut into three lengths, coupled parallel, the conductor consisting of three strands No. 8, then coiled into a box 3 feet by 2 feet by 2 feet, and gave a resistance of 6.5 ohms, carrying 80 ampères without over-heating. It was therefore capable of absorbing 55-horse power. To produce the same resistance with iron wire, 5,000 to 8,000 yards would be required, or, of expensive German-silver wire, 4,780 yards. Professor Barrett also finds that its increase when heated is only .136 per cent for each degree carbon, as against iron .5 per cent.

In the same way it is a bad conductor of heat. A rough test was made at the Hecla works by putting a bar of this material and one of ordinary wrought iron into a smith's fire. The latter became too hot to handle in about half the time required for the former. From this will be seen the importance of thoroughly 'soaking' this steel when forging it, or the outside only may be heated.

As regards its non-magnetic properties, a small piece of the No. 552 wire was not attracted in the slightest degree by the most powerful electro-magnet capable of lifting a ton; but, suspended by a thread, it behaved like a paramagnetic body. Professor Reinold found that the water-quenched or softened wire acquired slightly more permanent magnetism, but that with both a most sensitive galvanometer-needle was required to show that the material was not copper or other non-magnetic body. The exact amount was determined by Professor Barrett after most careful experiments. In comparing this with ordinary steel, he states that it was like weighing hundredweights and grains on the same balance. The magnetism of ordinary iron being represented by the figure 100,000, manganese steel is 20, and its susceptibility, i.e., the induced magnetization, is about as low as zinc or other non-magnetic metal. It is somewhat extraordinary to find no sensible attraction exerted on this steel by the most powerful magnetic field that could be obtained, this agreeing with Dr. Hopkinson's experiments. If other difficulties can be overcome, this peculiar quality should make it suitable for dynamo bed-plates. Ships built of such steel would have no sensible deviation of the compass. Magnetic influence, while not affecting this material, passes through it, so that a needle placed upon a flat sheet of manganese steel can be readily moved by a magnet placed underneath. The same thing occurs if brass or sheet copper be substituted, but not with ordinary steel or iron.

Further interesting experiments have also been lately made (September, 1887) by Profs. J. A. Ewing and William Low. The former concludes his experiments by stating, that, even under magnetic forces extending to 10,000 C.G.S. units, the resistance which this manganese steel offers to being magnetized suffers no change in any way comparable to that which occurs in wrought iron, cast iron, or ordinary steel, at a very early stage in the magnetizing process. On the contrary, the permeability is approximately constant under large and small forces, and may be therefore concluded as being only fractionally greater than that of copper, brass, or air.

MUSICAL BOXES.

MUSIC, both as a science and an art, has reached a stage of development so far advanced that further improvement in any department must necessarily seem slow and insignificant. Yet improvements are being made in many directions, seemingly small, but really great enough to demand more than a passing notice.

A good instrument is, of course, necessary to the production of

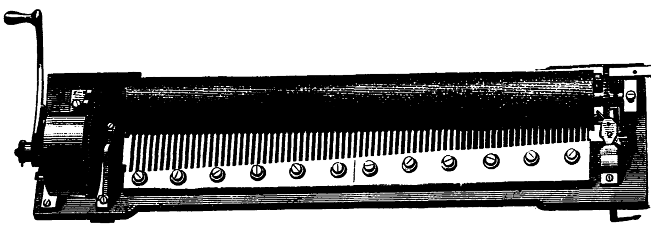


FIG. 1.

good music; but upon even the best of such instruments as the violin or piano, for instance, good music cannot be produced without the aid of a good musician. Of musicians, as musicians go, there are plenty, — ordinary every-day musicians, not born to the art, but bred to the business, working at music as a trade, not as an art; but of good musicians, with a heritage of genius supplemented by a lifetime of labor spent in study, there are few.

Most people are lovers of good music, or at least of melodious and harmonious sounds. Among these are many who are not musicians themselves, and by whom the services of a good musician are not at all times procurable, nor perhaps desirable. There is but one among the innumerable instruments in vogue to-day to which such persons can turn, — an instrument in which more or less successful attempts have been made to combine not only the parts to be played upon, perfect of their kind, but also as close an approximation to the executive talents of a musician as mechanical skill will give. This instrument is known as the musical box, not the crude mechanism of a few decades ago, but the improved instrument of to-day.