SOFT STEEL—A NEW TYPE OF FIXED CONVERTER.*

By GEORGE HATTON, Bilston.

THE development of the manufacture of steel has, until recently, been almost entirely in the direction of large outputs, entailing increasingly large and costly plants. Consequently, the revolution from iron in favor of steel has been very severely felt by iron manufacturers, inasmuch as their existing works and plant have not been adaptable to the new order of things.

Some method of making soft steel of the highest quality in moderate but, at the same time, rapid and continuous quantities, and with comparatively inexpensive plant, has, therefore, long been desirable, and for this purpose the fixed converter offers many advantages. The fixed converter is not a new invention. Sir Henry Bessemer conducted his early experiments in one, and it has been used somewhat extensively in Sweden for many years, making steel of very high quality.

In using the old type of fixed converter, a great difficulty experienced has been the necessity for keeping the full pressure of blast on during the tapping out of the metal after the process of conversion was completed, with the risk of more or less oxidation of the bath of metal, which oxidation would, of necessity, be continued till the last of the steel ran from the converter, owing to tuyeres being fixed on a level with the converter bottom.

M. Wittnöfft, of Bochum, Westphalia, in a paper read before the Cleveland Institute of Engineers, proposed, as a remedy for this undesirable after-blow, the employment of an auxiliary blast engine of considerably smaller dimensions than the engine used in blowing the charge, but which could be made to maintain the full pressure of blast, but with reduced volume. This smaller engine was to be started at the completion of the blow, and at the moment of tapping the converter, the large engine being stopped, or the blast from it shut off, as soon as the smaller one was in motion. Whether this suggestion was ever put into practice or not I am unable to say.

The Clapp & Griffiths converter (a South Wales invention) was specially intended to meet this difficulty, by stopping up the tuyeres at the termination of the blow, and thus preventing further oxidation of the bath; the risk of oxidation being further minimized by fixing the tuyeres in a position about half way between the converter bottom and the surface of the metal, so that, by the time about half the metal had left the converter, the tuyeres were free and oxidation was at an end.

The essential feature of this converter was a very ingenious arrangement for actuating the stoppers to the tuyeres. It consisted of two pistons, of unequal areas, attached to the spindle or rod carrying the stopper. The smaller piston was under the pressure of the blast during the operation of blowing, and served the purpose of holding back the stopper from the tuyere, the larger piston during that time being under atmospheric pressure only; but on the admission of the blast behind the larger piston at the end of the blow, which was done by simply opening a hand cock, the pressure on the larger area overcame the pressure on the smaller area, and the stopper was at once driven against the back of the tuyere, closing it with the exception of a very small hole provided through the center of the stopper, which was necessary to admit sufficient blast to keep the metal from coming back through the tuyere.

A Clapp & Griffiths converter was erected and started at the writer's works at Bilston early in 1884, but several practical difficulties were met with, due to the construction of the converter. The position of the differential piston and stopper appliance, immediately behind the tuyere, and on a lower level than the metal line (a position of danger), was very objectionable, owing to the delay in, and costliness of, replacing them if damaged. The exposure of the back end of the tuyere, and of a large area of lining material, to the full pressure of blast in the blast box, added considerably to this danger, it being difficult to keep the lining tight, the blast having a tendency to penetrate the joints and produce outbreaks of metal into the blast box. These faults, and the general inaccessibility and immovable character of the converter lining and bottom, causing great difficulty and delay when repairs were needed, led the writer, after a short experience, to design a fixed converter upon entirely different lines, with a view to overcoming these difficulties.

A sectional elevation of this new converter is exhibited, from which its general construction will be readily understood. The whole is rigidly supported on four strong cast iron columns, and for convenience of construction is attached to them by the blast chambers, which form part of the middle section of the converter shell. The lower section is readily detachable, and is secured in position by cotter bolts passing through the flanges, or by other suitable means. This lower section is made sufficiently deep to enable the portion of the lining liable to the greatest wear, together with the tuyeres, to be removed with it, so that, by simply changing a lower section, in a very short space of time a converter can be completely renovated, and in this way can be kept at work night and day, almost continuously. The lining of the middle and lower sections consists principally of ganister, rammed hard, according to the usual method of lining Bessemer converters.

It has been found more convenient to line the nose, or upper section, with silica bricks, and a course of silica bricks is used as a support to the ganister lining of the middle section, making it safe and independent when the lower section is removed.

The tuyeres are of fire brick, and preferably of square outer section, with a single round taper hole through the center of each, $1\frac{1}{4}$ in. diameter at the inner end. These tuyeres are so placed as to be about 6 in. below the surface of the molten metal, and about 10 in. above the bottom. The bottom of the lower section is made with silica bricks, set in ganister upon a bed of loam sand. One or more duplicate lower sections are provided, and as they are removed, with their linings worn out, they are repaired and placed in a stove to dry and keep warm till wanted.

The method of changing a lower section is simple. A bogie running on rails is placed under the center of the

converter, a hydraulic ram—which is actuated by a pair of manual pumps fixed any convenient distance away—then passes up through the center of the bogie, taking the weight of the lower section, and after the cotters are removed from the bolts and the tuyere pipes disconnected, gently lowers it on to the bogie, by which means it is then removed to the repairing shed. The new lower section can now be brought into position under the center of the converter, and raised by the ram and cotted to the middle section, the joint being made with a little plastic ganister, placed on the edge of the lower section, just before raising it into position. When the converter is blowing, the hydraulic ram is at rest, and entirely below the floor level, covered with a plate, and further protected by a bed of sand, some ten or twelve inches thick, from any possible damage from hot steel or cinder.

The blast connections to the tuyeres are so arranged that no costly valves or blast boxes are exposed to danger behind or on a level with the tuyeres, the blast being conveyed separately and directly from the blast chamber to the center of each tuyere, passing through the valve and down the cast iron pipe, which latter has a ball and socket connection to the valve, and is held in position by a bridle and set pin. The lower end of the pipe is faced and bolted to the cast iron tuyere block, which is also faced, and at this point a thin asbestos millboard ring forms an airtight joint.

When changing a lower section, it is not necessary to remove the connecting pipes. They are unbolted, the set pins in the bridles are slackened, the pipes then swing back into an oblique position, and are there held by the bridles by retightening the set pins, and in this position are out of the way of the lower section.

The valves are of the ordinary baffle type, are all connected together by levers, and can all be closed or opened by the movement of one handle.

Each valve has a hole $\frac{1}{4}$ inch diameter, through which sufficient blast passes while the valve is closed to support the weight of metal in the converter, and keep it out of the tuyeres during the process of tapping. The nose of the converter is accessible from an upper platform, and a movable spout is provided for the purpose of charging scrap during the blow.

The charge is run direct from a cupola, and consists of about 46 cwt. of hematite iron, the blast being put on at the converter at the moment the cupola is tapped. The blow usually lasts about fifteen to eighteen minutes, and just as the carbon blow is commencing, most of the silicon being then eliminated, a greater portion of the slag is allowed to boil out at the slag hole; this lasts about one to two minutes, when the hole is stopped up for the remainder of the blow. The charge is blown right down—that is, till the carbon flame has disappeared—when the signal is given to tap out; at this moment the valves are closed, and the steel instantly begins to run from the tapping spout. Ferro-manganese, finely crushed, is added in the ladle while the steel is running from the converter, in about the proportion of 20 lb. per ton (for 80 per cent. manganese). The quantity of steel produced per blow is about 2 tons.

The pressure of blast used may be from 5 to 8 lb. per square inch; in no case need it ever exceed about half that required in the ordinary Bessemer process, or say 10 lb. as a maximum.

The rapidity with which the converter can be worked depends very much upon the facilities at hand for dealing with the steel produced.

At the writer's works, twenty blows per shift of twelve hours have been done, but, with more efficient casting-pit arrangements, this output could be very considerably increased.

The usual numbers of Bessemer hematite pig iron are used, the percentage of silicon preferred in the mixture being about $1\frac{3}{4}$ to 2 per cent. When working rapidly, with surplus heat, a considerable quantity of scrap is added through the nose during the blow.

The steel produced by this process is of the highest quality, remarkably soft, and particularly adapted for welding, it being largely in demand for lap-welded boiler tubes and other similar purposes; it is also made into boiler plates, and is largely made into stamping sheets and tin plates for difficult work. Samples of it are to be seen at the Bingley Hall Exhibition.

The carbon is exceedingly low, averaging from 0.05 to 0.10 per cent., and seldom exceeding 0.15 per cent.

The silicon seems to be more thoroughly removed than in the Bessemer process, which is a great advantage, and is probably due to the less acid character of the slag at the end of the blow, resulting from the removal of the greater portion of the silicious slag at the end of the silicon blow as already described, the following being the analysis of the slag at the termination of the blow:

FeO.	SiO ₂ .	MnO.	Al ₂ O ₃ .
41.90	46.22	6.97	4.89

The tensile strength of the steel is about 24 to 26 tons per square inch, with elongations averaging 25 per cent. Some analyses are as follows:

C.	Si.	S.	P.	Mn.
0.04	trace	0.07	0.06	0.30
0.07	0.009	0.02	0.05	0.37
trace	0.008	0.05	—	0.30

The advantage claimed for the process over the ordinary Bessemer process, apart from the question of cost of outlay, is that a better quality is produced—one that is uniformly softer and more reliable; the reason for this being that the action in the converter is less violent. The charge can always be blown right down, with less risk of oxidation, owing to the fact that the final changes take place less rapidly; this is due to the low pressure of the blast and to the fact that instead of the whole charge being constantly penetrated and oxidized by direct contact with the blast, as is the case in the ordinary bottom-blown Bessemer converter, only about a third of the charge is subject to direct oxidation at any one time, a further indirect process of oxidation at the same time being carried on by circulation and admixture of the oxidized iron with the remaining portion of the bath.

Further, by tapping the steel from the bottom of the charge, all risk of taking up particles of partially converted metal, which may adhere in and around the nose, and contain more or less silicon, is avoided, as is

also all unnecessary contact with slag, which remains on the top of the bath, and only runs from the converter after the steel is in the ladle.

Some advantages of this process, compared with the Siemens process, are that—where only a moderate output of steel is required—the constant and regular production of ingots enables soaking pits to be economically used, instead of the more costly method of heating in furnaces. Also, softer material (lower in carbon) can be made with regularity and certainty; also, Welsh or other hematites made from Spanish ore, containing a larger percentage of manganese than West Coast brands, can be used with great advantage—in fact, are preferred—and when not used alone, are almost always used as a mixture with West Coast iron.

This converter is well adapted for making steel castings. Though the plant at the writer's works has not been designed with that view, castings weighing from a few pounds to upward of one ton each have been repeatedly made, and always with success. The following are analyses of some of them, which, though rather variable, the castings were all sound and satisfactory:

C.	Si.	S.	Mn.
0.16	0.113	—	0.18
0.50	0.30	0.027	0.99
0.42	0.046	0.04	0.46
0.66	—	—	0.50
0.28	0.181	—	—

ACTION OF MANGANESE ON THE PHOSPHORESCENT POWER OF CALCIUM CARBONATE.

By EDMOND BECQUEREL

ICELAND spar is one of the first substances which presented to the author a luminous appearance in the phosphoscope after the previous action of luminous rays. The color of the phosphorescent light is orange, but there are very great differences in the intensity of the light emitted by different specimens. The presence of foreign matter can very much modify the phosphorescent power of certain bodies, and it was therefore important to examine if the differences of luminous effects given by various specimens of calc spar might not be due to the presence of a minute trace of foreign matter mixed or combined with the spathic calcium carbonate. The most luminous crystals of spar, orange in the phosphoscope, contain a moderately high proportion of manganese, probably in the state of carbonate; there were scarcely any traces of iron carbonate. Fragments of calc spar, still very luminous, contained manganese in less proportions, and less brilliant specimens contained only very little, or none at all if examined by ordinary analytical methods.

Synthetic experiments lead to the same conclusion as the analysis of the natural crystals. These results show distinctly the action of manganese. Calcium carbonate obtained by dissolving fragments of Iceland spar in pure hydrochloric acid, even after several successive precipitations with ammonium carbonate, always led to the preparation of sulphides having an orange phosphorescence, while when the raw material used is arragonite the phosphorescence is always of a bright green. It is probable that the orange phosphorescence is either due to a double manganese-calcium carbonate or to the fact that the presence of manganese gives to the calcareous compound a peculiar molecular arrangement, whence results a phosphorescent power more or less energetic and a luminous emission of a given color. This substance would then merely exalt the intensity of the light emitted by the spar.

The author has shown that the crystalline form may interfere in these luminous reactions, since all the specimens of arragonite studied in the phosphoscope emit a green instead of an orange light. Other bodies besides manganese can produce, in calcium sulphides, profound modifications in the intensity and the quality of the light emitted; such are lithium carbonate, bismuth, antimony, various sulphides, etc.—*Chem. News*.

CHLORINE IN RAIN WATER.

By EDWARD KINCH, Royal Agricultural College, Cirencester.

DETERMINATIONS of chlorine in the rain water collected in a small five inch rain gauge, at the Royal Agricultural College, 443 feet above the mean sea level, have been made continuously since 1870. The rain collected during the six months April to September is kept apart from that of the six winter months October to March. The chlorine is determined in the mixed waters of each six months.

The amount of chlorides in the rain is nearly always greater in the winter months than in the summer months. An abnormal amount of chlorides can generally be traced to storms from the southwest, bringing salt spray from the Bristol Channel, about thirty-five miles distant. Crystals of common salt have been found after such storms on the windows of the College facing west. On one occasion, in September, 1869, Prof. Church found chlorine equivalent to 6.71 grains of common salt per gallon in storm water.

The rain collected during the winter six months, 1872-73, contained an abnormally large amount of chlorine. Excluding this period, the yearly averages for 16 years, 1870-1885, for the 12 years 1874-85-86, also the means of the last 12 summer periods and 12 winter periods are:

	Rainfall in inches.	Chlorine per million.	Equivalent to NaCl per acre.
Mean of 12 summer periods to 1885.	17.04	3.14	19.91
Mean of 12 winter periods to 1885-86.	17.65	3.58	23.56
Average for 16 years (excluding winter) 1872-73.	33.31	3.25	40.33
Average for 12 years to March, 1886.	34.69	3.36	43.47

Lawes, Gilbert, and Warrington have found in the rain collected at Rothamsted, as a mean of six years' monthly determinations, 1.99 of chlorine per million, with a mean rainfall of 33.15 inches, equivalent to 24.59 lb. of common salt per acre. They found the amount of chlorides in the summer months to be less than one-half that of the winter months.

* Read before the British Association, Birmingham meeting, Section B.