weighing about 12 tons, where a sinking head 2 feet 10½ inches long and weighing about two tons was added. When this head was cut off and broken under the ball the fracture was so interesting that it was carefully photographed. This shows that the head, which was much larger in area than the column proper, had been most efficiently feeding the column, as the molten metal in it was contracting in setting; but it showed a good deal more than that. In the large pockets left by the receding, cooling metal there were groups of crystals of pure iron . . . grouping together so that they all interlace one with another, the other ingredients combining with some of the iron, and forming a matrix which fills the interstices. The real strength of the casting is in these interlaced groups of crystals. In the body of such a casting these crystals exist in identically the same form, but very much smaller, due to the quicker cooling, perfectly interlaced and homogeneous, owing to the great pressure above them of the slower-cooling sinking head.

The most deleterious impurities contained in cast-iron as it leaves the cupola are slag globules, gases mechanically contained in the metal, and gases technically called "occluded," or absorbed physically in the metal, all or most of which will separate out as the metal passes from the liquid to the solid state. The excess of carbon in the metal separates into little plates of graphite as the metal solidifies, and there are also crystals of a very brittle substance known as phosphide of iron and little areas of sulphide of manganese. All these substances are potentially in the metal as it leaves the cupola and goes into the ladle. As the metal is being poured into the mould still more gases are formed by the action of the hot metal on the sand of the mould; the bulk of these escape through the cores and joints of the boxes in which the mould is formed, and when ignited burn with a non-luminous flame. Now the remainder of all the impurities mentioned—slag, gases, excessive graphite, etc., are of a much less gravity than the proper metal, and if they have a free passage in the mould escape upwards to the top, but if not they remain, and the result is a porous, weak casting.

When a long column such as has been described is cast on a sloping bank instead of vertically, crystals always begin forming at right angles to the cooling surface, with the result that millions of crystals form round the mould, and the passage of impurities is seriously impeded; if the column is cast horizontally, their escape is impossible, and they remain in the top side of the casting.

In small, thin castings the cooling is so rapid, and the gate is so near the body of the casting, that sinking heads are not necessary, as the air and gases escape readily, and the impurities have no time to segregate, but, being spread more or less uniformly over the whole casting, their effect is so diminished as to be practically negligible.

A BRITISH COMMENT ON THE LINDSAY REPORT.

The "Surveyor" in its issue of June 24th comments upon the Lindsay ozone plant, and notes the weak point in the Provincial Board of Health report, viz., that no engineering examination and report was made on the plant which failed because of certain engineering features. We quote as follows:—

"The Lindsay plant may be as defective as the chemists tell us, but to the unprejudiced reader any report upon engineering works prepared by laymen will not be convincing, and the reader may well wonder whether after all these gentlemen may not have found a mare's nest. Assuming that the mixing part of the apparatus is not hopelessly inadequate, it seems possible that it was merely out of order, and that an engineer might have been able to lay his finger upon the defect and to have set it right. We are told that enough ozone was produced to do the work, and that if it had been properly mixed the work would have been done. The fact that the ozone was not mixed with the water is at the root of the matter, and a report upon the reasons why this part of the installation failed, prepared by an engineer, would be more useful than analyses made of water with which ozone had not been mixed. Having been told that the ozone was not applied, there can be no interest in daily analyses, extending over a period of three months, which are exactly what one would expect them to be. The plant at Lindsay may or may not be as bad as the report infers, but it is to be hoped in the interest of the Lindsay authorities who have purchased the plant that it is capable of being set right, and that the Board will appoint an engineer to inspect the machinery before they condemn it on the chemists' report.

ELEMENTARY ELECTRICITY.

L. W. Gill, M.Sc.

Direct current motors, almost without exception, are excited in the same way as generators are, and they are distinguished accordingly. The "shunt" motor is identical in every respect with the "shunt" generator, as shown in Fig. 32, except that there is usually no rheostat in series with the exciting circuit, the rheostat being used only when it is desired to vary the speed of the motor. The exciting circuit of a shunt motor is thus connected directly to the line, and if the line voltage remains constant, the exciting current and flux remain constant. **The speed of a shunt motor will, therefore, remain practically constant from no load to full load, and it is consequently regarded as a constant-speed machine.** The decrease in speed due to armature resistance,

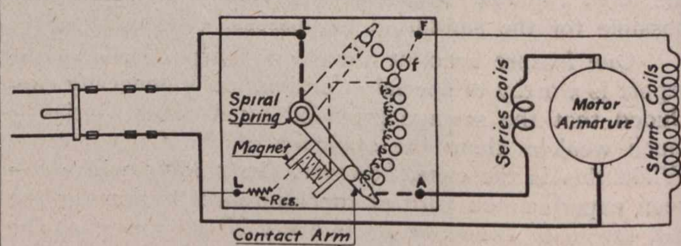

FIG. 38

which has been referred to above, varies from two per cent. in large machines to ten per cent. in small motors. In commercial work the majority of power-driven machinery runs at constant speed, and, excepting in railway service, the shunt motor is the most common type of direct-current motor in use.

If a motor has to start under a heavy load, it is desirable that it should have a large starting torque combined with a slow speed. Both these conditions are secured by using the "series" system of excitation, as shown in Fig. 36. When a motor of this class is started with a large retarding torque or load (a street car, for example) the large initial current, passing around the poles, will set up a dense magnetic flux, and the two combined will produce a correspondingly large torque. If, after this motor has attained a constant speed, the retarding torque is diminished, less current will be required to produce the driving torque, and in consequence, according to equation (16), the generated e.m.f.