and are known as strong steels, while those that are nearer malleable iron in composition are distinguished as mild steels or ingot irons.

We are now prepared to describe the conversion of pig iron into steel by what is known as the Siemens-Martin open hearth process, used exclusively by the Steel & Forge Co. The furnace is constructed with two pairs of regenerators built transversely beneath the furnace bed. Above the regenerators is the furnace, with its hearth supported upon cast-iron plates, between the under side of which and the top of the regenerator chambers air is free to circulate for the cooling of the bottom. The plates are lined with a single thickness of firebrick, and above this is the bottom made of sand, with a total depth of from 12 to 16 inches. The hearth is rectangular in form and slopes from all sides towards the tap-hole, situated at the back. At the front side of the furnace are three doors, used for charging purposes. The two ends of the furnace are constructed of silica-bricks, as is also the roof. The furnace is fitted with the usual valves, etc , for reversing the direction of the current of air and gas, the latter passing from the gas producers through the regenerators to the hearth by the port, where it meets with the heated air required for its combustion, the air having ascended on its way to the furnace through the regenerator. The air and gases are thus admitted at one end of the furnace, and the flame and waste gases escape at the same time by the ports at the opposite end of the hearth, and are drawn down by the chimney draught through the chequer work and pass on until they reach the flue, by which the waste gases pass to the chimney.

The presence of phosphorus over 0.10 per cent. brings about that condition in the steel which is very antagonistic to its constructive strength and to the easy facility with which it may be worked; when in the steel over and above the given percentage it makes the metal "cold short," or brittle when cold.

The way in which sulphur acts as a debasing constituent in steel is in giving it a tendency known as "red short," or brittleness when red hot; this is a very serious defect, as it prevents the rolling of steel in bars or hammering into forgings. The presence of silicon, manganese, and carbon are not so serious, as they can be reduced to small percentages by fusion, and to some extent they modify the exact amount of effect produced by a given quantity of phosphorus or sulphur.

We now turn our attention to the treatment of the iron in the furnace. This consists of mixing and fusing pig and scrap together to form a new metal; the purpose which the scrap serves in the process being the diluting to a certain point of the debasing or weakening constituents present in the pig or cast iron. The decarbonization and desiliconizing of the pig iron is brought about by subjecting the two metals, pig iron and scrap, to such very high temperatures that they are melted or fused—this high temperature being required as the metal becomes more and more refractory as the silicon and carbon disappear. By this process the silicon and manganese can be reduced to a mere trace and the carbon reduced until it stands at 0.10 per cent.; then the iron will become softer, less brittle and capable of being hammered or welded, but much more difficult to fuse or melt than before. In brief, it will be changed into wrought iron at a stage earlier than that at which the carbon is by 0.10 per cent., that is, when the carbon in the metal has been reduced from 2¼ per cent. present in the pig iron to 1¼ per cent., then metal called steel is formed. At judicious intervals the workmen throw into the bath pieces of ore which, under the influence of the great heat in the furnace, melt into a scum or slag which collects on the surface of the fused and fusing metals in the bath, and which serves the useful purpose of protecting the metal from the action of the flaming gas, which would otherwise oxidize it. This slag contains metallic iron, and from time to time the workmen endeavor to get it to deposit. This depositing, or cleaning the slag, as it is called, is effected by the addition of fusing substances such as lime, etc. When in the opinion of the furnaceman the process is complete, he passes into the furnace a small ladle or spoon attached to the end of a long handle, and takes out a sample of melted metal. After cooling it in water it is then hammered and broken by fracture. The character of the fracture and its behavior under the hammering enables the workman to judge whether the process of fusing has continued long enough to give the highest value to the steel. He may require to take many samples before he is satisfied that the metal is in a proper condition. When he so satisfies himself, the next part of the process is carried out. This consists in throwing into the bath of melted metal a quantity of ferro-manganese, the use of which is that this rich alloy prevents "red shortness." The manganese also being readily oxidized, combines with the oxygen present in the mass of steel; this combination prevents the formation of cells arising from the occlusion of gas in the body of the mass. It also enables the steelmaker to produce sound steel, and to give to the product the necessary percentage of manganese, while on the other hand the percentage of carbon may be decreased.

The furnace is then tapped, and the metal withdrawn from the hearth and emptied into a large ladle, from which it is discharged into moulds, forming what is known as ingot steel.

From the moulds the ingots are transferred to the mill furnaces, and, after being heated to a certain temperature, are rolled into long bars which are cut up into such lengths as required. These lengths or billets are reheated and rolled into flat and round bars, fish plates, nail plates, small rails, etc. The billets are hammered into car axles, shafting, cranks, and all kinds of marine work. We have now gone over all the leading points connected with the manufacture of pig iron and steel, and trust that with such natural resources as we possess, directed by skill not inferior to that found among our competitors, we shall move steadily onward, overcoming all obstacles or difficulties that may appear in our way, until at last we shall attain to what we are destined to be, the manufacturing centre of Canada.

For THE CANADIAN ENGINEER.

THE PROSPECTS OF THE GAS ENGINE.

BY J. H. KILLEY, HAMILTON, ONT.

Rivalry with steam power in an economical sense is now the order of the day among advanced mechanicians; perfectly successful gas engines up to 600 h.p. are now in operation, running with the steadiness and the regularity of the steam engine, not taking more than 1 lb. of inferior coal per h.p. per hour, while some builders claim that they can build them to run with ¾ lb. A gas works in the States has a 300 h.p. gas engine running a dynamo, enabling them to supply electric lights in addition to gas light at a net cost far below that of the most economical steam engines and boilers. A