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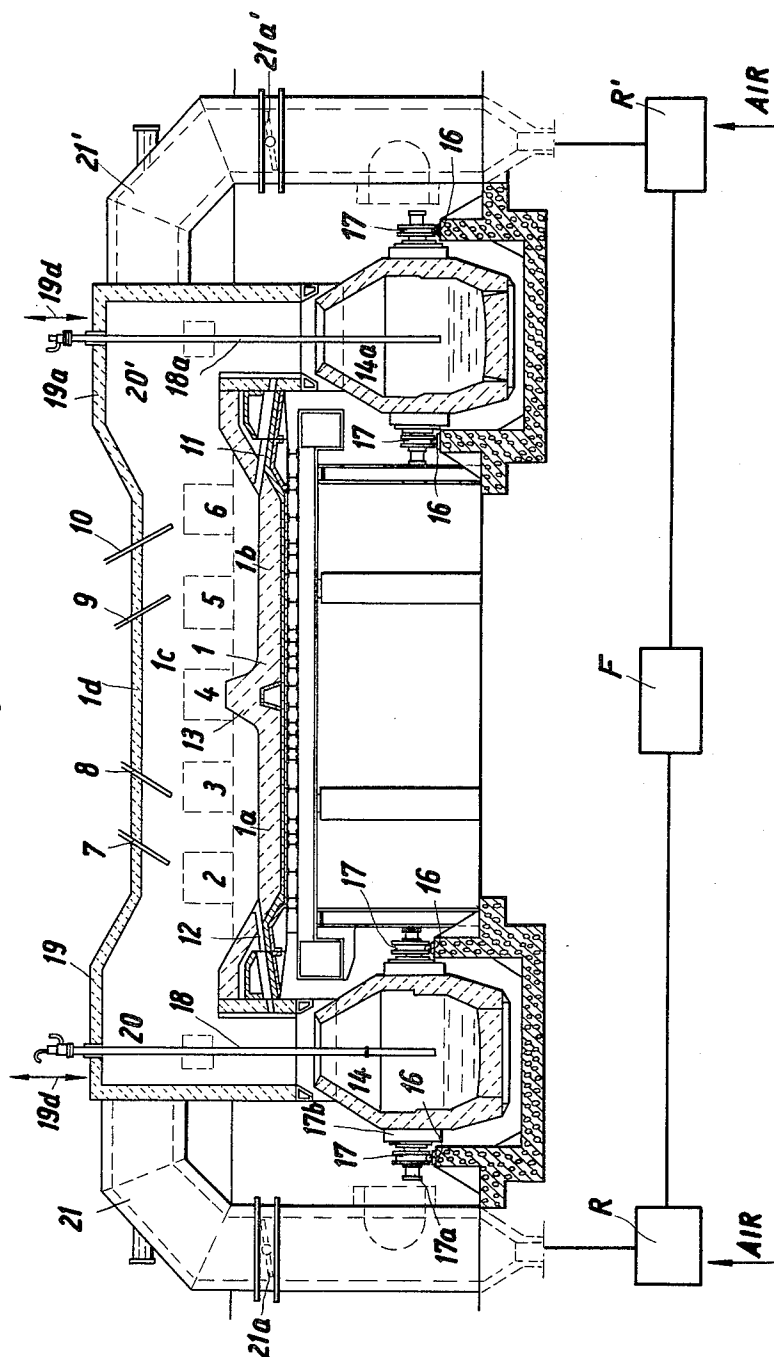
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METHOD OF MAKING STEEL

3,231,369

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Fig. 1



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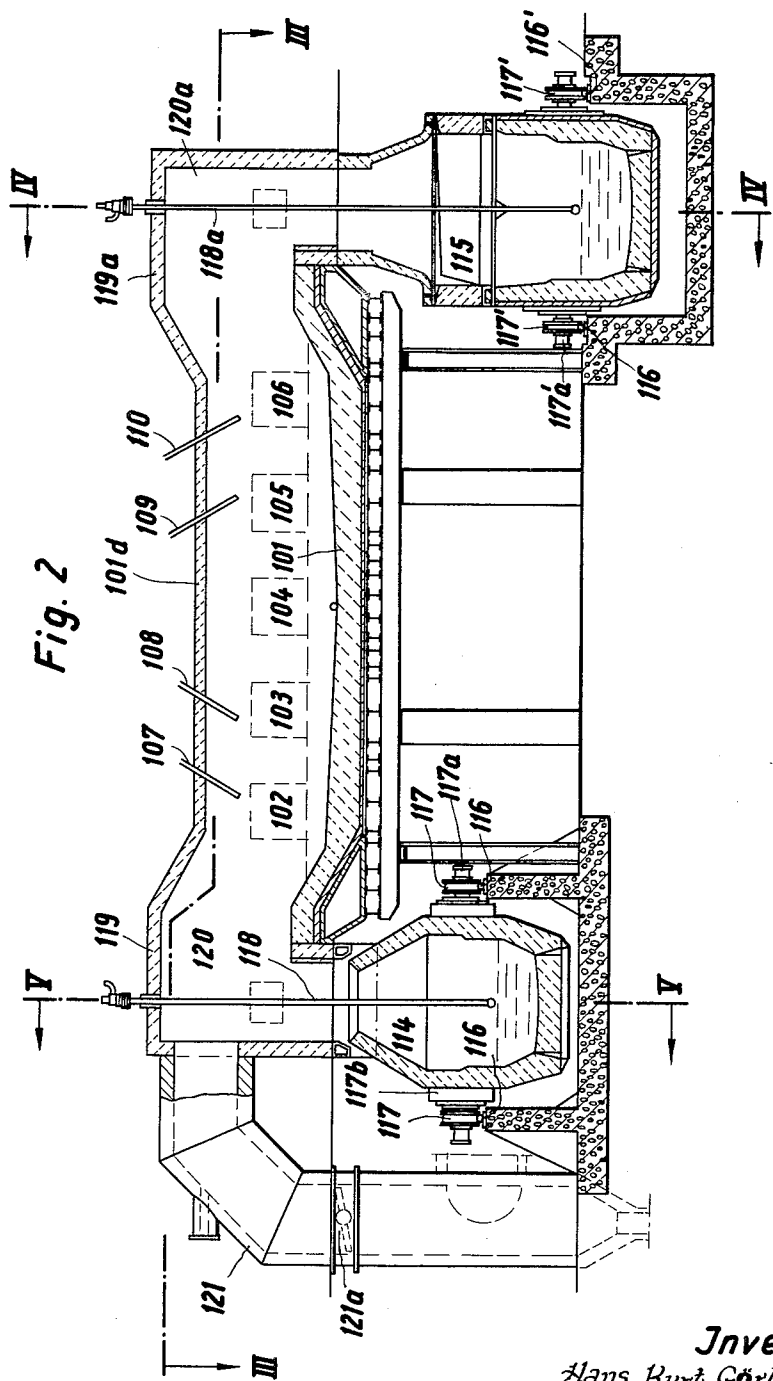
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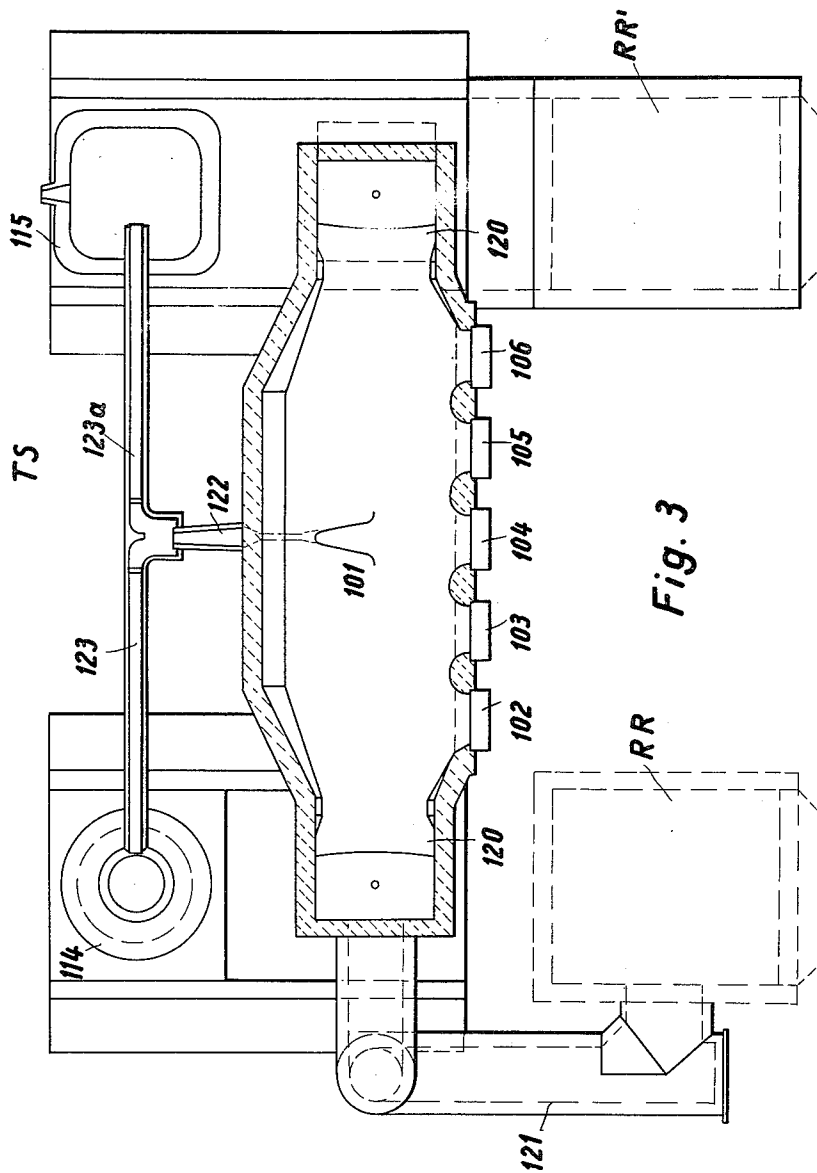


Fig. 3

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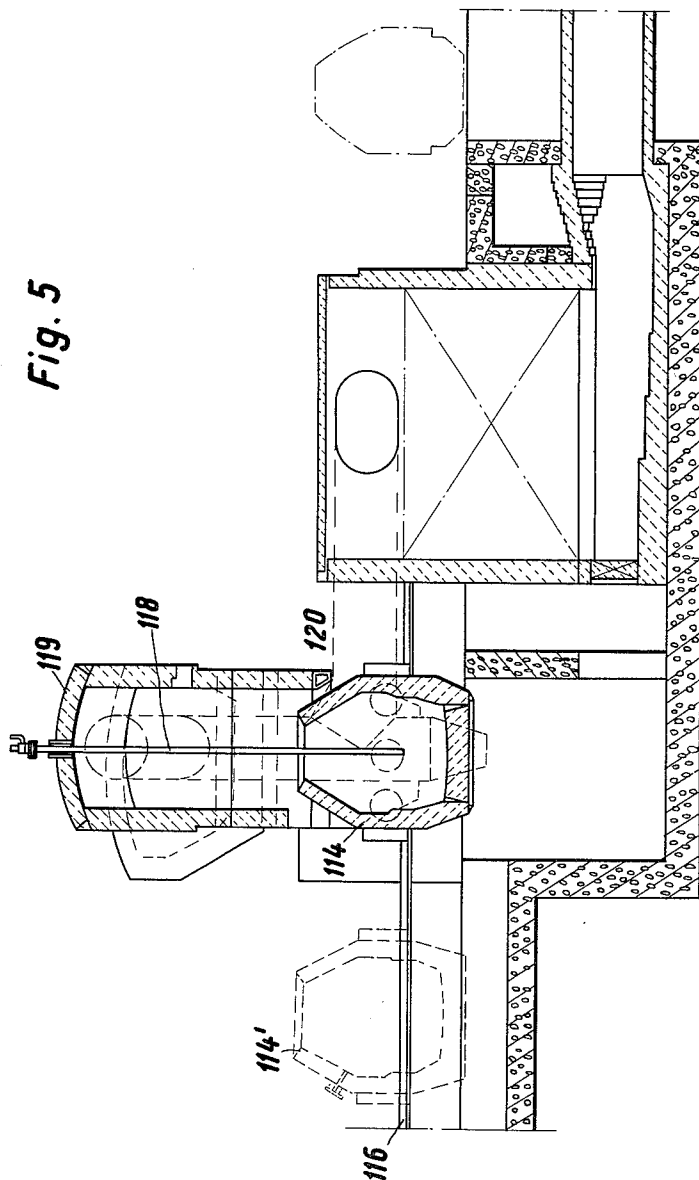
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Fig. 5



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METHOD OF MAKING STEEL

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K 46,289

2 Claims. (Cl. 75—60)

The present invention relates to the production of steel in open-hearth furnaces, and more particularly to a novel method of making steel in an improved open-hearth furnace.

It is well known to produce steel by melting scrap and pig iron in the hearth of a Siemens-Martin furnace. Oxygen necessary for carrying out the oxidizing step is admitted in the form of elemental oxygen or as oxygen-enriched air. Additional oxygen is released by iron ore and scrap in response to heating of the contents of the furnace. Steel of desired composition is obtained by adding to molten heat suitable quantities of alloy additions, such as manganese, nickel, chromium and others. A serious drawback of known Siemens-Martin processes is that the time necessary for making a given quantity of steel is rather long. Thus, a Siemens-Martin furnace of medium capacity can be tapped every 8–10 hours, and any reduction in the length of intervals between consecutive tapping steps can bring about substantial savings which are reflected in the cost of steel.

Accordingly, it is an important object of our invention to provide a novel time-saving method of making steel in open-hearth furnaces according to which the length of intervals between consecutive tapping steps is but a fraction of time which elapses between consecutive tappings of a conventional Siemens-Martin furnace.

Another object of the invention is to provide a method according to which two or more types of steel may be produced in a single furnace and in a simultaneous operation.

A further object of the invention is to provide a continuous method of making steel in open-hearth furnaces and to carry out such continuous method with substantial savings in time and fuel.

An additional object of the invention is to provide a method according to which the output of an open-hearth furnace may be multiplied without increasing the dimensions of the furnace.

With the above object in view, one feature of our invention resides in the provision of a method according to which the hearth of an open-hearth furnace is utilized solely to melt scrap and additions but no pig iron, and according to which a batch of molten scrap obtained upon melting of scrap is admixed to pools of molten pig iron which is formed externally of the furnace and which is not introduced into the hearth. Therefore, and particularly if the method is carried out in accordance with molten scrap which are formed in separated sections of a single hearth in an open-hearth furnace may be admitted to consecutively formed pools of molten pig so that, while one section of the hearth is being charged, scrap contained in one or more additional sections may be heated to form pools of molten scrap whereby the steel-making operation may be carried out on a continuous basis because, when the refining of a mixture containing molten pig and molten scrap is completed, another section of the hearth is ready to discharge a pool of molten scrap while the section which has discharged molten scrap in a preceding step may be charged and heated to furnish a new pool of molten scrap after elapse of an extremely short interval of time, e.g., 2–3 hours.

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In accordance with another feature of our invention, the apparatus for carrying out of the novel method comprises a series of vessels made of heat resistant material and arranged to occupy space normally occupied by slag pots in conventional Siemens-Martin furnaces, at least at such times when the hearth is ready to discharge a new supply of molten scrap. The vessels may assume the form of fixed bodies which are permanently installed in requisite positions to receive scrap from the furnace or, alternatively, the vessels may assume the form of wheel mounted conveyances (converters of ladles lined with heat-resistant material) which may be moved into the proximity of the hearth or to the tapping side of the furnace to discharge the newly formed masses of molten steel and to receive new pools of molten pig which may be taken from a conventional blast furnace or from another suitable source.

The hearth of the improved open-hearth furnace may discharge molten scrap through a series of runners or through tapholes which are provided at the opposite ends thereof and each of which may discharge molten scrap from a separate section of the hearth if the latter is formed with suitable partitioning means which divide its cavity into two or more scrap-receiving compartments.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The apparatus itself, however, both as to its construction and its method of operation, together with additional features and advantages thereof, will be best understood from the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a longitudinal vertical section through an open-hearth furnace which embodies one form of our invention;

FIG. 2 is a similar section through a modified furnace;

FIG. 3 is a horizontal section as seen in the direction of arrows from the line III—III of FIG. 2;

FIG. 4 is a transverse vertical section as seen in the direction of arrows from the line IV—IV of FIG. 2; and

FIG. 5 is a transverse vertical section as seen in the direction of arrows from the line V—V of FIG. 2.

Referring now in greater detail to the drawings, and first to FIG. 1, there is shown an elongated open-hearth furnace of the type generally known as Siemens-Martin furnace and whose elongated basin or hearth 1 is divided into a plurality of sections, e.g., two sections 1a, 1b, by a requisite number of partitions. FIG. 1 shows a single transversely extending trapeziform partition 13. The front side wall of the furnace (which is broken away in the view of FIG. 1) is provided with a series of charging doors 2, 3, 4, 5 and 6 (shown in phantom lines) through which scrap and additions are admitted by conventional charging machines, not shown. In accordance with a feature of our invention, the cavity of the hearth 1 is used solely for melting of scrap, i.e., no pig is being admitted through the doors 2–6. Such scrap is introduced with the help of customary charge boxes. The charge is heated by overhead burners 7, 8, 9 and 10 which preferably assume the form of inclined lances extending through the central portion of the roof 1d and into the melting chamber 1c. If desired, the lances may be mounted in vertical position. The height of the partition 13 should be sufficient to prevent overflowing of molten material from the sections 1a into the section 1b or vice versa.

When the melting operation is completed, molten scrap is discharged through tapholes 11, 12 disposed at the opposite ends of the hearth 1 and leading respectively to vessels 14, 14a which, in the embodiment of FIG. 1, assume the form of substantially pear-shaped converters. Each of these converters is provided with a trunnion ring

17b for two trunnions 17a which carry wheels 17 arranged to travel along spaced guideways here shown as rails 16 leading to the tapping side of the furnace. Such arrangement is of considerable advantage because, when molten scrap is being tapped from the left-hand section 1a to flow through the tap-hole 12 and into the converter 14, the other converter 14a may receive a supply of molten pig at the tapping side and may be returned to the position of FIG. 1 in time for tapping of molten scrap from the section 1b (taphole 11). Thus, the steel-making operation may be carried out on a continuous basis by alternately tapping molten scrap from the sections 1a, 1b and by alternately introducing molten pig into the converters 14, 14a.

For example, when the converter 14 contains a pool of molten pig and is placed beneath the discharge end of the taphole 12, the other converter 14a is conveyed to the tapping side of the furnace to discharge its supply of molten steel and subsequently receives a new pool of molten pig from a blast furnace or the like prior to tapping of molten scrap from the section 1b. In the meantime, a pool of molten scrap was discharged from the section 1a and was admixed to the pool of molten pig in the converter 14 so that this converter may be conveyed to the tapping side to discharge its contents and to receive a new pool of molten pig prior to returning to the position of FIG. 1. At the same time, the section 1a has received a new supply of scrap and additions and the lances 7, 8 produce heat to melt such new supply of scrap while the converter 14 is moved to and back from the tapping side. This tapping side is located to the rear of the plane of FIG. 1.

In the illustration of FIG. 1, the converters 14, 14a occupy positions normally occupied by slag pots of conventional Siemens-Martin furnaces. Thus, the refining or purifying operation may be carried out right on the spot, namely, at the exact point where molten scrap is being evacuated from the hearth 1. Such refining operation is carried out by tubular means here shown as oxygen lances 18, 18a which respectively pass through the end portions 19, 19a of the furnace roof 1d and which are reciprocable in directions indicated by double-headed arrows 19d, for example, by means of suitable winches or the like, not shown. The lower end portions of the lances 18, 18a may be introduced into the interior of the respective converters and the brown fumes which develop during such refining operation are preferably led through the chamber 1c to be discharged at the opposite end of the furnace. Thus, if the lance 18 discharges elemental oxygen or oxygen-enriched air into the contents of the converter 14, the flap valve 21a in a duct 21 is closed and the flap valve 21a' in a duct 21' at the opposite end of the furnace is open to insure that the fumes must pass along the surface of the molten scrap contained in the sections 1a, 1b and are discharged through the duct 21' to pass through a regenerative chamber R' and to the flue F. On the other hand, when the lance 18a discharges oxygen into the contents of the converter 14a (which is assumed to contain a mixture of molten pig and molten scrap), the flap valve 21a' is closed and the valve 21a is open so that the fumes are compelled to flow along the heat contained in the hearth 1 and escape through the other duct 21, through a second regenerative chamber R and into the flue F.

Of course, the furnace of FIG. 1 is provided with suitable doors (not shown) which are lined with refractory material and which are large enough to permit passage of the converters 14, 14a when the converters are removed from the furnace for the purpose of discharging the newly refined supply of molten steel and of receiving a new pool of molten pig. Such doors are provided in the lower parts of both end portions or heads 20, 20' of the furnace and one thereof will be described in connection with FIG. 4. When the converters 14, 14a receive a supply of molten scrap and when the lance 18 or 18a

admits oxygen into the respective converter, the doors are closed to prevent entry of false air. The converter doors assume the form of flaps or bells, as the case may be.

It goes without saying that some alloy additions, such as nickel and copper, may be added right into the section 1a or 1b so that the alloying process may begin before the molten scrap is discharged from the hearth. In other words, the tapholes 11, 12 may discharge pre-alloyed molten scrap which is then admitted to molten pig in the converter 14 or 14a. In such manner, one may simultaneously obtain two types of alloy steel one of which is being formed in the converter 14 and the other of which is formed in the converter 14a. It is also possible to add certain alloy additions to molten pig in the converter 14 or 14a and to admix to molten pig pre-alloyed molten scrap from the section 1a or 1b. Furthermore, one can add alloy additions only to molten pig or only to the mixture of molten pig and molten scrap, as the case may be. All such methods of forming alloy steel may be resorted to by utilizing the furnace of FIG. 1 or the furnace which will be described in connection with FIGS. 2 to 5.

By utilizing the system of ducts 21, 21a as shown in FIG. 1, we can insure that the heat energy of fumes is absorbed by scrap contained in the sections of the hearth 1 so that the percentage of heat energy withdrawn from such fumes is much higher than in known Siemens-Martin furnaces of which we have knowledge at this time. Thus, the fuel requirements of our furnace are comparatively low because the percentage of heat energy which is recovered from fumes is much higher than normal. It goes without saying that savings in fuel, combined with shorter periods which are required for obtaining a given quantity of steel result in greatly reduced manufacturing cost. As stated hereinabove, the period of time required to obtain a given quantity of steel is between 2-3 hours, in contrast to periods of between 8-10 hours in conventional Siemens-Martin furnaces.

An important advantage of lances 1, 1a which respectively extend into the heads 20, 20' of the furnace shown in FIG. 1 is that fumes developing during the refining operation may be led away in the aforesaid manner by simultaneously insuring that such fumes exchange heat with scrap contained in the hearth 1 and that they may be discharged through the regenerative chambers to exchange heat for a second time prior to being discharged into the flue.

Referring to FIG. 2, the open-hearth furnace of this illustration comprises a conventional fixed basin or hearth 101 defining a single cavity for reception of ferrous scrap which is introduced through charging doors 102-106, see particularly FIG. 3. Molten scrap is tapped through a conventional centrally located spout or runner 122 which leads to the tapping side TS and conveys the molten scrap to a pair of diverging runners 123, 123a respectively leading to vessels 114, 115. The vessel 114 again assumes the form of a converter whose trunnion ring 117b carries two trunnions 117a for wheels 117 which are guided by rails 116. The other vessel 115 assumes the form of a ladle which is also provided with trunnions 117a' for wheels 117' which are arranged to travel along rails 116'. The vessels 114, 115 may be moved to the positions of FIG. 2 or 3 which correspond to locations of slag pots in conventional Siemens-Martin furnaces. The arrangement of burners 107-110 and of lances 118, 118a is analogous to that of the corresponding parts in the furnace of FIG. 1.

While FIGS. 2 and 3 illustrate a furnace which utilizes two different vessels, just to show that it is possible to use different vessels in a single furnace, it is normally advisable to operate with similar vessels, i.e., with converters 114 or with ladles 115. Therefore, the left-hand portions of FIGS. 2 and 3 show a portion of a system of ducts which is utilized when the furnace operates with converters, such as the converter 114. This system comprises ducts 121 provided with flap valves 121a, the ducts

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leading to regenerative chambers RR one of which is shown in FIG. 3.

If the furnace of FIGS. 2 and 3 operates with ladles 115, the system of ducts is of conventional design and leads to regenerative chambers RR' one of which is shown in FIG. 3. FIG. 2 illustrates that the level of the ladle 115 is rather low, i.e., lower than the level of the converter 114, in order to make sure that the system of ducts used in connection with such ladles may be the same as in conventional Siemens-Martin furnaces. The duct 121 is connected to the head 120 at the respective end of the furnace.

FIG. 4 is a transverse vertical section through the right-hand head 120a of the furnace shown in FIGS. 2 and 3, and illustrates the position of the regenerative chamber RR' such as is used in conventional Siemens-Martin furnaces. There is also shown the end portion 119a of the roof 101d, the charging floor CF' and the system of conduits CC', leading into and from the regenerative chamber RR'. The position of the ladle 115 at the tapping side TS is shown in phantom lines, as at 115'. The door D' which is coated with refractory material normally seals the opening in the lower portion of the head 120' through which the ladle 115 may be moved to and from the tapping side. It will be noted that the regenerative chamber RR' is located at the charging or front side of the furnace, just as in conventional Siemens-Martin furnaces.

FIG. 5 shows the manner in which the converter 114 may be moved to the tapping side TS to occupy the phantom-line position 114' in which it may discharge a newly refined pool of molten steel to thereupon receive a pool of molten pig from a blast furnace or from another source, not shown.

A very important advantage of an open-hearth furnace of the type shown in FIG. 1 or in FIGS. 2 to 5 is that the time necessary for making a given quantity of steel is but a fraction of the time necessary for making an equal quantity of steel in conventional Siemens-Martin furnaces even though the construction of the improved furnace differentiates rather slightly from the construction of known furnaces. The quality of steel obtainable in our furnace at least equals the quality of steel which is obtained in conventional furnaces, but the time necessary for the production of a given quantity is reduced to between 2-3 hours in contrast to a period of about 8-10 hours which is normally required between consecutive tappings in known Siemens-Martin furnaces. A feature common to all embodiments of our invention is that, while the furnace is being charged (through the doors 2-6 or 102-106), the refining process may be carried out in vessels 14, 14a, 114 or 115 so that the refining process takes place simultaneously with the charging step. A further modification of our invention which

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is so close at hand that it can be comprehended without additional illustration consists in that the vessels 14, 14a, 114 and 115 are stationary and constitute permanent refining chambers which are built into the end portions of the furnace and which are lined with refractory material to withstand the melting temperature. Such stationary vessels are then provided with suitable tapholes and may receive molten pig from travelling ladles or converters, as the case may be. If the vessels are stationary (i.e., if such vessels occupy positions normally occupied by slag pots), fumes developing during refining may be conveyed directly into the customary conduit for spent gases.

Of course, when the furnace operates in a manner as illustrated in FIG. 1, i.e., when the hearth is sub-divided into a plurality of sections, savings in time are even more pronounced because melting of scrap may be carried on in one section of the hearth while molten scrap tapped from the other section or sections is being treated in the associated vessel or vessels. In other words, liquid scrap is being held ready for the next tapping operation as soon as a refining operation is completed and vice versa.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic and specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A method of making steel, comprising the steps of heating ferrous scrap in the hearth of an open-hearth furnace to obtain a pool of molten scrap; forming a supply of molten pig at a point externally of the furnace; tapping the furnace and conveying molten scrap from the hearth into the supply of molten pig to form a mixture of pig and molten scrap; admitting oxygen into such mixture whereby the mixture emits hot fumes; and conveying the fumes along the pool in the hearth so that the fumes exchange heat with the scrap.

2. A method as set forth in claim 1, wherein the fumes are conveyed from the one toward the other end of the furnace.

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BENJAMIN HENKIN, *Primary Examiner*.