May 24, 1960 A. J. KESTERTON 2,937,864

GUN ASSEMBLY USED IN AN OPEN HEARTH FURNACE

Filed Sept. 13, 1957 2 Sheets-Sheet 1

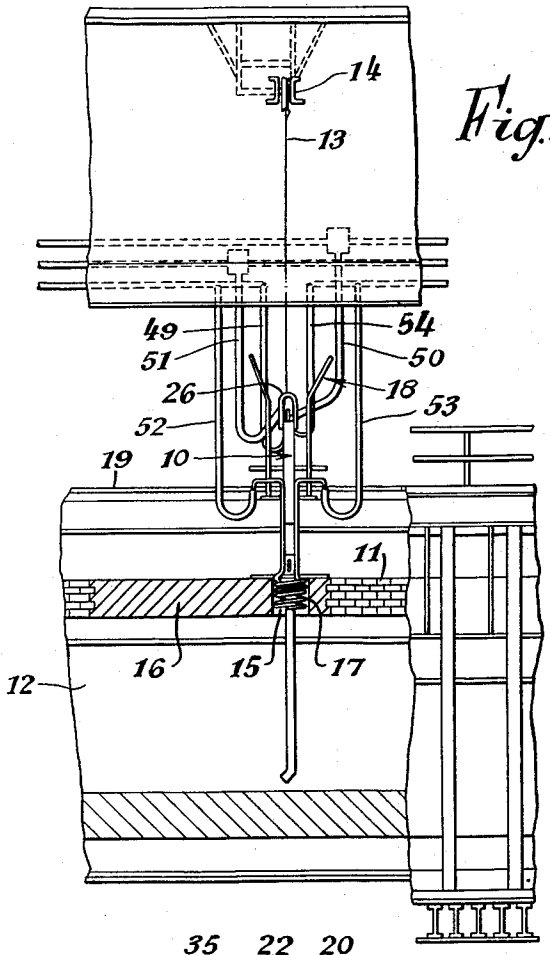


Fig. 1.

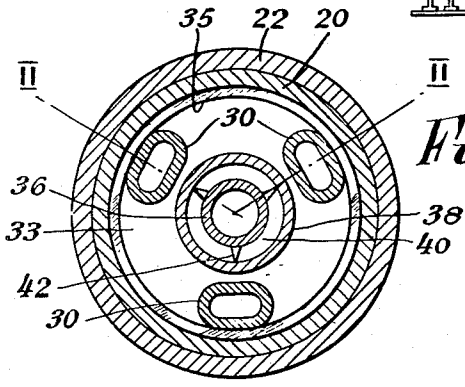


Fig. 4.

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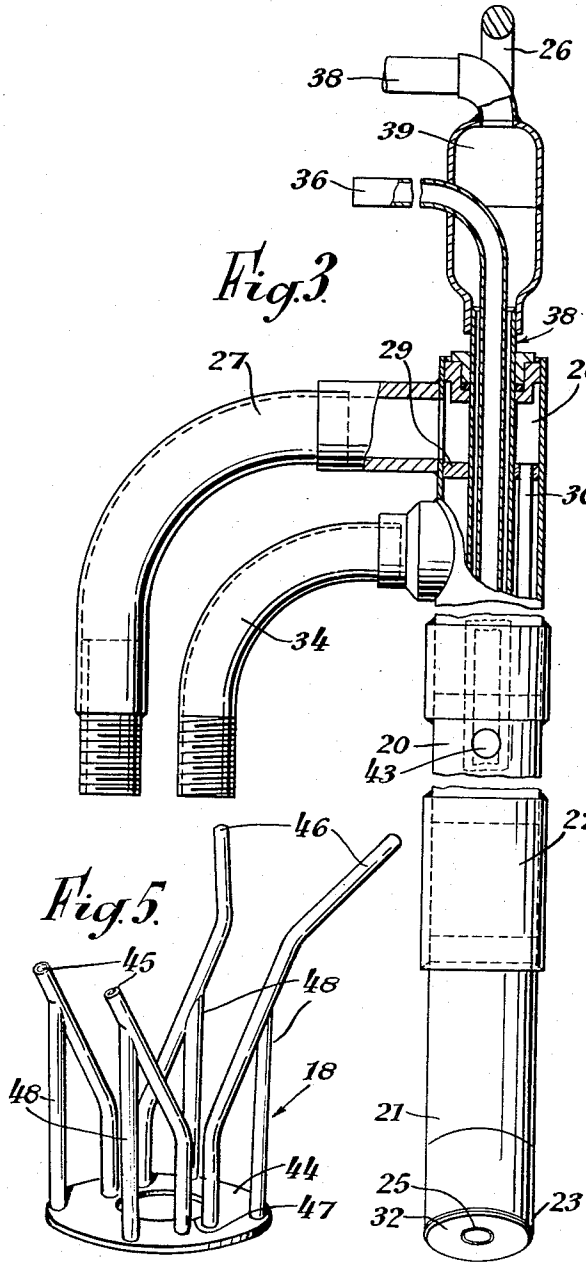


Fig. 3.

Fig. 5.

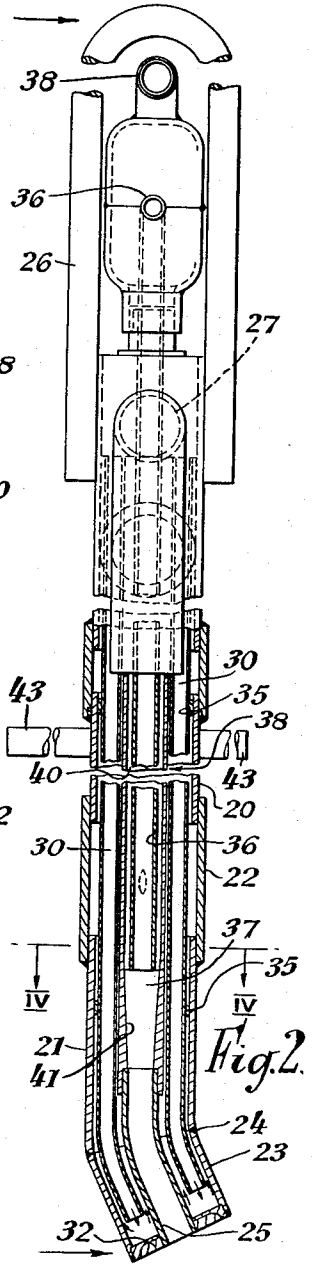


Fig. 2.

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United States Patent Office 2,937,864 Patented May 24, 1960

2,937,864

GUN ASSEMBLY USED IN AN OPEN HEARTH FURNACE

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Filed Sept. 13, 1957, Ser. No. 683,787

3 Claims. (Cl. 266—34)

This invention relates to a method and apparatus for the injection of oxydising gases in the form of a jet of near sonic speed on to the surface of molten iron or steel in open-hearth furnaces, tilting or stationary, and mixers, both of the "active" and "inactive" types.

It is a particular object of the present invention to provide an improved apparatus in which the oxydising gas delivered thereby may have steam or other diluent gases mixed with it before it reaches the surface of the molten iron or steel.

In our co-pending application No. 584,772 there is described and claimed an oxygen gun assembly having a cranked or bent nozzle end, the gun being introduced through the roof of the furnace in which it is adjustably mounted.

The construction of the gun of our above-mentioned co-pending application is intended for the delivery of oxygen alone on to the surface of the metal bath and this prior design has many advantages as set out in detail in said co-pending application. In particular the design of the gun provides for a long life and for adequate cooling. Furthermore, the mounting of the gun in the roof has the advantage that the introduction of the gun does not interfere with the normal charging and tapping of the furnace.

The use of oxydising gases consisting of oxygen or oxygen enriched air produces under certain circumstances considerable quantities of brown fumes when impinged upon the surface of molten steel or iron, especially if the bath contains substantial quantities of carbon. The brown fumes so produced are a considerable nuisance and it has been discovered that the mixture of steam with the oxygen greatly reduces the amount of brown fume produced. The present invention, therefore, has for another object the provision of a gun assembly, the construction of which allows for the ready mixing of the oxygen and steam, and control of the ratio so as to suit the composition of the charge.

According to one aspect of the invention there is provided a method of refining a charge of molten steel in an open-hearth furnace, said method comprising the injection of a mixture of oxygen and steam or other diluent gases into the charge, the steam or other diluent gases being mixed with the oxygen before it reaches the surface of the charge.

According to a further aspect of the invention there is provided a gun assembly for lowering through the roof of an open-hearth furnace to direct a combined stream of oxygen and steam or other diluent gases on a charge within the surface, said assembly comprising an elongated body, a tubular member centrally located within said body for the passage of oxygen therethrough, the end of said tubular member being flush with the end of said body, a second tubular member located within said first tubular member for the passage of steam or other diluent gases therethrough, the lower end of said second tubular member terminating short

of said first tubular member to provide a mixing chamber in the lower end of said first tubular member for said oxygen and diluent gas or gases.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a longitudinally vertical cross-sectional view of an open-hearth furnace showing the steam/oxygen gun of the present invention in its lowered or operative position;

Figure 2 is an elevational view of the gun with portions in section to show the internal construction, the section being taken on the line II—II of Figure 4;

Figure 3 is an elevational view of the gun of Figure 2 looking in the direction of the arrows of Figure 2, part of the gun being shown in section to show further details of the internal construction;

Figure 4 is a sectional view taken on the line IV—IV of Figure 2 showing in particular the arrangement of the coolant pipes about the central oxygen and steam pipes; and

Figure 5 is a perspective view of the guide on the the roof of the furnace for the gun.

Referring to the drawings and more particularly to Figure 1, the steam/oxygen gun assembly is shown generally by the reference numeral **10** and is located and supported in the roof **11** of an open-hearth furnace **12** in the manner described in our co-pending application No. 584,772. Briefly, however, the gun assembly is supported by a cable **13** extending over a pulley **14** secured in the roof of the building containing the furnace. The cable **13** extends horizontally (not shown) to another pulley and down to the winding drums of an electrically operated winch secured to girders above the furnace or in any other suitable position.

The gun assembly **10** extends downwardly through an opening **15** in the roof **11** of the furnace. The opening **15** is adjacent one end of a panel **16** of chrome magnesite bricks which is inserted in the roof **11** of the furnace. Chrome magnesite is more resistant to the effects of molten slag than the silica brick of the furnace and the panel **16** is, therefore, so arranged that its greater portion is in the direction of the jet of steam and oxygen being discharged from the gun so as to prevent damage to the roof of the furnace from splashing slag. Located within the opening **15** is a cooling annulus **17** which surrounds the gun assembly **10**. By cooling the opening **15**, the furnace gases escaping from the opening will be cooled and their cutting action on the roof **11** and position of the hole will be considerably reduced. The gun assembly is furthermore provided with a guide **18** which is positioned directly above the opening **15** upon a beam construction indicated at **19**. The guide **18**, which will be described later in detail with reference to Figure 5, is for the purpose of assisting the cable **13** in supporting the gun in position and to prevent the gun assembly from rotating when it is in its operative position in the furnace.

The gun assembly **10** will now be described with reference to Figures 2 to 4.

The gun assembly comprises a steel body **20** consisting of a 4 inch bore, 4½ inch outside diameter mild steel pipe, to the lower end of which is fixed a copper pipe **21** of the same bore and outside diameter by a ring **22**. The lower end **23** of the copper tube **21** is bent at **24** at an angle of approximately 25° and includes the mixed steam/oxygen blast delivery nozzle pipe **25**. The longer side of the bent portion is about 4½ inches in length. Secured to the upper end of the steel body **20** is a U-shaped connecting member **26** to which the steel lowering cable **13** is attached (see Figure 1).

Attached to the upper portion of the gun body **20** is a curved inlet pipe **27** for the cooling water. The cooling water enters a chamber **28** above a diaphragm **29** into which project the open top ends of three mild steel pipes **30** which extend virtually the full length of the gun. This cluster of three steel pipes **30** surrounds a central steam and oxygen pipe assembly **31**, and carry water to within 1 inch of a closing plate **32** at the extreme lower end of the gun. The water impinges against the plate **32** carrying out effectively the cooling action required at the nozzle, and then returns up the gun in the space **33** between the walls of the gun body **20** and the central steam and oxygen pipe assembly **31**. When the water reaches the underside of the diaphragm **29** it passes outwards through a water outlet pipe **34**.

The cluster of water cooling pipes **30** are oval in shape, having been made in this form by flattening ordinary circular steel pipe, in order to obtain a sufficiently large cross-sectional area of pipe to carry the necessary water to the tip of the nozzle end **25** of the gun, and yet to incorporate these pipes, together with the central steam and oxygen pipe assembly **31**, in an outer pipe **20** of the smallest possible diameter, thus minimizing heat losses from the furnace and reducing the size of the hole **15** required through the roof **11**. Spacing rings **35** welded to the pipe **20** maintain the pipes **30** in proper spaced position from the pipe **20**.

Steam is supplied to the gun along a mild steel pipe **36**, and is carried down through the centre of the gun to a mixing point **37** approximately at the beginning of the copper tube **21**. The oxygen is conveyed to the gun along a mild steel inlet pipe **38**, and enters an enlarged mild steel chamber **39** before flowing down the centre of the gun in an annular space **40** between the inner surface of its mild steel supply pipe **38** and the steam pipe **36** which is located therein. The oxygen is also conveyed through this annular space **40** to the mixing point **37** where both oxygen and steam enter and mix in a tapering mild steel pipe **41** fixed to the end of the outer oxygen supply pipe **38**. The mixed oxygen/steam blast then flows into the bent copper delivery nozzle pipe **25** which is fixed to the end of the tapering steel pipe **41** in the copper tube **23** and from whence it is ejected from the end of the gun in the form of a jet towards the iron or steel bath in the furnace **12**.

Segmental mild steel spacers **42** welded to the inner steam steel pipe **36**, maintain it in a properly spaced position from the oxygen pipe **38**, thus preserving the annular space **40** through which the oxygen flows.

The enlarged chamber **39** in the oxygen supply pipe **38** at the top of the gun is provided so that there shall be no loss of pressure in the oxygen supply caused by its having to impinge at high velocity upon the central steam pipe **36** which enters this chamber as a curved pipe below the oxygen entry. The enlarged chamber **39** slows down the oxygen gas as it flows over the curved steam pipe, reducing the pressure losses which such an obstruction to its flow would otherpise cause.

An essential feature of this gun is that the oxygen is carried down the annular space **40** formed between the central steam pipe **36** and the inner surface of the oxygen pipe **38**. Thus it is the oxygen pipe **38** which is in contact with the water jacket, so that the oxygen in the annular space **40** acts as an insulator to the steam pipe **36**, to minimise loss of heat from the steam to the water jacket which would otherwise occur, causing condensation of steam, and loss of pressure.

Near the upper end of the gun body **20** there is a pair of radially extending locating bars **43**. These bars **43** are of high grade steel and are used to support and locate the gun in the gun guide **18** in a manner which will now be described.

When the gun is in its lowered operative position (as shown in Figure 1), it is supported in the gun guide **18** which is illustrated in Figure 5. The gun guide **18** comprises an annular base **44**. Extending vertically upward from the base **44** are bent front tubes **45** and bent high back tubes **46**. It will be noted that the tubes **45** and **46** are bent in such a manner that the lower portions thereof form slots **47**. The slots **47** accommodate the locating bars **43** which are mounted on the oxygen gun.

Vertically extending supports **48** connect and brace the tubes **45** and **46** to the base **44**. The entire gun guide construction is made of steel.

The guide **18** is positioned upon the roof of the open-hearth furnace in such a position that the axis of the jet of steam and oxygen emitted from the gun is parallel to the longitudinal axis of the furnace. Since there is considerable agitation of the steel bath by the jet of steam and oxygen, it is desirable to direct the jet along the longitudinal axis of the furnace. The positioning of the locating bars **43** in the slots **47** of the guides will prevent rotating of the oxygen gun during the operation thereof.

The high back tubes **46** are for gathering the various hoses connected to the gun to prevent fouling of the hoses in any auxiliary equipment which is adjacent to the furnace. In Figure 1, the water inlet pipe **27** is connected to a source of cooling water by a hose **54** and the water outlet pipe **34** to an exit manifold by a hose **49**. The steam enters through a hose **50** and the oxygen by a hose **51**.

The guide **18** also serves to support the gun above the bath should there be a failure of the supporting cable **13**.

The annulus **17** comprises a continuous length of steel tubing which is in the shape of a coil. The cooling water enters through the water inlet **52** and circulates through the coil from the bottom upwardly to be exited from the water outlet **53**.

The use of a roof cooler in the form of a continuous coil has the outstanding advantage in that there is a constant flow of the cooling water throughout the entire annulus. This results in an equal maximum flow rate throughout the entire coil. By having a constant maximum flow rate, the life of the water-cooled helical coil is greatly improved, this improvement being on the order of a fivefold increase in its life.

When the gun is required to operate, it is desirable before lowering, to turn on the steam in order to purge out any small accumulation of water there may be remaining in the pipes from the previous occasion of use. The steam is then turned off, and the gun lowered to the operating position, which is 4 to 5 inches above the bath surface level, and the oxygen turned on first. This ensures that the first impact of the blast upon the surface of the liquid, does not cause solidification, of metal or slag in the region of the orifice, which might cause partial blocking. After a few seconds of oxygen blowing, it is quite satisfactory to open up the steam valve and mix the blast. Withdrawal of the gun takes place in the reverse order, in that the steam is turned off first, followed by the oxygen and the gun then retracted into the hole in the roof until required for the next operation.

The quality of the steam used for an operation such as this is important, and it is desirable that the steam should be super-heated to the greatest extent possible. This will then minimise any condensation of steam which may occur during its passage through the gun. So far, steam has been supplied at a temperature of 550° F., and at a pressure of up to 200 lbs. p.s.i.

For operation in a 200 ton open hearth furnace the oxygen flow rate may vary typically in the range 30,000 to 36,000 cu. ft, per hour, and the steam in the range 30,000 to 40,000 cu. ft, per hour. The steam volume is thus about 50% of the total blast volume. The total flow rate of 70,000 to 75,000 cu. ft. per hour steam plus oxygen, is in excess of that used for straight oxygen blowing, giving equivalent oxidation. This, coupled with the fact that the steam fraction does not react with the

bath to produce non-gaseous products of oxidation as does the oxygen, ensures that the turbulence and disturbance occurring in the reaction zone are greater than with oxygen alone.

Possibily due to this greater turbulance higher decarburisation rates can be achieved with the steam oxygen blast as compared with the equivalent on pure oxygen.

The steam suffers dissociation in contact with the molten iron or steel, decomposing to hydrogen and oxygen, which latter makes a contribution to the total amount of oxidation occurring in the reaction zone. It is estimated that approximately one half of the steam volume is dissociated to give free oxygen taking part in the reaction. This, of course, constitutes a considerable saving in the volume of oxygen required and therefore of cost.

The major advantage of the use of a mixed steam/oxygen blast, compared with pure oxygen, is that the brown fume being emitted from the furnace stack is greatly reduced in density. This is due, it is thought, partly to the fact that a smaller quantity of pure oxygen is used for an equivalent oxydising reaction rate, coupled with the fact that the presence of steam in the reaction zone exerts a cooling ffect, reducing volatilisation of iron.

The mixed oxygen/steam blast is less exothermic than pure oxygen, and this factor may be varied by altering the proportion of steam to oxygen. As a result, whereas during the refining process in steel-manufacture, the use of oxygen alone, sometimes tends to cause a too rapid rise in temperature, even with all the fuel taken off the furnace, the oxygen/steam blast gives a steadier and a more controllable rise in temperature, so that the desired tapping temperature may be more precisely achieved.

I claim:

1. A gun assembly for lowering through the roof of an open hearth furnace to direct a combined stream of oxygen and steam on a molten charge in the furnace, said assembly comprising an elongated body, a tubular member centrally located within said body for the passage of oxygen therethrough, the end of said tubular member being flush with the end of said body, a second tubular member located within said first tubular member for the passage of steam therethrough, the lower end of said second tubular member terminating short of said first tubular member, a tubular section within said first tubular member with one end thereof adjacent the lower end of said second tubular member and tapering to decreasing diameter toward the outlet of said gun assembly to provide a mixing chamber in the lower end of said first tubular member for said oxygen and steam, the remainder of the lower portion of said first tubular member having a diameter smaller than that of the portion of the first tubular member above said tapering section to provide a passage for the mixture of oxygen and steam, an annular plate in the space between the lower end of said first tubular member and the body for centrally supporting the lower end of the first tubular member, a plurality of pipes annularly spaced about said first tubular member with their lower ends terminating short of said annular plate, means for conveying a liquid cooling medium to said pipes, and means for exhausting the cooling medium from the gun after the medium emerges from the lower ends of said pipes and flows upwardly through the space between the first tubular member and the gun body.

2. A gun assembly as claimed in claim 1, in which the second tubular member is provided with an expansion chamber for reducing the velocity of the oxygen entering the gun.

3. A gun assembly as claimed in claim 1, in which the first tubular member is formed with a tapered portion extending beyond the termination of the second tubular member, and provided with a bent delivery pipe for the discharge of the gaseous fluids mixed in the said tapered portion.

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