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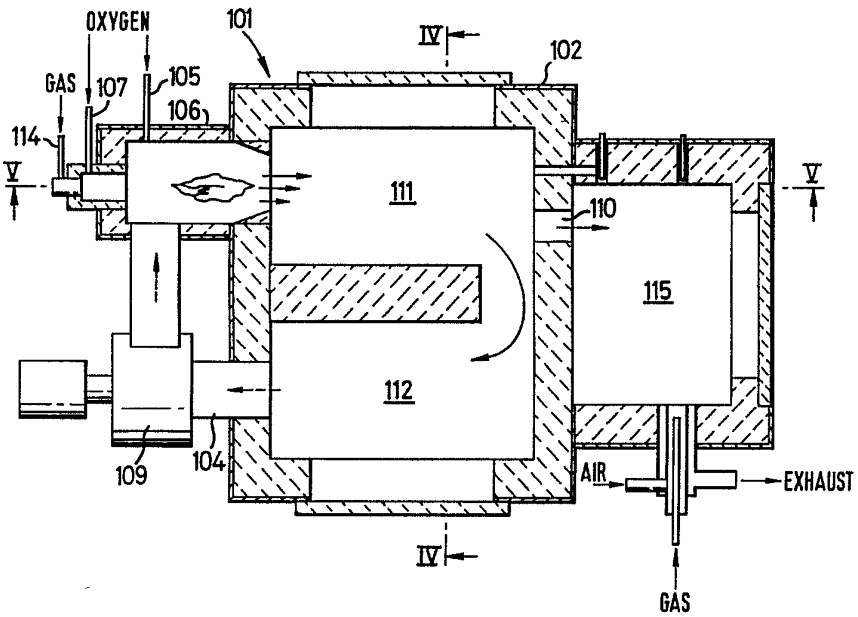
(54) Title: RECLAMATION OF METAL FROM SCRAP



(57) Abstract

The noxious fumes leaving the dry hearth chamber (112) of a metal recovery furnace (102) are fed to an incinerator (106) where they are burnt at high temperature with oxygen. The hot, clean exhaust gas is introduced to the bath chamber (111) of the furnace (102). This arrangement typically saves 60 % of fuel costs. Furthermore, since the fumes are recycled the exhaust emission to atmosphere simply reflects the input of fuel and oxygen. This can be nearly one eighteenth of a conventional plant thereby reducing filter and/or scrubber duty and stack size. This arrangement thus has particular advantages in fuel conservation and conservation of the environment. It enables metals to be recycled in an installation which produces little pollution and which utilizes the heat available in the waste material to conserve fuel.

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RECLAMATION OF METAL FROM SCRAP

This invention relates to the reclamation of metal from scrap.

It is becoming increasingly common to reclaim metal from scrap, for example copper from copper wire, steel from tyres and aluminium from aluminium cans and containers.

Typically, the scrap is heated in a furnace to vaporise and/or partially combust the unwanted material leaving the required metal which is melted and flows to the bottom of the furnace. The vaporised and partially combusted material typically comprises acrid black fumes derived from plastic, oil, paint and grease on the metal which are then passed to an incinerator where they are burnt to convert most of the hydrocarbons to carbon dioxide and water vapour. The gas is then filtered to remove particulate material and/or scrubbed and vented to atmosphere together with some residual pollutants.

Over recent years the permissible levels of pollutants which can be released to the atmosphere has been reduced and this has necessitated the use of more fuel in the incinerators to remove a greater proportion of the hydrocarbons and more efficient filters and/or scrubbers.

The object of at least preferred embodiments of the present invention is to reduce the volume of fuel needed for the entire reclamation process, the total volume of gas emitted to the atmosphere and the total size of the installation.

According to the present invention there is provided an installation for recovering metal from scrap which installation comprises a furnace and an incinerator for burning fumes from said furnace, and wherein said furnace has a dry hearth chamber and a bath chamber, characterized in that said installation further comprises a source of oxygen or oxygen enriched air and means for conveying said oxygen or oxygen enriched air to said incinerator, and wherein at least a major portion of the gases leaving said incinerator is introduced into said bath chamber.

A minor portion of the gases leaving the incinerator may be vented directly to atmosphere.

Preferably however, all the gases leaving said incinerator are introduced into said bath chamber.

Advantageously, said installation includes a fan for blowing fumes from said dry hearth chamber into said incinerator.

Preferably, said fan is connected to a variable speed motor to control the flow of fumes to the incinerator. Alternatively, or in addition, a control valve may be provided to control the flow of fumes to the incinerator.

If desired, said incinerator may be extended into said bath chamber and may, if desired, comprise an integral part thereof.

Preferably, an exhaust duct is provided in said bath chamber, preferably at the downstream end of said bath chamber.

In addition to satisfying the needs of the fuel (generally natural gas (methane)), oxygen should be supplied to the installation when needed to combust with the hydrocarbons in the black acrid fumes.

Advantageously, the admission of oxygen is controlled by an oxygen sensor in the furnace or in a duct which conveys hot combustion gases from the incinerator to the furnace.

The oxygen level at the sensor is preferably maintained between 0% and 21% by volume to enable the rate of combustion to be limited and controlled.

If desired, the incinerator may be the sole or main power of heat for the furnace.

Suitable sources of oxygen or oxygen enriched air include liquid oxygen and oxygen enriched air produced by adsorption. In the former case the installation should include a tank for holding liquid oxygen and a vaporizer. In the latter case, an adsorption unit using molecular sieve adsorbent may be utilized.

For a better understanding of the present invention reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a schematic flowsheet of a prior art installation for the reclamation of aluminium;

Figure 2 is a schematic flowsheet of one embodiment of an installation for the reclamation of aluminium in accordance with the present invention;

Figure 3 is a horizontal section through the installation schematically shown in Figure 2;

Figure 4 is a view taken on line IV-IV of Figure 3;

Figure 5 is a view taken on line V-V of Figure 3;

Figure 6 is a cross-sectional view, on an enlarged scale, of the incinerator shown in Figure 3; and

Figure 7 is an end view of the incinerator of Figure 6.

Referring to Figure 1 of the drawings, there is shown a prior art installation, which is generally identified by reference numeral 1, for reclaiming aluminium from scrap aluminium typically comprising oil cans, grease containers and beer cans, most of which are painted and some of which are covered in plastic.

The scrap aluminium is placed in the dry hearth chamber 11 of a batch furnace 2 and is heated by hot gases emanating from a burner 3 firing into the bath chamber 12 of the furnace 2 and combusting stoichiometric proportions of air and natural gas. The heat melts the aluminium in the dry hearth chamber 11 and, at the same time, vaporizes and partially combusts the plastic, oil, grease and paint which leaves the furnace 2 through a duct 4 in the form of acrid black fumes.

Air is added to the duct 4 through pipe 5 and the gaseous mixture is passed into an incinerator 6 where it is burnt by combusting stoichiometric proportions of air and natural gas introduced through duct 7. The volume of air injected through pipe 5 is found by trial and error. Some of this air may also be admitted directly to the furnace 2 as secondary air, to control the combustion of the hearth.

In practice acrid black fumes are not given off continuously from the furnace 2 but over an extended period sometime after the start of the heating operation depending on the nature of the scrap. Because the time when the fumes will be emitted is not known precisely it is the practice to inject the maximum amount of air which will be required for combustion at any one time throughout the whole batch operation.

The incinerated gas finally leaves the incinerator 6 through duct 8 at about 850^{O} and, after being filtered to remove particulate material, is vented to atmosphere.

For the purposes of comparison in a typical installation the burner 3 will inject over a complete batch one volume of natural gas and 9.5 volumes of air into the installation. The burner 7 will inject 0.27 volumes of natural gas and 2.6 volumes of air and 10.5 volumes of air will be injected through pipe 5. The total exhaust will thus be 23.87 volumes. Typically, 2046 KW of heat from natural gas will be required per tonne of aluminium reclaimed.

Turning now to Figure 2, there is shown an installation in accordance with the invention. The installation, which is generally identified by reference numeral 101, comprises a furnace 102 having a dry hearth chamber 112 and a bath chamber 111. A fan 109 is arranged to convey acrid black fumes of unburnt hydrocarbons through duct 104 to an incinerator 106 which is arranged to exhaust directly into the furnace 102. An exhaust duct 110 is situated at the downstream end of the bath chamber 111.

In use stoichiometric quantities of oxygen and natural gas are fed to incinerator 106 via duct 107. The oxygen and natural gas mix with the fumes from duct 104 and additional oxygen from pipe 105. The whole burns to produce a hot, clean exhaust gas which is introduced into the bath chamber 111 of the furnace 102.

Part of the clean exhaust gas is vented to atmosphere (via a filter) through exhaust duct 110 at the downstream end of the bath chamber 111 whilst the balance passes over the scrap in the dry hearth chamber 112 of the furnace 102 melting the aluminium and vaporizing and partially combusting the unwanted plastic, oil, grease and paint which leaves the furnace 102 through duct 104 as acrid black fumes.

The arrangement described with reference to Figure 2 has several advantages. In particular, using industrially pure oxygen as the oxidizing agent, and recycling the heat in the exhaust gases from the furnace enables a substantial reduction in the amount of fuel required compared with the installation shown in Figure 1, without taking into account any heat contribution from combustible materials in the scrap or fume and vapours derived therefrom.

A second advantage concerns the heat generated by combustion of solid waste (e.g., rubber and plastic contaminants, vaporized oil, grease, paint and carbon smoke particles) this heat also being fed directly into the furnace 102. In the prior art this heat was either wasted or used to heat water.

In practice, according to the calorific value the amount of the combustible waste material mixed with the metal to be recycled, the supply of fuel used via duct 107 can be reduced further or even cut off for part of the cycle with the result that the overall fuel consumption can be reduced by at least 60% when compared with the installation in Figure 1. Thus it may be advantageous to add combustible waste material to the scrap metal to achieve the absolute minimum fuel consumption.

A third advantage concerns the total volume of emissions and the concentration of impurities in the exhaust. Firstly, because the incinerator 106 is acting as the sole heat source for the installation 101 and oxygen is being used rather than air the temperature in the incinerator 106 can be relatively high (up to 3000°C) depending on the flow of recycled fumes. Higher temperatures result in more rapid and more complete combustion of the impurities. Generally the temperature in the incinerator 106 will be between 1000°C and 2000°C and typically 1700°C. Secondly, because of the recycle of the black acrid fumes, the volume of exhaust gas is substantially equal to the volume of methane and oxygen introduced to the incinerator 106. This reduces the loading on the filters to nearly one eighteenth of the prior art and also reduces the size of chimney required.

Whilst it is desirable that the temperature in the incinerator 106 should be high it should be noted that the temperature of the molten metal in the bath chamber should not be raised to such an extent that an unacceptable proportion of the molten metal vaporizes.

For the purposes of comparison with the installation shown in Figure 1, over one batch 0.4 volumes of natural gas are supplied through duct 107. This requires 0.8 volumes of oxygen for complete combustion. This in turn mixes with 7.5 volumes of hot exhaust gas from the furnace, delivered through duct 104.

To combust the fume and hydrocarbon vapours around 10% of excess oxygen is used, giving a total oxygen volume of 0.88 volumes oxygen, through pipe 105. This supply of oxygen is preferably split in two streams, one stream of oxygen through pipe 105 being introduced directly to the incinerator 106.

Thus the total volume leaving the incinerator 106 and passing to the furnace 102 equals 8.78 volumes. The volume exhausted from the system, via exhaust duct 110, must equal the volume of fuel and oxygen added to the system, i.e., 1.28 volumes, measured at NTP.

Thus the comparison between the two systems as depicted in Figures 1 and 2, indicate exhaust volumes in the ratio of 1.28 to 23.87, i.e., the exhaust volume is typically only 5.4% of the exhaust from a conventional system.

The typical fuel consumption of the new system is around 818 KW per tonne of aluminium reclaimed, before taking into consideration the heat energy available in the combustible materials and vaporized hydrocarbons present in the scrap metal.

Referring now to Figures 3, 4 and 5, the installation 101 comprises a furnace 102 which comprises a bath chamber 111 and a dry hearth chamber 112.

In use, scrap aluminium is loaded into the dry hearth chamber 112. Fan 109 is started to purge the installation 101. Natural gas is then introduced through pipe 114 and combusts in incinerator 106 with the oxygen present in the air. Oxygen is then introduced through pipe 107 in stoichiometric proportion to the natural gas. The hot exhaust at about 1700^{o}C from the incinerator 106 passes through the bath chamber 111 where it initially heats the refractory lining and a small portion is exhausted to atmosphere via exhaust duct 110 and holding furnace 115. The balance passes through the dry hearth chamber 112 where it heats the scrap aluminium. The hot gas then passes through duct 104 and is returned to the incinerator 106 by fan 109.

Additional oxygen is introduced through pipe 105 in accordance with a predetermined programme. This oxygen is introduced to react with combustible material in the scrap. A monitor in bath chamber 111 monitors the oxygen content.

After some time the plastic, grease, oil and paint on the scrap aluminium start vaporizing and partially combusting. These form acrid black fumes which pass through duct 104 and are fully combusted in incinerator 106, with the oxygen supplied through pipe 105.

As the aluminium in the dry hearth chamber 112 becomes molten it flows into a bath chamber 111 where it is heated to about 800°C. The aluminium oxide present floats to the surface and can be skimmed off as dross. The aluminium itself is drained off into the holding furnace 115 as and when required.

It will be appreciated that since the bath chamber 111 contains little or no material responsible for producing acrid black fumes the exhaust duct 110 can be disposed at the end of the bath chamber 111 between the bath chamber 111 and the dry hearth chamber 112. This utilises the heat in the exhaust gas as much as possible and maximises the time during which any unburnt impurities in the gas can be oxidized.

Referring now to Figures 6 and 7, the incinerator 106 comprises cylinders 116, 117 and 118 which are concentrically disposed around an axis X-X. As shown in Figure 7, natural gas (methane) is introduced tangentially into cylinder 118 and oxygen is introduced tangentially into cylinder 117. The natural gas and oxygen mix and pass into cylinder 116 where they mix with fumes from the duct 104 and oxygen from pipe 105 (if any). The mixture thus formed combusts inside the incinerator 106 providing a supply of hot (1700°), clean exhaust gas to the furnace 102.

If desired, the proportion of the gas recycled may be adjusted by a valve 120 in the duct 104.

Alternatively, or in addition, the proportion of the gas recycled may be varied by an invertor controlling its electric drive monitor, in turn controlled by a programmable logic controller (not shown) controlling the system.

By varying the proportion of gas recycled the temperature of the hot exhaust from the incinerator 106 can be adjusted between 1000°C at high recycle rates up to 3000°C at low recycle rates to suit the type of metal to be melted. For example, for aluminium scrap, the exit gas temperature from the incinerator 106 may be as high as 1900°C. A much lower temperature may be appropriate for fine metal turnings which may easily be vaporized and thus lower the yield.

As indicated earlier the oxygen supply is preferably varied throughout the batch process. In the preferred embodiment the oxygen supply is initially fixed at twice the volume of fuel required at start up. As the temperature in the returned exhaust gases increase the amount of fuel required to maintain the temperature in the furnace is reduced. When the flow of fuel is reduced the excess oxygen then available maintains the combustion of sufficient combustible materials in the recycle flow to supply an amount of heat equivalent to the heat output of fuel reduced. The fuel supply is then further reduced to a level where equilibrium is achieved, or until such time as the combustible materials are exhausted and more fuel is required to maintain the furnace temperature.

As the oxygen supply enters the system at the incinerator 106, the combustion of fuel and fume is satisfied preferentially to combustion on the dry hearth 112.

In a more refined control system a temperature sensor is provided to sense the temperature of liquid metal in the bath chamber 111. When the temperature exceeds the desired level the flow of oxygen through pipe 107 is reduced. This reduces the level of oxygen in the bath chamber which is sensed by the monitor. The signal from the monitor is used to reduce the supply of natural gas to the incinerator 106 so a pre-programmed volume of oxygen is available after stoichiometric combustion of the fuel and the oxygen.

If the oxygen concentration sensed by the monitor is below the expected value the supply of fuel is further reduced since there is clearly an excess of combustible material present. Similarly, if the oxygen concentration sensed by the monitor is above the expected value the supply of fuel is increased.

In order to appreciate the significance of the present invention estimates for the supply of a small prior art installation were received at approximately £1M. An installation based on Figures 3 to 7 for the same duty should cost less than £0.35M.

CLAIMS:

1. An installation for recovering metal from scrap which installation (101) comprises a furnace (102) and an incinerator (106) for burning fumes from said furnace (102), and wherein said furnace (102) has a dry hearth chamber (112) and a bath chamber (111), characterized in that said installation (101) further comprises a source of oxygen or oxygen enriched air, and means (105, 107) for conveying said oxygen or oxygen enriched air to said incinerator (106), and wherein at least a major portion of the gases leaving said incinerator (106) is introduced into said bath chamber (111).

2. An installation as claimed in Claim 1, characterized in that all the gases leaving said incinerator (106) are introduced into said bath chamber (111).

3. An installation as claimed in Claim 1 or 2, characterized in that it includes a fan (109) for blowing fumes from said dry hearth chamber (112) into said incinerator (106).

4. An installation as claimed in Claim 3, wherein said fan (109) is connected to a variable speed motor.

5. An installation as claimed in Claim 3 or 4, including a control valve (120) for, in use, controlling the flow of fumes to the incinerator (106).

6. An installation as claimed in any preceding Claim, characterized in that the incinerator (106) comprises an integral part of said bath chamber (111).

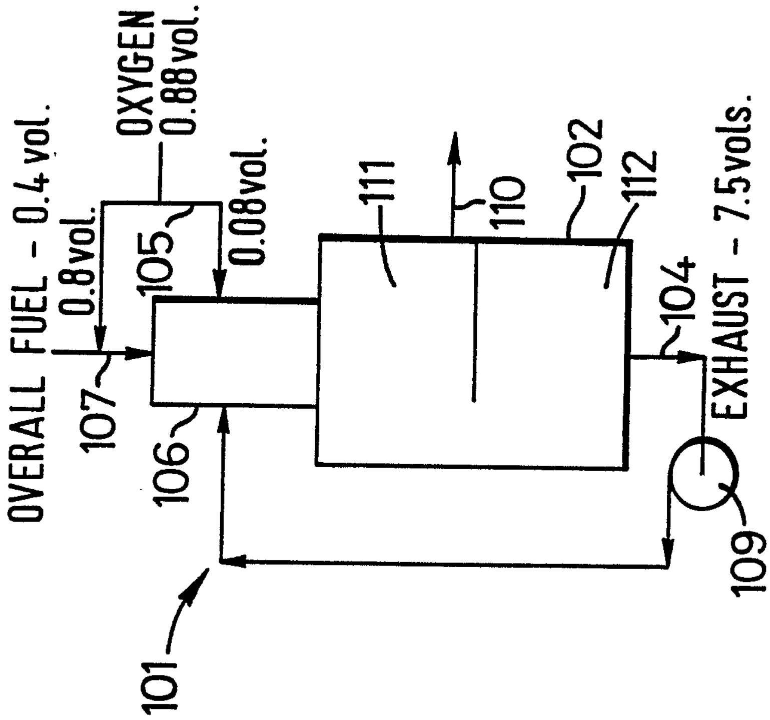
7. An installation as claimed in any preceding Claim, characterized in that an exhaust duct (110) is provided in said bath chamber (111) at the downstream end of said bath chamber (111).

8. An installation as claimed in Claim 7, characterized in that said exhaust duct is provided at the downstream end of said bath chamber (111).

9. An installation as claimed in any preceding Claim, characterized in that it includes a sensor for determining the concentration of oxygen present in said furnace (102) or in a duct (104) which conveys hot combustion gases from the incinerator (106) to the furnace (102) and means responsive to said sensor for controlling the volume of oxygen admitted to said incinerator (106).

10. An installation as claimed in any preceding Claim, characterized in that said incinerator (106) is the sole or main source of heat for the furnace (102).

11. An installation as claimed in any preceding Claim, including a tank for holding liquid oxygen and a vaporizer connected to said means (105, 107) for conveying oxygen or oxygen enriched gas to said incinerator (106).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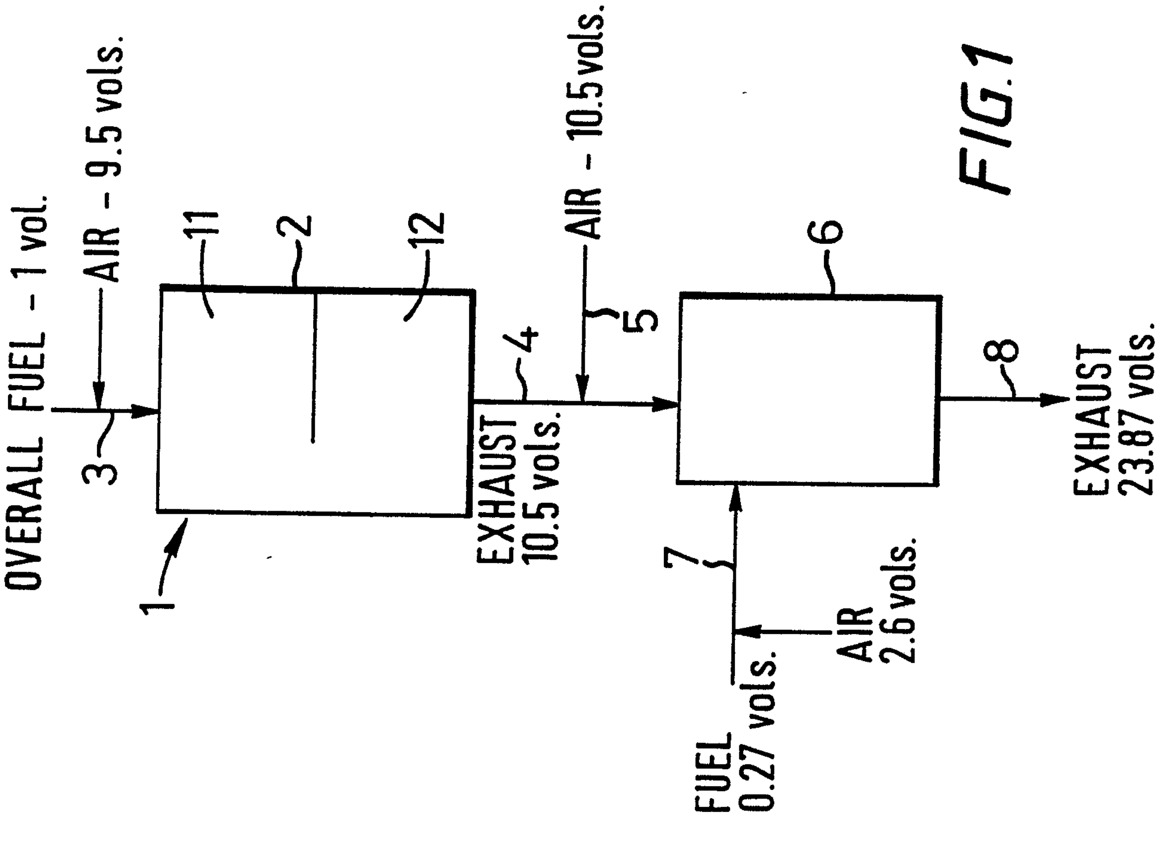
0.08 vol.
105
107
106
111
110
102
112
104
EXHAUST - 7.5 vols.
109
101

FIG. 2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AIR - 9.5 vols.
3
11
2
12
1
EXHAUST
10.5 vols.
4
AIR - 10.5 vols.
5
6
8
EXHAUST
23.87 vols.
7
AIR
2.6 vols.
FUEL
0.27 vols.

FIG.1

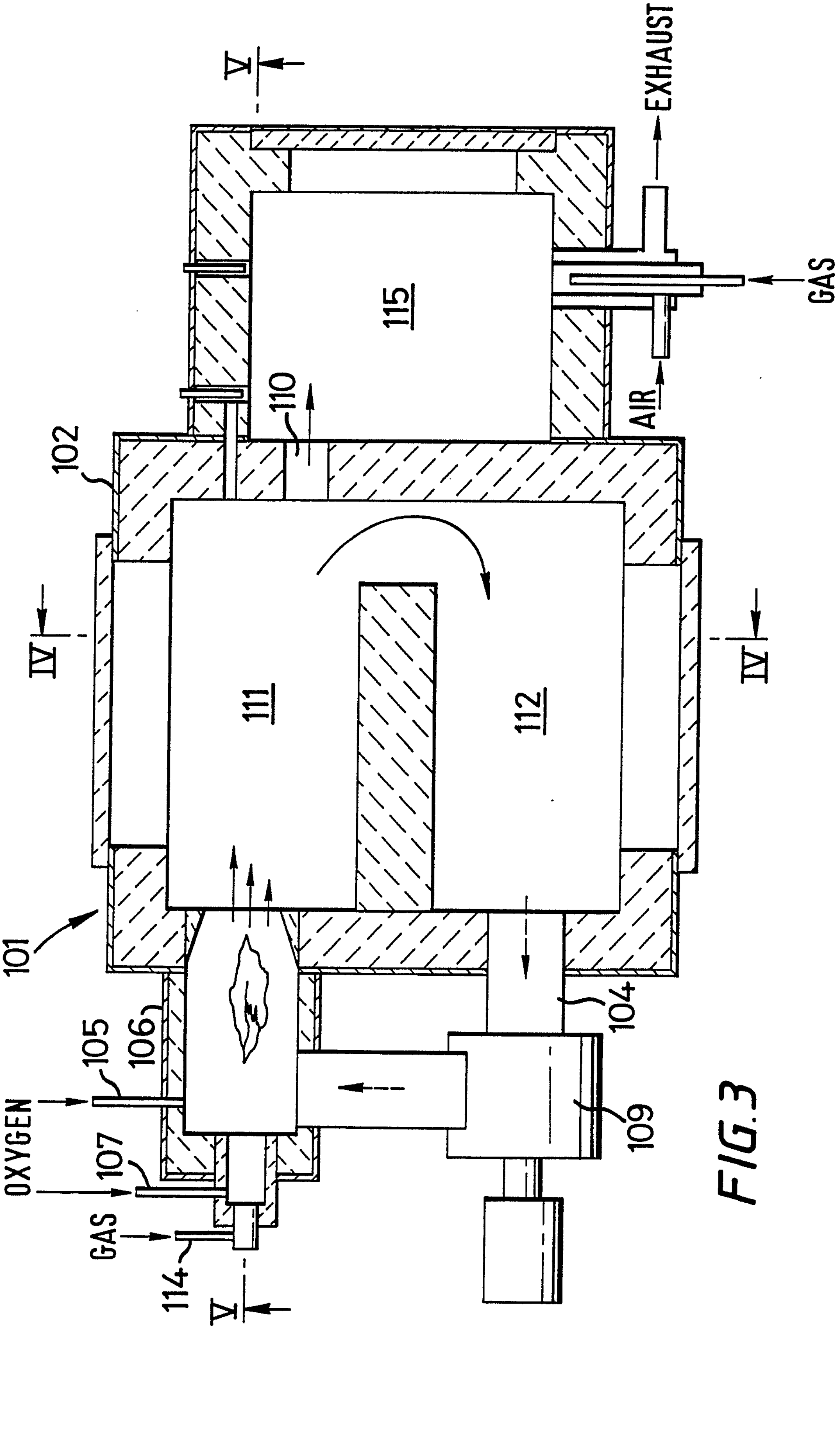

V
EXHAUST
GAS
AIR
115
110
102
IV
111
112
IV
101
104
105
106
OXYGEN
107
GAS
114
109
V

FIG.3

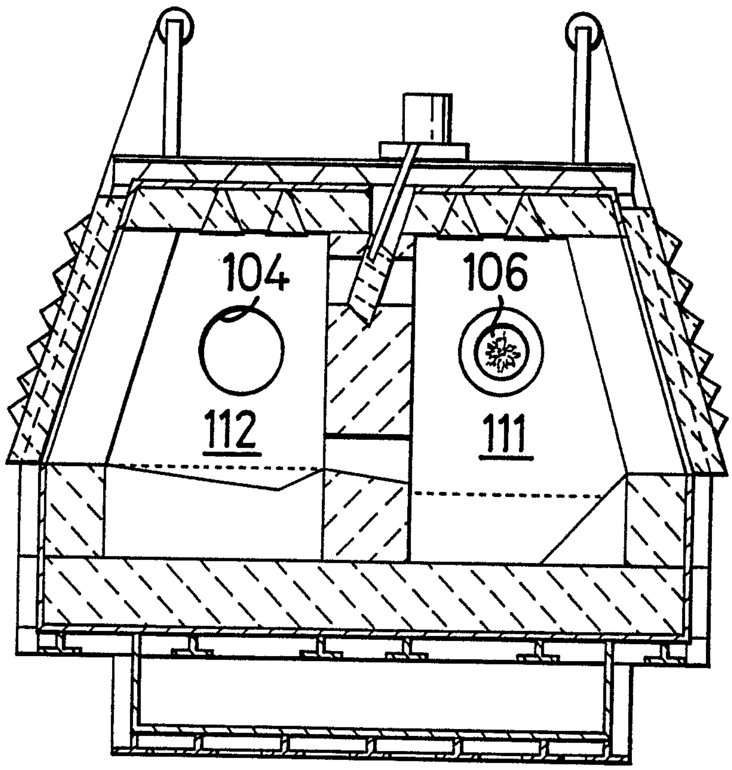


FIG.4

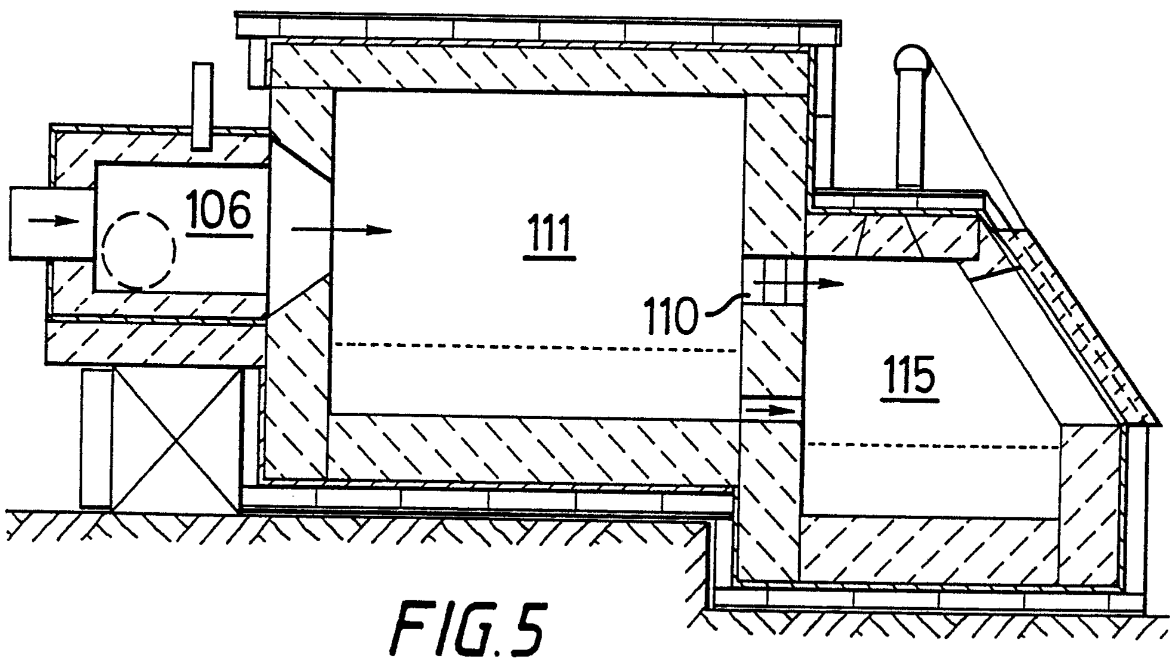
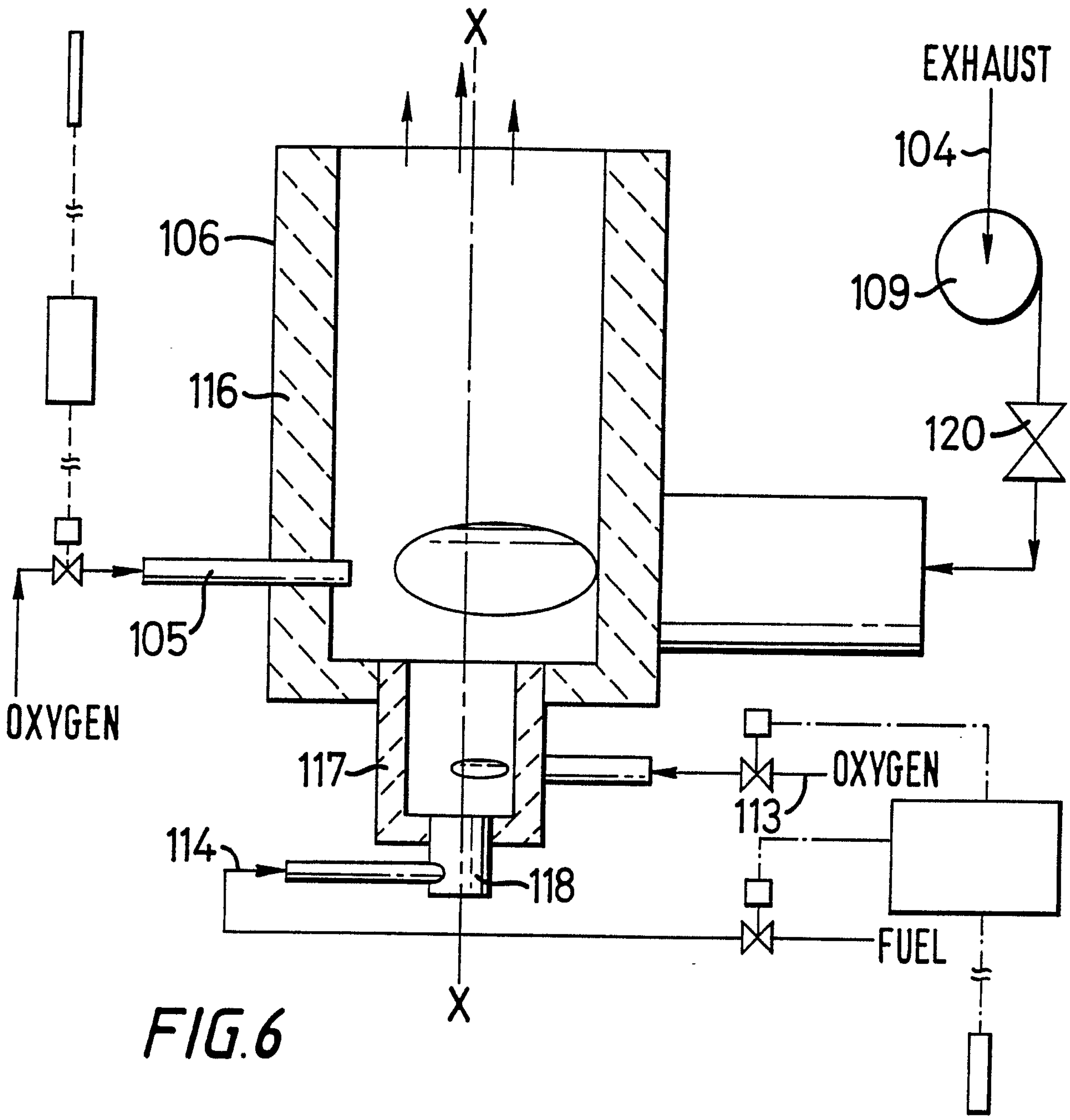


FIG.5


X
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104
106
109
116
120
105
OXYGEN
117
OXYGEN
113
114
118
FUEL
X

FIG.6

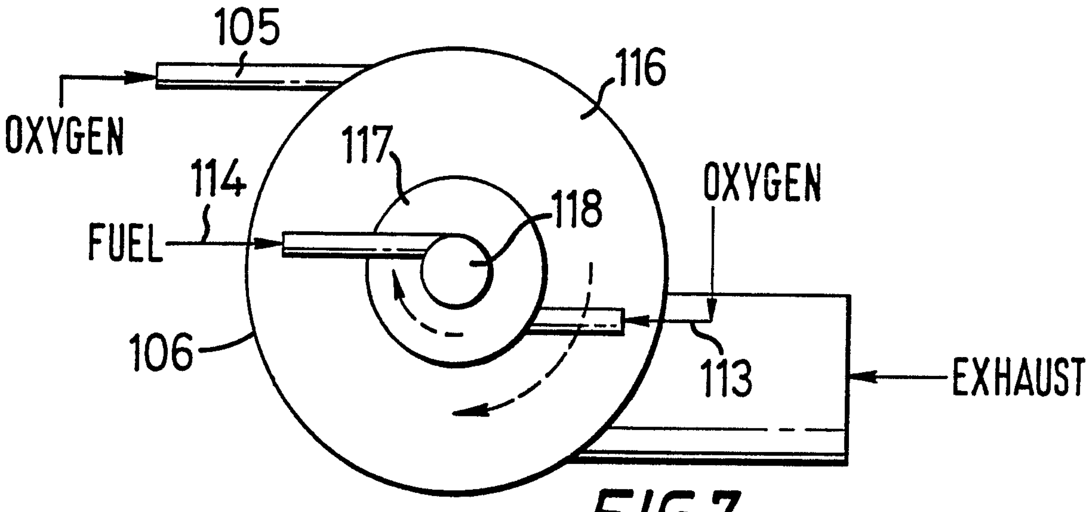
105
116
OXYGEN
117
114
118
OXYGEN
FUEL
106
113
EXHAUST

FIG.7

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/00911

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 C22B7/00 ; C22B21/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	F27D ; F27B ; C22B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
Y	EP,A,0 050 795 (CELOTEX CORP.) May 5, 1982 see page 3, line 19 - page 3, line 39; claims 1,2,5,6,10; figures 3,6	1-3,6-8
Y	DE,A,2 704 101 (ALUMAX INC.) August 11, 1977 see claims 1,2; figure 1	1-3,6-8
A	US,A,3 869 112 (HABAYEB) March 4, 1975 see claim 1	1
A	US,A,4 601 750 (ROBAK ET AL.) July 22, 1986	
A	US,A,4 394 166 (KENNEDY) July 19, 1983	
A	US,A,4 548 651 (RAMSEY) October 22, 1985	
A	US,A,4 402 738 (AKIO) September 6, 1983	
A	US,A,4 060 408 (KUHN) November 29, 1977	

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
18 SEPTEMBER 1991	-1.0. 10. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	WITTBLAD U.A.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9100911
SA 48329

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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18/09/91

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		AU-A- 7635581	29-04-82
		CA-A- 1171285	24-07-84
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82