

C. S. PALMER.

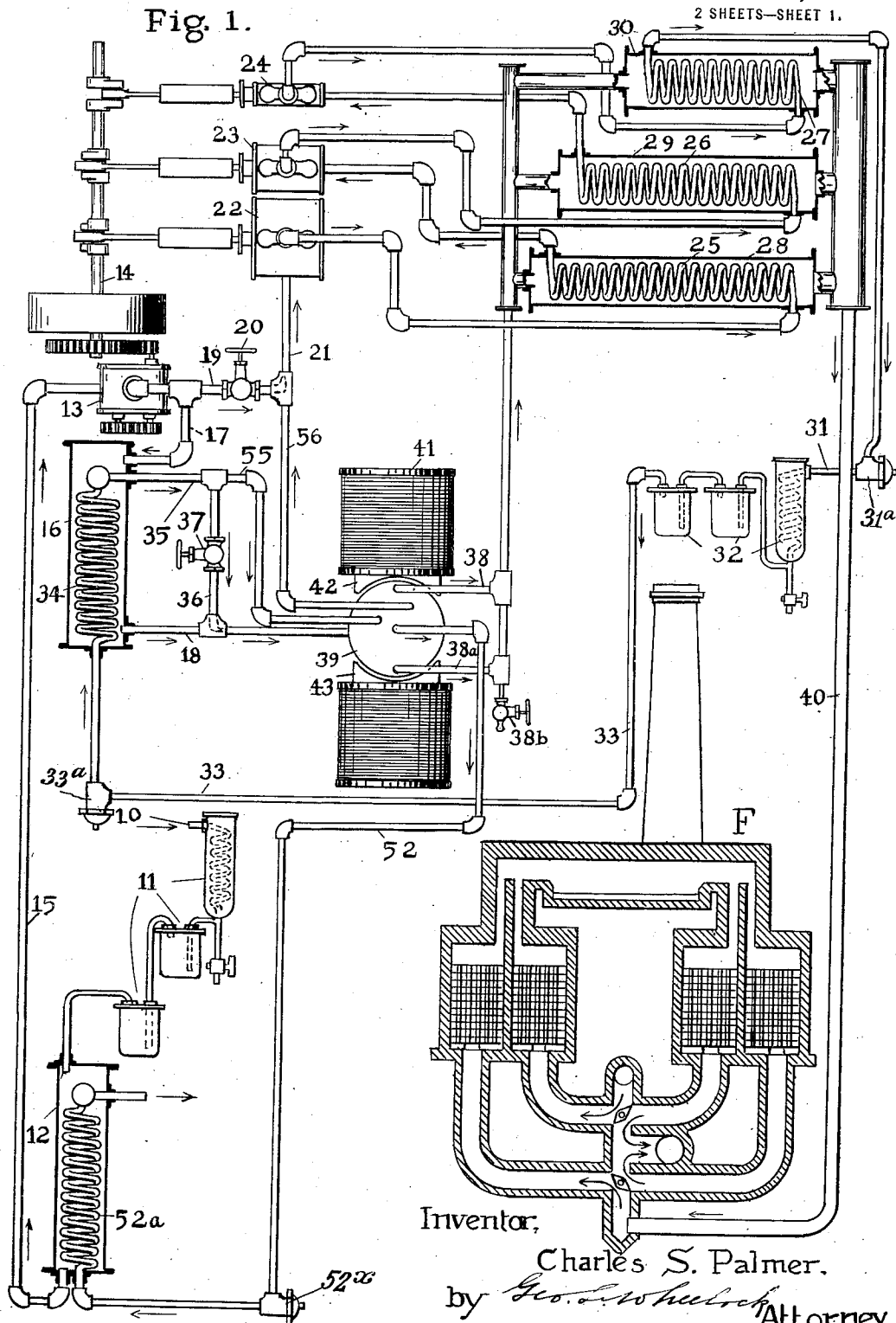
PROCESS OF AND APPARATUS FOR TREATING MIXED GASES.

APPLICATION FILED OCT. 28, 1918.

1,364,136.

Patented Jan. 4, 1921.

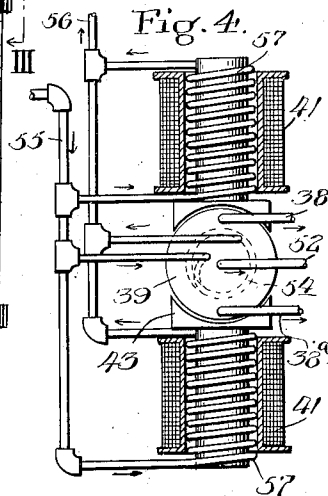
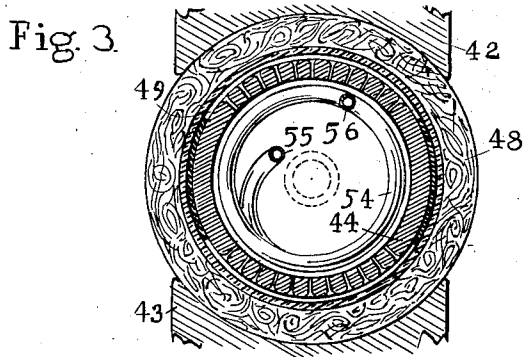
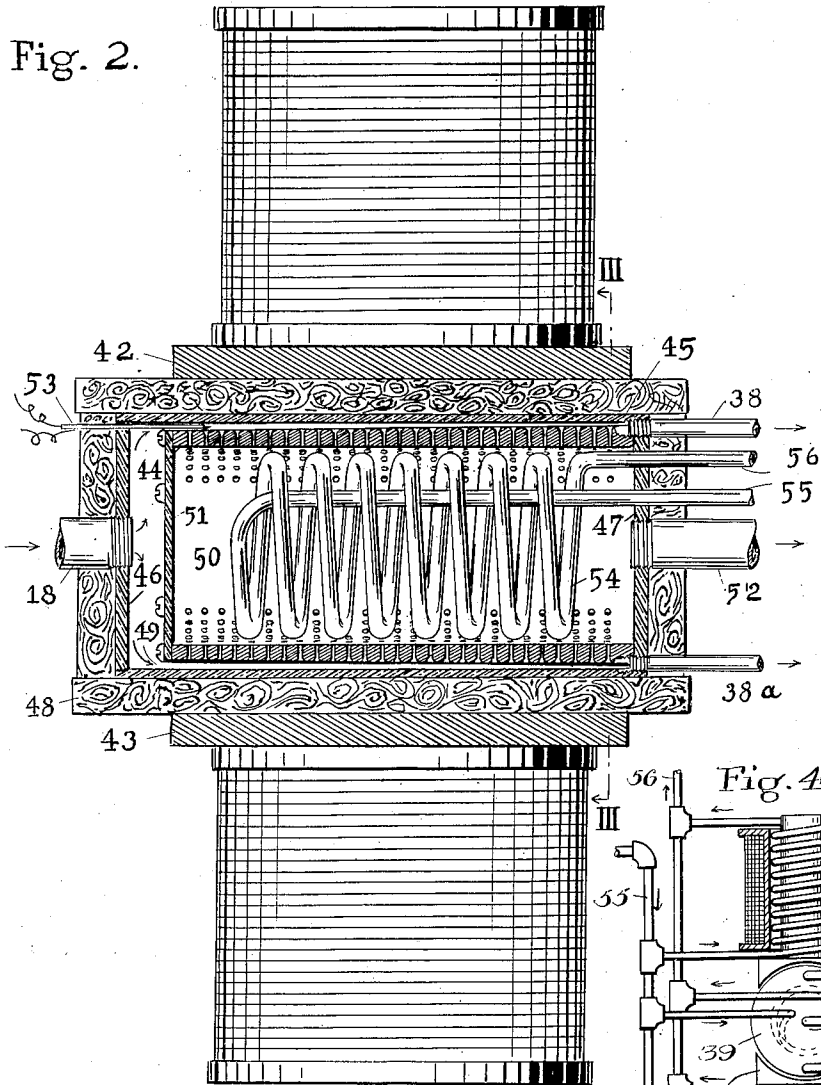
Fig. 1.



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 2 SHEETS—SHEET 2.



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UNITED STATES PATENT OFFICE.

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PROCESS OF AND APPARATUS FOR TREATING MIXED GASES.

1,364,136.

Specification of Letters Patent.

Patented Jan. 4, 1921.

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To all whom it may concern:

Be it known that I, CHARLES S. PALMER, a citizen of the United States, residing at Pittsburgh, in the State of Pennsylvania, have invented certain new and useful Improvements in Processes of and Apparatus for Treating Mixed Gases, of which the following is a specification.

This invention relates to processes of and apparatus for treating mixed gases, increasing the percentage of oxygen in air, for the main purpose of preparing said air for use in the burning of fuel; such, for instance, as a fuel gas which is of poor or lean quality, although the use of the invention may be extended to the process of burning hydrocarbon oils, coal or other fuel, or rich gases.

The invention is directed more particularly, but not necessarily, to meet the present day tendency toward the use of a fuel gas which is much leaner than natural gas; and make it possible to obtain more degrees of heat from burning such leaner gas than are now obtained. It should further be stated that when atmospheric air is used to support combustion, there must not only be heated, but there is in the way, approximately four times as much nitrogen as there is available oxygen. The nitrogen is therefore a great hindrance to the process of combustion. This is so whether a rich gas like natural gas is used as the fuel, or a lean or poor gas like producer gas, and, for this reason, both of such gases give off in process of burning about the same,—a little more in the case of natural gas,—degrees of heat per cubic foot of actual burning mixture. It is known that the oxygen of the air is the supporter of combustion, and it follows that the higher the percentage of oxygen in air fed to the point of combustion for supporting combustion, the more perfect will be the combustion; and this is particularly desirable in burning lean or poor gases. An increase of oxygen in the air fed to the point of combustion to one per cent. is even desirable, and possibly as much as ten per cent. would be within the limits of safety of known furnaces. Experimental results obtained by some of the large steel producers show that air enriched, through the use of liquid air machines, gives a decided increase of heat, by raising the oxygen only a per cent. or two.

Calculations show that with only a five

per cent. increase in the air mixed with the combustible fuel gas, there is a great increase of heat produced per cubic foot of mixed fuel gas and air necessary to burn all or most of the carbon to carbon-dioxid and the hydrogen to water vapor; which I term the "actual burning mixture"; and that probably no available furnace brick material would stand an oxygen enrichment of much over ten per cent. This means that the thoughtful inventor need not aim at a great oxygen enrichment in the actual burning mixture, but only a small increase; thus by raising the oxygen content of the air blast from 21 per cent. of natural air to 25 or 30 per cent., all practical results on this score would be attained for years to come.

Hence, I arrive at this point in showing the urgent necessity of raising the oxygen content of the air; and, also, by reason of the fact that with an air richer in oxygen, then even poorer fuel gases would develop more heat per cubic foot of actual burning mixture. The commercial tendency of gas manufacturers is, and will necessarily be for some time, toward fuel gas leaner than natural gas.

One of the properties of liquid oxygen which is known is that it is quite magnetic. That is, it may be picked up by a strong magnet in much the same way as we might imagine liquid mercury would act if it were magnetic like iron tacks or filings.

This suggests, not that we should try to extract oxygen from liquid air, where the molecular enmeshment would hinder separation of oxygen from nitrogen, to say nothing of the expense and slowness of going into the liquid phase, although this as a possible first step is not precluded under the present invention,—but, rather the possibility of separating the oxygen as a gas from the nitrogen by magnetic action on cold, but unliquefied air. The question arises: Is it possible that not liquid oxygen alone, but cold gaseous oxygen also, is sufficiently magnetic to separate itself from nitrogen, in cold air, in the magnetic field.

Tests would show that this is so, and would apparently be due to the molecular kinetic freedom of the magnetic oxygen molecules in dodging the entangling non-magnetic nitrogen molecules; and thus the oxygen would be attracted to strong magnetic poles,

Now it is known that oxygen gas at ordinary temperatures has some slight magnetism or magnetic susceptibility, while nitrogen has but little, and less than oxygen; and it is also known that this magnetic susceptibility of oxygen increases as the temperature goes down. Prof. Kammerlingh Ohnes, of Leyden, has shown this.

In standard works on magnetism it is shown that metals like cobalt and nickel with a low magnetic susceptibility at ordinary temperatures, greatly increase that property as the temperature falls; and one naturally asks whether oxygen does a similar thing; and whether, if one should cool it enough, oxygen would show a highly rising curve.

The work of Ohnes would indicate that with oxygen, the magnetic susceptibility curve is rectilinear for some distance below 0° centigrade; perhaps down to -100° centigrade.

Lack of positive information held open the possibility that cold gaseous oxygen, say from -100° to -180° centigrade, may be sufficiently magnetic to yield to separation in a strong magnetic field. It is here noted that we are here dealing with the special use of cold gaseous air as such; not liquefied air, unless that has been raised in temperature to the point of evaporation. Let it be noted here that I have discovered that the magnetic separation of oxygen from cold air is possible.

While the above recited adaptability of the present invention to combustion processes may be one of the specific commercial uses of the invention, the invention is not necessarily so utilized.

Certain objects of the invention will appear from the preceding introductory matter; while these and other objects of the invention will appear more clearly from the detailed description.

In order that my invention may be fully understood, I will proceed to describe the same with reference to the accompanying drawings illustrating a suitable embodiment of the invention, and in which drawings—

Figure 1 is a diagrammatic view of a complete apparatus or plant for carrying out the process of increasing the percentage of oxygen in air for use in supporting combustion in a furnace;

Fig. 2 is an enlarged detail longitudinal sectional view of a magnetic separator which may be used in enriching air with oxygen;

Fig. 3 is a cross-section thereof on the line III—III Fig. 2; and Fig. 4 is a view showing means for cooling the magnet.

The cooling and circulating apparatus generally and which may be employed will first be described, and then the construction of magnetic separator, which is illustrated merely as one form thereof, will be described in detail. The air which is to be treated and

used in the apparatus is led through an intake 10 (Fig. 1), into the first of the air purifying devices 11, and from thence the purified air is led into a preliminary cooling chamber 12, cooled in any suitable manner. From the preliminary cooling chamber 12 the cooled air is conducted by a pipe 15, to a blower 13, of any suitable type, the said blower being operated through power-driven mechanism 14, which may be the same as that which operates the air compressor of the system. By means of said blower an enforced circulation of the purified and preliminarily cooled air is created in the direction of the arrows opposite some of the above enumerated parts and opposite a pipe 17, which leads from the blower to a second cooling chamber 16, at one end thereof, and through a pipe 18, which leads from the opposite end of said cooling chamber to a magnetic separator for the air, and which separator will be hereinafter described in detail.

Branching from the pipe 17, there is a pipe 19, provided with a valve 20, and communicating with a pipe 21, which leads to the first of a plurality of air compressors 22, 23 and 24, but it is obvious that one or any desired number of compressors may be used, depending upon the degree of compression which is desired. As illustrated, the air compressors 22, 23, 24, are connected by a series of outlet and return pipes with the coils 25, 26 and 27, in the chambers 28, 29 and 30, of suitable inter-coolers.

The last cooling chamber 30, leads from the coil 27 to a second set of air purifying devices 32, and the air in the compression system, at a moderately lowered temperature, and under high pressure, is led from the purifying devices 32, through a pipe 33, which connects through an expansion valve 33^a with a coil 34, where it expands and produces intense cold in the second cooling chamber 16, said coil delivering its air through pipe 35, and may go through pipe 36, to the pipe 18 beforementioned, and which conducts the extremely cold air, to be separated, to the magnetic separator. Said pipe 36 is controlled by a valve 37.

The side of the magnetic separator 39, to be shortly described, and from which side oxygen enriched air is led, is provided for that purpose with an outlet pipe 38, which conducts the said air to the chambers 28, 29 and 30 of the inter-coolers. From the latter chambers the oxygen enriched air is conducted by a pipe 40, to the air heating chambers of a suitable type of furnace F. The course through the various pipes and chambers is indicated by arrows. Before describing the cooling and purifying system before briefly outlined, as to just what takes place therein, I will now describe a preferred form of magnetic separator for separating the air into a current of oxy-

gen enriched air and a current of impoverished air—that is to say, air from which some of the oxygen has been removed and, therefore, contains a higher percentage of nitrogen.

As before stated, I have discovered that the magnetic separation of oxygen from cold air is possible, but in a comparatively simple magnetic separator in which the air or the mixed gases may be treated and separated in commercially possible quantities, and this being so, the separation can take place in the form of magnetic separator illustrated in Figs. 2 and 3, and which comprises an electromagnet 41, provided with pole-pieces 42 and 43, and supplied with current from a suitable source of electricity, preferably continuously, although not necessarily so. Preferably the said magnet is of high potential and is of ample dimensions for the treatment of large quantities of air. In the gap between the pole-pieces of said magnet there is symmetrically disposed a commodious, porous or perforated magnetizable member 44, which is preferably cylindrical and composed of soft iron. This member 44, is provided with a multitude of minute but sufficiently open perforations, substantially as shown, and it is surrounded by a casing 45, which may be of brass, so as to stand up in use—that is, to have sufficient strength, and durability—and said casing is provided with suitable heads 46, 47, so that the said cylindrical magnetizable member is inclosed in the said casing. Surrounding the casing 45, is a sleeve of insulation 48, as of felt, which closely fills the space between the said casing and the pole-faces. The external diameter of the cylindrical magnetizable member 44, and the internal diameter of the casing 45, are such as to provide an annular and tapered air-circulating space 49, between them, the air being conducted into one end of said circulating space by pipe 18, and from the other end by outlet pipes 38, and 38^a. The perforated magnetizable member 44, is provided with an inner chamber 50, which is closed at one end by a deflector 51, directly opposite the inlet pipe 18, into which flows the supply of extremely cold air. The other end of the capacious inner chamber 50 is substantially closed by the head 47, which constitutes a single head, at that end of said chamber, for the cylindrical magnetizable member 44 and the casing 45. From the inner chamber 50, of member 44, there leads a pipe 52, which constitutes an outlet pipe for nitrogenous or impoverished air. A tap 38^b may be provided to enable a sample of the oxygen enriched air to be obtained. There should preferably be provided an electro-thermal-couple 53, for obtaining the temperature of the air in the annular space 49, and pref-

erably also there should be provided a cooling coil 54, which is located within the chamber 50, and which is supplied with cold air by a pipe 55, which is branched from the pipes 35, 36, the cooling air for said coil being conducted by pipe 56 to pipe 21. Extra cooling coils may obviously be disposed about the casing 45.

The process carried out, in the described system as a whole, is as follows: Preferably atmospheric air is admitted at 10, from whence it passes through the set of purifiers 11, and is purified, and it then passes through the preliminary cooling chamber 12, which is cooled in any suitable manner, as by an expansion coil 52^a controlled by an expansion valve 52^x, through which is conducted the impoverished air, or air with a higher percentage of nitrogen, which is led away from the magnetic separator. This use of the low temperature of the impoverished air, in order to cool the incoming air, is simply illustrated as one of the many possible economies of the apparatus or system. From the cooling chamber 12, the purified and cooled air is conducted by pipe 15 to the blower 13, which causes a circulation of the air through pipe 17, and cooling chamber 16, from whence the more highly cooled air is led to the magnetic separator by means of the pipe 18. The chamber 16, whether it be the second or a higher number of such chambers, is that chamber in which is obtained the desirable temperature of air to be separated in the magnetic separator. It will be seen that the cold air passing through chamber 16 has its temperature materially lowered by reason of the intense cold produced by the expansion, in the coil 34, of the highly compressed air in the compression part of the system.

The compression pumps are started and a circulation of air or other suitable mixed gases is established as follows: The valve 20, is opened to the desired degree and the partially cooled air will be conducted to the compression pump or pumps, where its temperature is slightly lowered by passage through the cooling coil or coils, 25, 26, and 27, the air being led by pipe 31 having an expansion valve 31^a, through the set of purifiers 32, by pipe 33, to the expansion coil 34 within the cooling chamber 16, and by the pipes 35 and 55, to the cooling coil 54 for the parts of the magnetic separator, from whence the cold air passes by pipes 56 and 21, back to the compressors. In this way the compression system would be kept full of cold air and, when the valve 37 is opened, some of this air may be passed through the pipe 36, and caused to mingle, in greater or less proportion, with the cold air, to be separated, passing through the pipe 18, depending upon the extent to which the valve 37

is opened. Much of the time the valve 37 may be closed. At this point I would remark that I found that the best results in the magnetic separation of air are obtained
5 from air which has had its temperature lowered in the cooling chamber 16, so that at the magnetic separator it is within a region of temperature between,—approximately—
100° centigrade and the temperature of
10 say approximately -175° C., so that there will be no liquefied air in the system.

From the illustrated form of magnetic separator, and the description thereof which has been given, it will be seen that it has
15 been so designed that a magnetic separation results, in passing the outgoing cold air through the active portions of the intense magnetic field of the electromagnet, due to the magnetic qualities of the oxygen in the
20 air. In the magnetic separator, the extremely cold air, as distinguished from liquefied air, flows out of pipe 18 into the space between the deflector 51 and the head
46 of the casing 45, from whence the said air
25 passes into the annular space 49. Due to the presence of the magnetic member or septum 44, in the field of the magnet, the molecules of oxygen and nitrogen in the air are so
30 manipulated and agitated by the induced magnetism in the magnetizable member or septum and the field of the magnet, that air containing a higher percentage of oxygen,
say from one per cent. to ten per cent., is
35 passed along the air-circulating space to the outlet therefor. In other words, a percentage of the oxygen molecules in the air is entrained, as it were, in the circulating space
49, while a portion of the air passes through
40 the perforations of the magnetizable member or septum 44, and this air contains a greater percentage of the nitrogen molecules which are not attracted to the magnetic
45 field, as are the molecules of oxygen, there practically being a repulsion of the molecules of nitrogen through the perforations
of the magnetizable member or septum and into the chamber 50. Hence, the air which
passes through the perforations of the mag-
50 netizable member 44 is impoverished and has a lower percentage of oxygen as compared with the air which is caught or entrained in the space 49, by reason of the
magnetic quality of the oxygen.

55 Attention is directed to the following attributes of the preferred form of magnetic separator. The gap between the pole faces of the electro-magnet is practically, except for the walls of the parts which actually
60 bring about the separation, filled with the air or other suitable gas mixture susceptible of magnetic separation, and the separation takes place in a direction substantially perpendicular to the lines of force of the mag-
65 netic field. It will be observed that the

pores or perforations of the magnetic septum are distributed over the entire magnetic field, at the points just where the magnetic separation is effected by reason of the magnetism induced in the said porous magnet- 70
izable septum 44. This being so, all of the lines of force in the magnetic field of the electro-magnet may be utilized in inducing
a local and concentrated magnetism; which
75 is focused directly in the path of flow within the field of the electro-magnet and at the points where the magnetic separation takes place. In such a construction of magnetic
separator the gases pass but once across the
80 magnetic field, and the separating action takes place immediately and directly, across the magnetic field. Also, the mechanical
baffling effect produced by the walls of the pores of the magnetic septum assists the
85 magnetism induced about said pores in effecting the separation directly in the path of the flow of gases which are being treated. It is clear that the greatest possible number
of cubic feet of mixed gases can be
90 treated within any given size of electro-magnet, and that all of the lines of force in the magnetic field may be utilized, thereby making it possible to treat, and effectuate the desired
separation of, commercial quantities of
95 such gases.

The enriched air or air containing a higher percentage of oxygen, is preferably, but not necessarily, preheated before being
led away to the furnace F. for instance, for supporting combustion of the fuel therein, 100
as by subjecting it to the action of the heat of compression of the air in the coils 25, 26, 27, such lost heat being radiated from said coils. If the air enriched with oxygen is to
be used for some other purpose than as a 105
medium to support combustion, this preliminary preheating step may not be desirable. As before stated, the impoverished
air, or air having a lower percentage of oxygen may be employed as one of the econo- 110
mies of the system.

Obviously the apparatus or system as a whole may be modified, and the magnetic separator may also be modified, as by changing, omitting, or adding parts, all of which 115
would be within the range of those skilled in the art to which the invention appertains, without departing from the spirit and scope thereof, as expressed in the claims. For instance, the cores of the magnet may be provided
120 with cooling means or the magnetic separator may be cooled in any desired manner so as to decrease the resistance of the energized parts. Such a means for cooling the magnet, or source of the magnetic field
125 is shown in Fig. 4, in which the cores of the magnet are shown as surrounded by cooling coils 57, 57, which are located within the windings of the magnet. The said cooling 130

coils may be connected with the pipes 55, 56; the same with which the cooling coil 54 is connected.

What I claim as new is:

5 1. The process of treating mixed gases, which consists in producing a flow of mixed gases which are at a temperature low enough to render one of the gases, which is relatively more magnetic than the balance
10 of the mixture, more sensible to magnetism, and locally generating, and concentrating, in the path of said flow, a zone of magnetism, and establishing,—in part, magnetically, and, in part, mechanically,—two separate streams of said gases directly in, and
15 diverging from, the so-generated zone of magnetism, and thereby causing one of said streams to contain a higher percentage of said more magnetic gas than the other.

20 2. The process of treating mixed gases, which consists in producing a flow of mixed gases which are at a temperature low enough to render one of the gases, which is relatively more magnetic than the balance of
25 the mixture, more sensible to magnetism, passing said mixed gases at their low temperature through a magnetic field, and inducing in the path of said flow, through the effect of said magnetic field, a local zone of
30 magnetism, in which zone approximately all of the lines of force of said field are concentrated, and producing through the intervention of the so produced zone of magnetism two streams of gases intersecting the
35 so concentrated lines of force, one of which streams will contain a higher percentage of said more magnetic gas than the other.

3. The process of treating mixed gases, which consists in producing a degree of
40 temperature of the mixed gases sufficient to render one of the gases, which is relatively more magnetic than the balance of the mixture, more sensible to magnetization, magnetizing a porous magnetizable member,
45 passing the gases partly over and partly through said magnetized member, and conducting off the gases in two streams at opposite surfaces of said member, one of which streams will contain a higher percentage of
50 said more magnetic gas than the other.

4. The process of treating mixed gases, which consists in producing a degree of
temperature of the mixed gases sufficient to render one of the gases, which is relatively
55 more magnetic than the balance of the mixture, more sensible to magnetization, passing the gases partly over and partly through a porous member, subjecting said gases to the action of magnetism, induced in an electric field in which said porous member is
60 located, and conducting off said gas mixture in two streams at opposite surfaces of said member, one of which streams will contain a higher percentage of said more magnetic gas than the other.

5. The process of treating mixed gases, which consists in producing a degree of temperature of the mixed gases sufficient to render one of the gases, which is relatively more magnetic than the balance of the mixture, more sensible to magnetism, magnetizing a porous magnetizable member, passing
70 said mixed gases partly over and partly through said magnetized member, and conducting off said gas mixture in two streams at opposite sides of said member, one of which streams contains a higher percentage of said more magnetic gas than the other, and independently cooling the source of the magnetic field.

6. The process of increasing the percentage of oxygen in air, which consists in reducing the temperature of air to a region of temperature between,—approximately
85 -100°C. , and approximately -175°C. , and passing said air of reduced temperature through a magnetic field and separating said air into two streams, one of which will contain a higher percentage of oxygen than the other and independently cooling the said
90 magnetic field.

7. The process of treating mixtures of oxygen and another gas, which consists in subjecting such gases at low temperature to the action of magnetism induced within and
95 by a sufficiently strong and independently cooled magnetic field.

8. The process of increasing the percentage of oxygen in air, which consists in producing a degree of temperature of air sufficient to render the gaseous oxygen thereof more sensible to magnetization, and passing
100 said air of reduced temperature through a magnetic field and separating said air into two gas streams, one of which will contain a higher percentage of gaseous oxygen than the other, and independently cooling the said magnetic field.

9. The process of increasing the percentage of oxygen in air, which consists in producing a temperature of air approximating at least as low as -100°C. , but not so low as to liquefy the oxygen, establishing a magnetic field, inducing a local zone of magnetism in a magnetizable member in said
115 field through the action of said field, conducting said air of reduced temperature into said field and subjecting the oxygen of said air to the intimate magnetic action of said induced magnetism in said local zone, and conducting the air from said field in
120 two streams, one of which will contain more oxygen than the other.

10. The process of increasing the percentage of oxygen in air, which consists in producing a degree of temperature of air sufficient to render the gaseous oxygen thereof more sensible to magnetization, and passing said air of reduced temperature
125 through a magnetic field and separating

said air into two gas streams, one of which will contain a higher percentage of gaseous oxygen than the other, and cooling the source of the magnetic field independently of the effect of the presence of said air in said field.

11. The process of increasing the percentage of oxygen in air, which consists in establishing a magnetic field, and subjecting a current of extremely cold air to the inductive action of said field to effectuate a magnetic separation of air having a relatively higher gaseous oxygen content from air having a relatively lower gaseous oxygen content, and independently cooling said field.

12. The process of increasing the percentage of oxygen in air, which consists in establishing a magnetic field, establishing two paths within said field for dividing a current of extremely cold air, and causing the inductive action of the greater number of the lines of force of said field at a great number of points, at the juncture of said two paths, to effectuate a magnetic separation of air having a relatively higher oxygen content from air having a relatively lower oxygen content in such a way that the air having the higher percentage of oxygen follows the one path while that having the lesser percentage follows the other path.

13. The process of increasing the percentage of oxygen in air, by passing the air through a magnetic separator, which consists in producing a degree of temperature of air sufficient to render the oxygen thereof more sensible to magnetization, independently cooling magnetic parts of said magnetic separator, conducting the so-cooled air into the field of the magnet of said separator, and conducting away from said magnetic separator a stream of oxygen-enriched air and a separate stream of oxygen-impo-

14. In apparatus of the class described, the combination of means for producing a degree of temperature of air sufficient to render the oxygen thereof more sensible to magnetization, a magnet, magnetizable means in the field of said magnet for inducing a local zone of magnetism in the field of said magnet, and means for passing said air of reduced temperature into said local zone of magnetism and separating said air into two streams, so that one of said streams will contain a higher percentage of oxygen than the other.

15. In apparatus of the class described, the combination of means for producing a degree of temperature of air sufficient to render the oxygen thereof more sensible to magnetization, a magnet, means including a magnetizable member for passing said air of reduced temperature through the field of

said magnet and indirectly of the magnetic field of said magnet for electrically and mechanically separating said air into two streams directly within the zone of greatest intensity of said field, so that one of said streams will contain a higher percentage of oxygen than the other.

16. In apparatus of the class described, the combination of means for producing a degree of temperature of air sufficient to render the oxygen thereof more sensible to magnetization, a magnet, means for passing said air of reduced temperature through the field of said magnet and for electrically and mechanically separating said air into two streams directly within the zone of greatest intensity of said field, so that one of said streams will contain a higher percentage of oxygen than the other, and means for independently cooling said magnetic field.

17. In apparatus of the class described, the combination of a magnet, means for conducting a supply of air having extremely low degrees of cold to the magnetic field thereof, and means positioned directly within said field and intersected by the greater number of the lines of force of said field for dividing said air into two currents and for subjecting the oxygen of said air to the inductive effect of said field, whereby one of said currents is enriched with oxygen equivalent to a loss thereof from the other current.

18. In apparatus of the class described, the combination of a magnet, means for conducting a supply of air having extremely low degrees of cold to the magnetic field thereof, and means, comprising a multi-perforated septum, exemplified by soft iron, positioned within said field for dividing said air into two currents and for subjecting the oxygen of said air to the inductive effect of said field, whereby one of said currents is enriched with oxygen equivalent to a loss thereof from the other current.

19. In apparatus of the class described, means for producing a flow of mixed gases of low temperature and of different susceptibility to magnetism, and means for locally generating, and concentrating, in the path of said flow, a zone of magnetism, and establishing,—in part, magnetically, and, in part, mechanically,—two separate streams of said gases directly in, and diverging from, the so-generated zone of magnetism, and thereby causing one of said streams to contain a higher percentage of said more magnetic gas than the other.

20. In apparatus of the class described, the combination of means for producing a flow of mixed gases, means for establishing a magnetic field through which said flow of gases is caused to pass, and magnetic means within said field in which magnetism

may be induced and concentrated by said field, said magnetic means being adapted to effectuate a separation of the gases in such a way that a portion of said gases
5 will contain a greater percentage of the more magnetic gas than another portion.

21. In apparatus of the class described, the combination of a magnet, means for conducting a supply of mixed gases having ex-
10 tremely low degrees of temperature to the

magnetic field thereof, gas chambers within said field and which are separated by a porous septum across which the lines of force of said field are adapted to pass, and means for generating induced magnetism
15 in said field and adjacent to the pores of said septum, for substantially the purposes set forth.

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