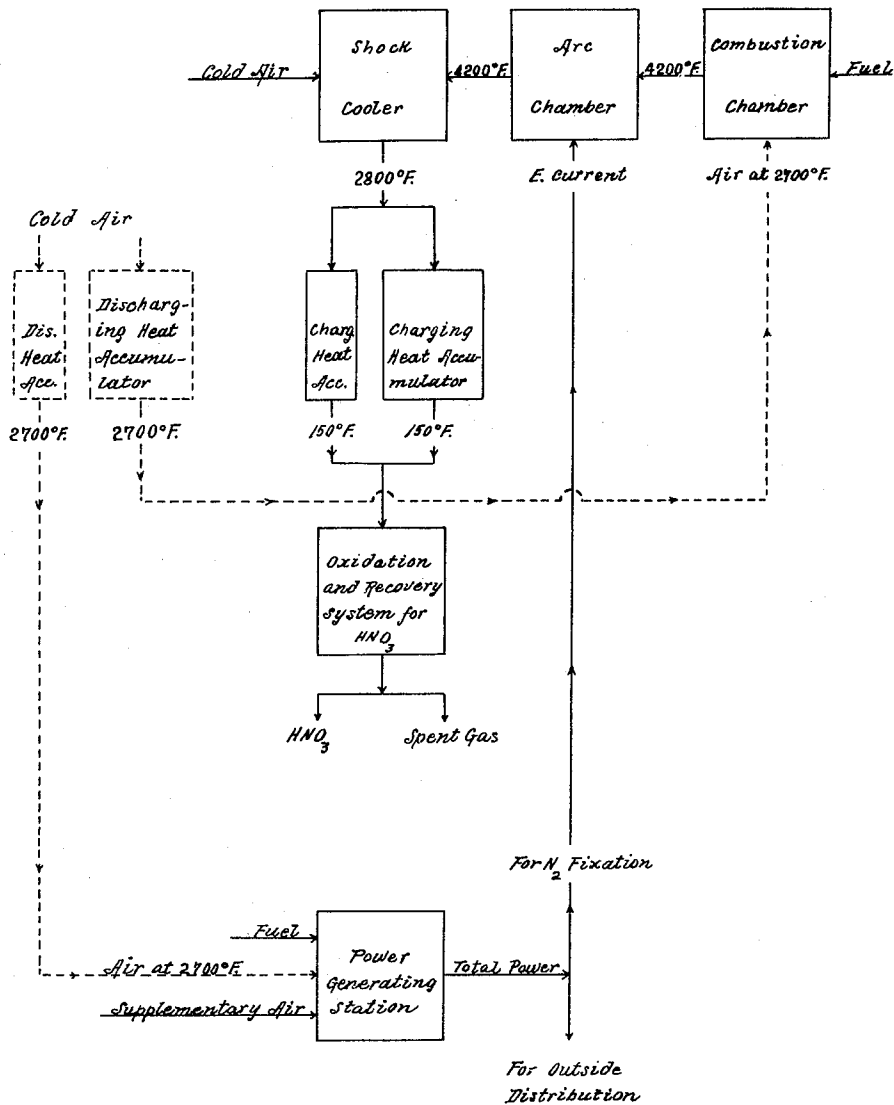


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METHOD OF MAINTAINING CONTINUOUS PEAK LOAD OPERATION
AT POWER GENERATING CENTERS BASED ON FUEL
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**METHOD OF MAINTAINING CONTINUOUS PEAK
LOAD OPERATION AT POWER GENERATING
CENTERS BASED ON FUEL**
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It is a well known fact that large, central power stations are much influenced by human habits. At certain more or less definite periods during each 24 hour cycle there is a much greater demand for power than at other times. This is, roughly, caused by the presence or absence of daylight. The all but universal practice now operating at full load for certain periods and in the interims much valuable equipment with attendant supervision is not delivering the full quota of energy of which it is capable and at virtually no additional cost save the added increment of fuel consumed, an item that often is relatively small due to the high thermal efficiency of the modern station.

Inasmuch as the general public demands top performance at all times this makes it necessary to have excess capacity in the generating station so that no shortage of energy may appear. Stated otherwise, said station is only operating at full load for certain periods and in the interims much valuable equipment with attendant supervision is not delivering the full quota of energy of which it is capable and at virtually no additional cost save the added increment of fuel consumed, an item that often is relatively small due to the high thermal efficiency of the modern station.

It is obvious that to utilize the generating station to best advantage some means must be found that will permit the use of a very varying load, consuming a small amount at all times and instantly ready to avail itself of any surplus as soon as it becomes available. The capital outlay for the new installation must be relatively small or else much of the apparent gain will not be realized. The market for the commodity must be potentially unlimited, if the price be right, and storage must be no problem.

I believe that these exacting demands can well be met by a new system of nitrogen fixation which, as an addenda to a power station, may well have the effect of rendering the present ammonia process obsolete. I have illustrated this complex in the annexed drawing which I will now proceed to explain. I am well aware of the fact that a modification of the arc, the so-called flaming arc, was extensively used in the past as a means of forcing the combination between atmospheric nitrogen and oxygen. This concept perish before the cheaper ammonia. I am also aware of the recent attempts to accomplish the same object by the use of fuel alone, aided by an intense use of heat recuperation. To the best of my knowledge, even this later method has not scored any success and has been officially abandoned after the expenditure of much money. I mention these facts at the start for I do use both the arc, fuel, and heat recuperation so it may seem at the first glance that I have merely combined two well known systems and called the result NEW. Such, however, is not the case. While certain items are common to all, additional items are needed as well and these I have furnished as well as a better use of the common items.

The system of heat recuperation I employ is the well known technique of the open hearth furnace of the steel maker. Alternately, heat is stored and discharged from a heat refractory structure. In the drawing, I have represented by solid lines such recuperators, or as I have more properly called them, accumulators when such devices are receiving heat, and by dotted lines the same devices when in the discharging phase.

Commencing then at the upper right hand corner of the drawing I have indicated a "combustion chamber" in

which fuel is burned in a pre-heated atmosphere and said incoming air, at a provisional temperature of 2700° F., is thus raised to a temperature of 4200° F. with attendant formation of some nitric oxide, NO. The source of the pre-heated air is seen to be a discharging accumulator which takes in air in cold condition and raises it to the above mentioned peak.

Such formation of NO is endothermic and hence will cause a lowering of temperature so I have shown the reacting gases passing into an "arc chamber" where the conventional arc, not the flaming arc, is used to retain the temperature and prevents such drop in NO content. Such use of the arc is specifically diverse from the old practice where the flaming arc was the sole source of heat. It is essential that cooling from the peak temperature to something akin to 2800° F. takes place instantly and I accomplish this by an instantaneous commingling with about 50% of its weight of cold air. This takes place in the "shock cooler" where I have shown entering cold air and gases leaving at 2800° F. Said hot gases now pass into a heat accumulator, placed directly below, where the temperature is rapidly, but far more slowly than in the shock cooler, reduced to a stable condition while the heat is salvaged for future use.

Inasmuch as this admixture with cold air increases the gas volume correspondingly, I have shown said heat accumulator as being in two divisions, one approximately twice the size of the other. The reason for this is obvious. The combustion chamber, at the extreme right, can only deal with the amount previously passed so one-third of the heat would be wasted. By the two divisions I can send two-thirds of said stored heat back to the combustion chamber while the heat stored in the smaller one can find a use elsewhere as will be described later on. As it is necessary to go to a temperature well below 212° F. before oxidation of the NO can take place I have indicated the gases leaving this pair of accumulators at 150° F. Said gases then pass into an "oxidation and recovery system" which is entirely conventional and definitely outside of the scope of this disclosure. My process, in so far as this application is concerned, stops when the combustion chamber product with its subsequently acquired NO has passed through the charging accumulators.

There remains to be described the use of the stored heat in the smaller division of said accumulator. At the extreme left of the drawing the dotted-lined accumulator is shown in the discharging phase, receiving cold air and raising it to the temperature of 2700° F. This heated air, for which there is no place in the nitrogen circuit, per se, is then shown serving an equally important purpose where it serves as air of combustion for the power generating station at the bottom of the drawing. By this step I have made the fuel burned in said "combustion chamber" of equal value, commercially, with the fuel burned specifically to generate power. Hence, only the power required to maintain temperature in the arc chamber is consumed in the operation, and this should definitely be less than one kw. hr. per pound of "fixed" nitrogen.

The temperatures given on the drawing and referred to in the text have been termed "provisional." They are truly comparative but not absolute. Contrariwise, they may vary by as much as 600° F. from the figures given, in both directions, without deviating from my disclosure. I deem them to be a representative medium value but I am not limited thereby. True, at 5000° F. a higher percentage of NO will be formed, but it will be more difficult to make the refractories stand up, and the proportions of cold air needed to cool to the relative safety of 2800° F. will be correspondingly increased. Similarly, if the top temperature be dropped to 3600° F. the amount of NO formed will be much less. Nevertheless, under special conditions, such variations may be possible.

Entering into the "power generating station," at the bottom of the drawing I have shown besides the pre-heated air of combustion both supplementary air and fuel. Obviously, if but little power is available for use in nitrogen fixation then the corresponding amount of air and fuel must be burned to generate full power with but little return through the nitrogen circuit. Contrariwise, if a far greater amount of power can be spared for the arc chamber then much more "reclaimed heat" will appear in the form of pre-heated air.

It might also seem that I limit myself to a conventional type of a steam generating station but such is not the case. It will be obvious that if compressed air were passed through the smaller discharging accumulator on its way to a gas turbine, then the stored heat of said accumulator would take the place of the fuel otherwise injected into said air. And at this point I wish to state that in all cases, these accumulators are in multiple, so that a smooth flow without surges is always obtained.

Having thus fully described the technical aspect of my process, in the explanation of the drawing, I will now add some figures showing what I have really accomplished in an economic sense. I will take as my measure 100 pounds of air, which after it leaves the arc chamber is assumed to contain 2% of NO. Starting then at the combustion chamber, as before, and using round numbers I shall require some 35,000 B.t.u. to bring the temperature up to 4200° F. The pre-heated air will bring into the combustion chamber about twice that amount from the accumulator. The gas passing the arc chamber and entering the shock cooler will thus carry some 105,000 B.t.u. Of this amount the larger division of the accumulator will salvage about two-thirds or 70,000 B.t.u. which is returned to the combustion chamber.

There remains the 35,000 B.t.u. stored in the smaller accumulator which is salvaged as air of combustion going highly pre-heated to boiler setting or its equivalent. If we assume a 40% conversion into electric energy this becomes about 4 kw. hr. If we take the lower efficiency of the turbine, 25% we will have about 2.5 kw. hr., but then the highly heated exhaust is still to be considered, or with top heat recuperation the gas turbine can come quite close to the thermal efficiency of the steam generating station with 2,000 p.s.i. and 1000° F. of superheat. Be that as it may, the point to which I wish to call attention is that the power consumption by the arc chamber in passing said 100 lbs. of air is actually 0.8 kw. hr. To sum up: The heat represented by fuel burned in the combustion chamber will in the generating station produce from 3 to 5 times the amount of power required by the arc chamber. It is such striking innovations as this that definitely set my process apart from anything I have learned about past attempts.

In saying that I have now fully explained my process, both technically and economically, I have in mind that I am supposed to be addressing one "skilled in the art." That means in this case that the reader is presumed to be familiar with the older methods of producing "fixed nitrogen" be it by the use of the flaming arc, the explosion technique, or the more recent version of combustion heat alone, aided by a relatively new version of "surface combustion" and heat recuperation. To such a person it would be superfluous to explain the meaning of equilibrium between NO and the unreacted gases or to state that, theoretically, by Nernst's thermo-dynamic equation, it will require a temperature of about 4200° F. to obtain the 2% of NO I have previously referred to as the approximate composition of the fully reacted gases. I similarly comment upon the expression "instantaneous" which I have used in describing the step wherein the reacting gases are cooled by commingling with cold air. Strictly speaking such cooling is impossible, nothing is truly "instantaneous"; but if the cold air be introduced under considerable pressure through a plurality of orifices much turbulence with intermixture of hot and cold fluids, respectively, will

take place rendering such cooling approximately instantaneous and this is the sense of the expression when used in the claims. Obviously, the rate of flow through the combustion chamber and arc chamber is determined by such equilibrium as nothing would be gained by prolonging the time. Finally, I have dismissed the oxidation and collection of the "fixed nitrogen" as of no moment to my process because it is entirely conventional and I am simply using the old technique. There is, however, one limitation. The final oxidation of NO is quite slow, hence the spent gas, of the drawing, will retain a little NO. I can reclaim this at no cost by using said spent gas, in part at least, as cooling air, and after pre-heating, also in the combustion chamber.

For the sake of brevity I have omitted all description of the type that might be regarded as known to any one "skilled in the art" and if it seems that I have been amiss in so doing then the reader is courteously referred to the voluminous literature on the subject. One item I do wish once more to emphasize. The fuel burned to raise temperature from that degree at which air leaves the heat accumulator to that at which it enters the arc chamber, and which is salvaged in the form of pre-heated air in excess of that required by the combustion chamber, will if converted into electrical energy by standard, modern methods furnish far more power than can be consumed in the arc chamber if the object is merely to maintain temperature during the NO formation. While quite feasible, such excess could be used to produce additional NO, and thus reduce the fuel burned, but the economy of the process would be very adversely affected thereby. It is thus seen that to develop full usefulness of my process, i.e., to produce "fixed nitrogen" at the lowest cost, it is essential that this "unbalance" of heat requirement be made up by combining my process with some other industry capable of utilizing said heat. In the instant case I have done so by regarding my process as an addenda to the production of electric power for public distribution, and this may well be the best usage.

However, I do not wish to confine it to this illustration. Instead of used to take up such a fluctuating load as herein described it could be equally well used by a power station, say a "captive one," delivering a constant load to some industry also requiring a constant load, say to the aluminum industry, in which case all that I have said would equally well apply and some very cheap "fixed" nitrogen would be the result. Nor is it necessary that power be involved, as there are many uses in industry for highly pre-heated air or other substituted gas.

All such deviations from the illustration herein presented I regard as within the scope of my disclosure.

Having thus fully described my process, I claim:

1. The method of making nitric oxide from air at substantially atmospheric pressure which comprises: pre-heating a flow of said air to a temperature of approximately 2700° F. by passage through heat accumulators previously charged with heat by the traverse in the reverse direction of hot nitric oxide containing gas with an entering temperature of approximately 2800° F.; further heating said pre-heated air by the combustion of sufficient fuel therein to reach a temperature between a low of 3000° F. and a high of 4800° F.; commingling said current of highly heated air and gas, now containing the percentage of nitric oxide corresponding to equilibrium at the selected temperature, with sufficient relatively cold air in a state of violent turbulence to reduce the temperature of the mixture, substantially instantaneously, to approximately 2800° F.; passing said mixture through heat accumulators to abstract substantially all the sensible heat therein; subsequently conveying said stored heat to a current of air, in the reverse direction, thus pre-heating same to approximately 2700° F.; re-cycling to the combustion phase that part of said pre-heated air required therein and discharging the remainder as surplus.

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2. The method of making nitric oxide from air set forth in claim 1, with the added step that auxiliary electric heating be combined with combustion heating to facilitate reaching the high temperature indicated.

3. The method of making nitric oxide from air set forth in claim 1, with the added step that the discarded surplus of highly heated air described therein be used as a power source.

4. The method of making nitric oxide from air set forth in claim 2, with the added step that the electric energy required therein be obtained by using the discarded surplus of highly heated air as a power source.

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952,248
2,619,412
2,642,338
2,643,937
2,776,872

718,011
728,392
131,510

6

References Cited in the file of this patent

UNITED STATES PATENTS

Howard	Mar. 15, 1910
Hendrickson	Nov. 25, 1952
Pike	June 16, 1953
Pike	June 30, 1953
Norton	Jan. 8, 1957

FOREIGN PATENTS

Great Britain	Nov. 10, 1954
Great Britain	Apr. 20, 1955
Australia	Aug. 9, 1946