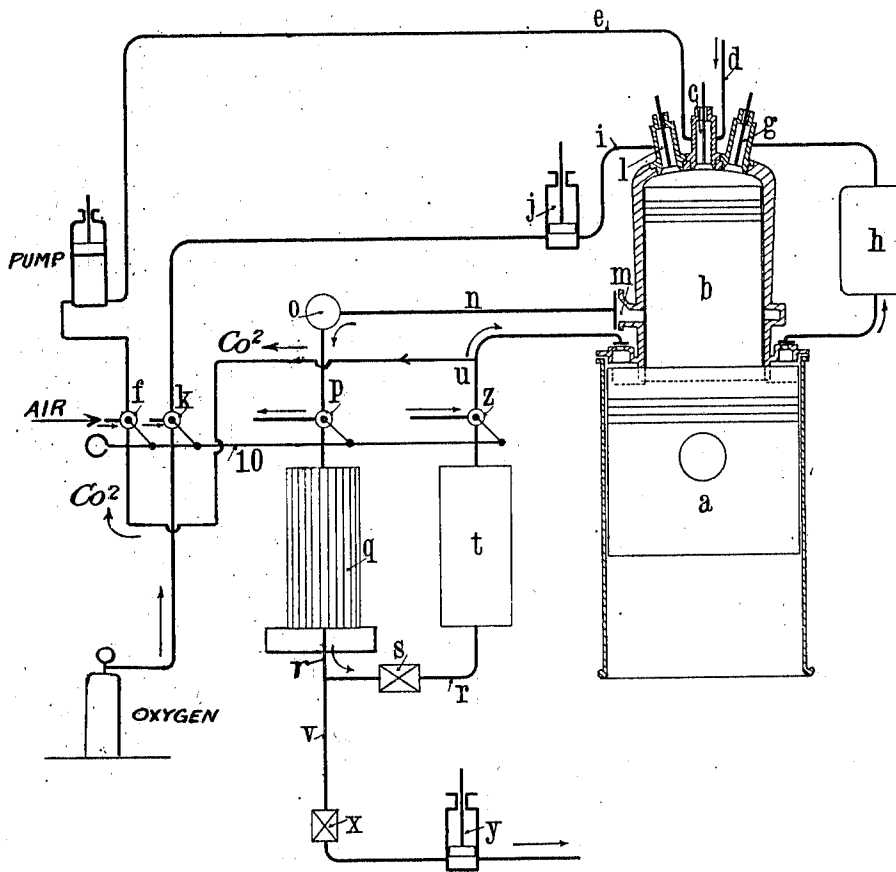


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METHOD OF RUNNING INTERNAL COMBUSTION ENGINES.
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1,099,445.

Patented June 9, 1914.



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UNITED STATES PATENT OFFICE.

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METHOD OF RUNNING INTERNAL-COMBUSTION ENGINES.

1,099,445.

Specification of Letters Patent.

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To all whom it may concern;

Be it known that I, GEORGE FRANÇOIS JAUBERT, a citizen of the Swiss Republic, residing at Paris, France, have invented certain new and useful Improvements in Methods of Running Internal-Combustion Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to an improved method of running internal combustion motors, (such for example as motors burning a liquid hydrocarbon like paraffin oil, and more particularly the Diesel motors) when utilized for submarine boats during their period of submersion. It has already been proposed to supply motors of this type during the submersion period with pure oxygen diluted either with the decarbonated exhaust gases (that is to say with almost pure nitrogen) or with these exhaust gases in an unpurified state, (that is to say a gaseous mixture containing a large quantity of nitrogen and of steam, carbon-dioxid and a little carbon-monoxid and oxygen). In the first case a combustion-supporting mixture identical with atmospheric air is reconstituted; in the second case the combustion-supporting mixture although analogous to the air contains in addition a certain amount of steam and carbon-dioxid and perhaps a little carbon-monoxid.

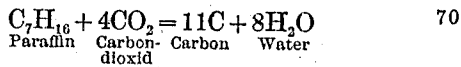
35 It is known that the composition of the exhaust gases of a Diesel motor is as follows (Schroetter *Journal of the Association of German Engineers* No. 30 of the 24th July 1897).

40		<i>Motor running with full charge.</i>	<i>Motor running with half charge.</i>
	Nitrogen -----	84.8%	82.0%
	Carbon-dioxid -----	10.0%	6.2%
45	Oxygen -----	5.0%	11.8%
	Carbon-monoxid -----	0.2%	0.0%

50 I have found that if the operation is precisely opposite to that heretofore adopted, that is to say if the nitrogen be completely eliminated from the exhaust gases and the carbon-dioxid retained, very important industrial results are obtained.

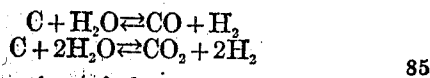
If, during the running of a motor of this kind in which the exhaust gases are utilized, 55 the concentration (percentage) of the carbonic dioxid be increased in the combustion

supporting gas without affecting the pure oxygen, but at the expense of the other two constituents of the exhaust gases, nitrogen and steam which constitute six-sevenths of the exhaust gases; it is found that the carbonic dioxid in this state of greater concentration and in the presence of only a small quantity of steam takes part in the combustion with the liberation of free carbon in accordance with the following equation, this steam being produced by the combustion of the hydrocarbon oil wherein the H in the hydrocarbon is thereby converted into H_2O :



It will be noted that the products of this reaction are both non gaseous at the ordinary temperature and can consequently be readily stored on board ship, and need not be discharged overboard during submersion. 75

The reaction represented by the above equation is the counter-part of the transformation of carbon into carbon-dioxid and carbon-monoxid under the influence of the steam.



The inspection of these two equations of equilibrium indicates that for the desired reaction to take place it is necessary in the mixture undergoing combustion to eliminate the nitrogen, diminish the proportion of steam and increase the proportion of carbon-dioxid and of hydrogen, that is to say in the present case to increase the admission of the hydrocarbon fuel (paraffin). The process which comprises the subject matter of the present invention consequently consists in effecting the combustion of the paraffin during the submersion period in the presence of a combustion-supporting gas formed of carbon-dioxid and oxygen with the object of causing the oxygen of the carbon-dioxid to participate in the combustion of the paraffin, of effecting a reduction of the consumption of free oxygen, and a reduction of the non-condensable products in the exhaust gases and of rendering the excess of the exhaust gases readily soluble in water.

For the purpose of illustrating one form of apparatus suitable for practising the invention, the accompanying drawing shows diagrammatically the installation on a submarine boat of a two-cycle Diesel motor op-

erating in accordance with the improved method.

The two-cycle motor of known construction comprises two cylinders *a* and *b* arranged end to end, their pistons being arranged in tandem. The cylinder *a* serves as a compression pump and delivers into a reservoir *h*, and the other cylinder *b*, which is the motor cylinder, has a valve *c* for the admission of the paraffin oil or other liquid fuel which is conducted to said valve through a conduit *d*. The injection may be effected by means of air or carbon-dioxid under pressure conducted into the valve *c* through a pipe *e* provided with a three-way cock *f*. The cylinder *b*, through valve *g*, is in communication with the reservoir *h* which is also connected to the compression cylinder *a*. A valve *l* communicates with a conduit *i* into which a pump *j* delivers; this pump *j* is driven by the motor and may be placed in communication with the atmosphere by means of a three-way cock *k*. The exhaust port *m* of the cylinder *b* is connected by a pipe *n* with an exhaust collector *o* upon which there is mounted a three-way cock *p* communicating on the one hand with the atmosphere and on the other hand with a separator condenser *q*. This separator condenser is connected by a pipe *r* containing a pressure regulator *s* with a dry separator or purifier *t* containing at one of its ends an absorbent mass such as peat which may be placed in communication with a conduit *u* terminating at the suction chamber of the cylinder *a*, or with the atmosphere, by means of a three-way cock *z*. The purifier *t* may comprise a device (not shown) permitting of optical examination of the gases. A branch pipe *v* from the pipe *r* is fitted with a valve *x* adjusted in such a manner as to open for a given pressure of the cycle and this branch pipe ends at the suction chamber of a pump *y* delivering to the exterior. A rod 10 provided with an operating handle connects the plugs of the cocks *z*, *p*, *k* and *f* in such a manner as to permit of simultaneously operating the various cocks.

For traveling on the surface of the water the rod 10 is arranged in such a manner that the cocks *k*, *p*, *z* communicate with the atmosphere, the cock *f* then placing the paraffin oil injection valve in communication with a compressed air reservoir (not shown), so that the injection of the paraffin oil is produced by means of compressed air. The piston *a* draws atmospheric air through the cock *z* and compresses it in the reservoir *h* from which it is used for scavenging the motor cylinder *b*. The pump *j* delivers atmospheric air at suitable pressure through the valve *l* into this cylinder *b*, this air forming a part of the explosive mixture with the fuel supplied through the

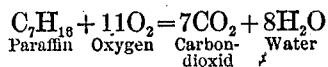
valve *c*. The purification appliances *q* and *t* are not utilized at this time and the pump *y* which does not effect any useful work can then be unclutched during that time.

When running submersed the rod 10 is moved so as to change the three-way valves *f*, *k*, *p* and *z* and the compressed air previously utilized for the injection of the paraffin oil is at first replaced by carbon-dioxid under pressure supplied through the pipe *e* from a suitable reservoir (not shown). The exhaust gases of the motor cylinder are scavenged by carbon-dioxid under pressure furnished, during the first few strokes of the motor after it has been cut off from the atmosphere, from some convenient source such for example as the reservoir just mentioned. The exhaust gases are conducted through the conduit *n* to the condenser separator *q* which retains the steam and to a large extent the particles of carbon that are formed. The dry separator *t* still further removes the dust and the substances in suspension that may have passed through the condenser separator and this filtering is completed by the peat in the dry separator until an optical examination of the gases indicates complete purification. The purified gases proceed to the suction chamber of the cylinder *a* through the pipe *u*, and are compressed into the reservoir *h* from which they are utilized for scavenging. If desired the reservoir *h* may be connected through suitable piping to the valve *c*, in such manner that the compressed gases therein, whether air or purified exhaust gases, may be used at the proper period of the cycle for the injection of the fuel.

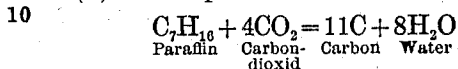
From the moment of shutting off communication with the atmosphere no fresh nitrogen enters the piping and it is only necessary to eliminate that which is already there. The excess of the gaseous products of combustion is, however, constantly being eliminated through the valve *x*, so that the nitrogen that has remained in the reservoirs *q* and *t* is gradually expelled through this valve, this taking place at the end of a very short time in view of the large volume of carbonated gases produced by the combustion of the paraffin in the cylinder relatively to the small volume of the nitrogenated gases contained in the piping and its accessories. In this manner an exhaust gas is obtained which contains only pure and dry carbon-dioxid with, perhaps, a certain quantity of oxygen which has escaped combustion. From this moment, which is readily determined by the deposits of carbon which form the heat necessary for the operation of the engine is produced simultaneously by the two following reactions, the pure oxygen involved in the process during submersion being obtained from a reservoir (not shown) through the pipe *i* and

valve *l*, although under some circumstances compressed oxygen may be mixed with the carbon dioxid and supplied to the cylinder *b* through the pipe *e* and valve *c*, if desired.

5 (1) Ordinary combustion:



(2). Decomposition of the carbon-dioxid:



The final products of combustion are 3CO_2 , 11C , $16\text{H}_2\text{O}$, as may be determined by adding together the right-hand members of equations (1) and (2) and subtracting therefrom the 4CO_2 which is used to break up the paraffin noted in the left-hand member of equations (2). That is to say in accordance with the final products of combustion, as rated above, the quantity of gaseous carbon-dioxid or in other words of gas to be expelled overboard, produced by a given quantity of paraffin, is reduced to about half what it would be if the combustion took place only in accordance with equation number 1. Similarly these equations show that the consumption of free oxygen is one-half what it would be if all the paraffin were burned in accordance with equation (1). Finally it follows that the excess of exhaust gases which forms in accordance with equation 1 is pure carbon-dioxid soluble volume for volume in cold water and which can readily be disposed of by discharging it into the sea without attracting the attention of the enemy by the presence of bubbles of gas bursting at the surface. In other words this method of supplying the fuel permits of economizing in the consumption of free oxygen which is a point of the highest importance for a submarine vessel as regards its radius of action because the supply of free oxygen gas whether in the form of compressed gas or in the form of chemical products capable of liberating this gas is always bulky; the combustion results in a large quantity of carbon and water both of which products are condensable and the quantity of exhaust gas to be expelled into the sea or to be stored is correspondingly diminished; and the gases to be expelled into the sea contain only pure carbon-dioxid; a gas which is very soluble in water, and a small quantity of oxygen.

Obviously the injection of paraffin with air can be retained, the quantity of injected air being very small relatively to a cylinder charge, but in this case it is found that a small quantity of nitrogen is present in the 60 cycle.

It will be at once understood that the invention is in nowise limited to the apparatus above described, but resides rather in the method of carrying on the combustion, 65 and in the discovery that by increasing the proportion of carbon-dioxid and hydrogen and reducing the nitrogen and steam, the hydrogen of the original fuel will burn with the carbon-dioxid to produce carbon and 70 water, and the application of that discovery to the operation of submarine boats, with the beneficial results above described.

What I claim is:

1. The method of running internal combustion motors utilized for submarine or the like boats during the submersion period, which consists in producing combustion of a hydrocarbon fuel, by means of a gas formed of carbon-dioxid and free oxygen, to thereby cause the oxygen of the carbon-dioxid to participate in the combustion of the fuel, diminishing on the one hand the consumption of free oxygen and on the other hand the quantity of non-condensable products in the products of combustion, and rendering the excess products of combustion soluble in water.

2. The method of running internal combustion motors, on submarine or the like boats during surface running and during submersion, which consists in burning a hydrocarbon fuel with air during surface running and, preparatory to submersion, shutting off the air supply and substituting for it a gas formed of carbon-dioxid and free oxygen, to thereby eliminate the nitrogen and cause the oxygen of the carbon-dioxid to participate in the combustion of the fuel, diminishing on the one hand the consumption of free oxygen and on the other hand the quantity of non-condensable products in the products of combustion; and rendering the excess products of combustion soluble in water.

In testimony whereof I affix my signature, 105
in presence of two witnesses.

GEORGE FRANÇOIS JAUBERT.

Witnesses:

DEAN B. MASON.

HENRY SCHWAB.