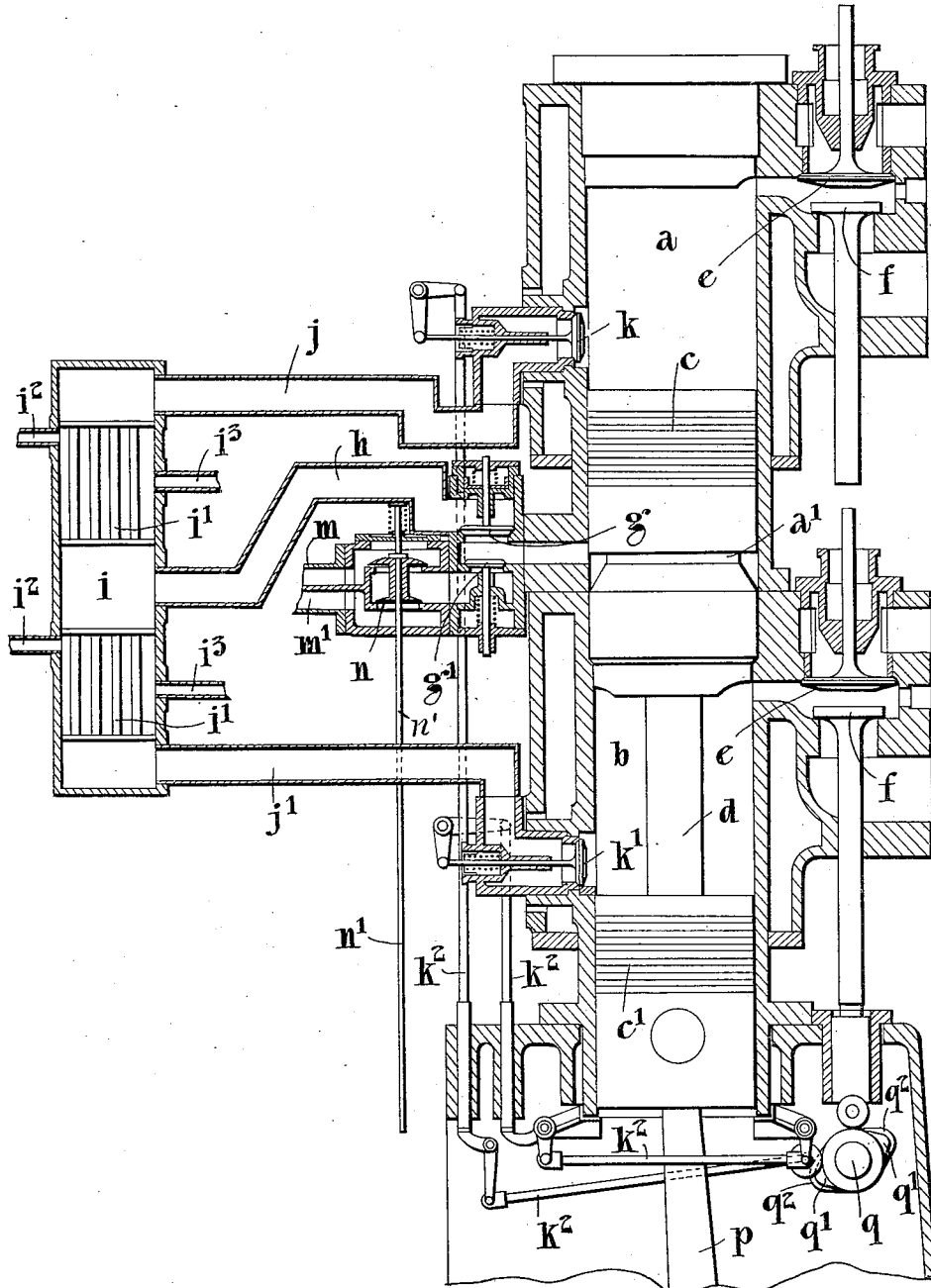


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 METHOD OF WORKING AND GOVERNING INTERNAL COMBUSTION ENGINES.  
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1,017,592.

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Witnesses.  
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# UNITED STATES PATENT OFFICE.

THOMAS RIGBY, OF DUMFRIES, SCOTLAND.

METHOD OF WORKING AND GOVERNING INTERNAL-COMBUSTION ENGINES.

1,017,592.

Specification of Letters Patent.

Patented Feb. 13, 1912.

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*To all whom it may concern:*

Be it known that I, THOMAS RIGBY, a subject of the King of Great Britain and Ireland, and resident of Station Hotel, Dumfries, Scotland, have invented certain new and useful Improvements in the Methods of Working and Governing of Internal-Combustion Engines, of which the following is a specification.

10 This invention relates to improvements in internal combustion engines and is mainly intended to be used in connection with those engines working on the single acting Otto cycle in which an extra charge of combustible gas, or air, or a mixture of both is admitted to the working cylinder in addition to the ordinary working charge drawn in during the suction stroke.

15 The type of engine to which the invention is particularly applicable, is that illustrated in the accompanying drawing and which is known as the vertical tandem type of engine (single acting Otto cycle) in which the upper cylinder is supported by the top of the lower cylinder in such a manner that there is a clearance space between the upper piston at the end of the down stroke and the cover of the lower cylinder, which space may be used for compressing and supplying additional gaseous fluid to either working cylinder by the displacement of the upper piston. The gaseous fluid is admitted to the clearance space in any suitable manner, but preferably by way of a back pressure valve which closes automatically at the commencement of the down stroke of the coupled pistons compressing the gaseous fluid in the clearance space to the necessary pressure prior to its admission to a working cylinder or receiver. In such an engine the compressed gaseous fluid if delivered direct is preferably admitted once every revolution to either cylinder alternately and preferably only for the purposes of carrying overload.

20 With such engines as those hereinbefore referred to, there may be expected to be a little cooling of the additional gaseous fluid (which is heated by the compression) before it is admitted to the working cylinder, but this is chiefly owing to radiation losses.

25 The present invention consists in working internal combustion engines on a new cycle of operations in which additional gaseous fluid is admitted to the working cylinder at or near the end of the suction stroke and is cooled preferably by water prior to its ad-

mission to the working cylinder to a temperature below the suction temperature usual in engines working on the Otto cycle, for the purposes hereinafter described. The cooling may be effected by bringing the water or other cooling medium into direct contact with the heated gases or the heated gases into contact with water cooled surfaces, preferably the additional gaseous fluid being cooled to as near the temperature of the atmosphere or to the temperature of the cooling water as possible prior to its admission to the working cylinder.

30 According to the invention the cooling required is in practice considerable, and large surfaces are required to effect it; it is essential that the additional working fluid should be cooled below the temperature of the ordinary charge and admitted at or near the end of the suction stroke, and engines in which but slight cooling of the added charge takes place form no part of this invention.

35 The temperature of the working charge in the cylinder of an ordinary internal combustion engine, before compression commences, has a great influence on the working temperatures, both at compression and throughout the combustion or power stroke. For instance, in an ordinary Otto cycle engine, the suction temperature at the end of the suction stroke is seldom less than eighty degrees centigrade and often rises to over one hundred degrees centigrade. If additional gaseous fluid at atmospheric temperature or thereabout is added to the working charge the effect of such addition is to reduce the temperature of the charge before the return of the piston on the compression stroke. For instance, if half the weight of the ordinary working charge is added in the form of additional gaseous fluid at atmospheric temperature to the working charge, having at the time a suction temperature of eighty degrees centigrade, the effect will be to raise the pressure in the cylinder to approximately half an atmosphere above that of the atmosphere while the temperature of the mixture will be less than the original eighty degrees centigrade. The direct result of this reduction of temperature and increase of pressure before the actual compression stroke has commenced, is to reduce the maximum temperature of combustion to a much lower temperature, say to the neighborhood of one thousand two hundred to one thousand three hundred

degrees centigrade, instead of the usual much higher temperature, without in any way reducing the percentage of combustible present in the final mixture prior to ignition and combustion. In consequence the heat losses in the water jacket of a working cylinder are considerably reduced and a heat gain is effected which is much greater than the heat dissipated by cooling the additional gaseous fluid before it is admitted to the working cylinder. It is obvious that if additional cooled gaseous fluid be not added to the working cylinder of an engine of the type indicated the maximum temperature of combustion will be far higher than the maximum hereinbefore indicated, namely one thousand two hundred to one thousand three hundred degrees centigrade or thereabout, and as below a certain load it is not economical to introduce the additional cooled gaseous fluid it is therefore preferable that the additional cooled gaseous fluid shall only be admitted to a working cylinder when the load is at or above a predetermined portion of the maximum load, and the amount of gaseous fluid admitted is governed in accordance with the load up to the maximum load with maximum delivery of additional gaseous fluid at maximum load, no additional cooled gaseous fluid being admitted when working below the predetermined load.

The governing of the engine is preferably on the throttle system but not necessarily so, and the predetermined point above referred to is usually arranged to be somewhat below the full load of an ordinary engine (without addition of gaseous fluid) so that the maximum temperature of combustion at the predetermined point will not exceed the maximum temperature of combustion obtained at the maximum load with maximum addition of cooled gaseous fluid.

When air only is delivered as the additional charge, it is preferable to admit it at or above a predetermined load corresponding to the maximum temperature desired as hereinbefore described, but at the time additional air is admitted the proportion of air may be automatically reduced and the proportion of gas increased in the charge drawn into the working cylinder during the suction stroke to such an extent that although air under pressure is admitted to the working cylinder, the final mixture before ignition of the charge is not unduly diluted by excess of air. In all cases where air alone is admitted, the added air is cooled in the manner above described before its admission to the working cylinder.

In some cases, the point at which the additional cooled gaseous fluid is admitted to the working cylinder corresponds to the full load of the engine (without any addition of gaseous fluid), a mixture weak in combusti-

ble being drawn into the working cylinder during the ordinary suction stroke to give a maximum temperature of combustion not higher than that desired at maximum load with maximum addition of cooled gaseous fluid. In such a case it is preferable that the added cooled gaseous fluid (when a mixture of gas and air) shall be richer in gas than usual, so that the final mixture at maximum load before ignition will be of the full strength required. Any suitable mechanism or valve gear may be used to effect this purpose. When the additional cooled gaseous fluid is gas, the point at which it is admitted preferably corresponds to the full load of the engine (without addition of gaseous fluid) a weak mixture of gas and air being drawn into the working cylinder during the ordinary suction stroke of the engine. The ordinary gas supply is preferably in such a case automatically reduced to correspond with the addition of cooled gaseous fluid to the working charge the mixture being thus altered to the right proportions to insure full strength of the final mixture at maximum load before ignition and combustion takes place. When the additional cooled gaseous fluid is air and a weak mixture is used at full load (without addition of cooled air) the proportions of gas and air drawn in during the ordinary suction stroke are automatically altered and the proportions of gas increased to insure full strength of the final mixture before ignition and combustion at maximum load. Any suitable mechanism or gear may be employed to effect the above mentioned alterations of the mixture to enable the engine to give maximum power at maximum load if desired in all cases.

In some cases the gaseous fluid in the first place is passed into a receiver or receivers in which it is cooled before it is admitted to a working cylinder.

The invention may be applied to any Otto type engine in which the additional gas or air or mixture of gas and air is obtained by using the displacement of the opposite side to the combustion side of a working piston to pump the gaseous fluid into a working cylinder or more than one working cylinder and any modification may be used of the system of employing this displacement of the piston or any projection thereof in any desirable manner either passing the cooled gaseous fluid direct to the working cylinders or by way of a receiver or receivers.

Any of the above mentioned methods of sustaining a maximum load may be employed in this cycle.

The accompanying drawing is a sectional elevation of a vertical tandem two cylinder internal combustion engine, working on the Otto cycle.

In this view, *a* and *b* designate the two working cylinders arranged tandem; *c c'* their respective pistons; *d* the common piston rod upon which the two pistons are mounted; *p* a rod connecting the piston rod *c'* to the crankshaft (not shown); *a'* the compression space formed by closing in the end of the cylinder *a*; *e e* the gas or combustible mixture admission valves, and *f f* the exhaust valves of the two working cylinders; *g* the delivery valve controlling the pipe *h* leading from the compression space *a'* in the working cylinder *a* to the receiver *i*; *i'* an arrangement of cooling tubes placed within the receiver and cooled by water or other liquid supplied through pipes *i<sup>2</sup>* and caused to circulate around the outside of the tubes *i'*, the heated water passing away through the pipes *i<sup>3</sup>*; *j j'* pipes leading from the receiver to the cylinders *a b* and controlled by extra admission valves *k k'* operated by connections *k<sup>2</sup>* from the side shaft *q*, *m m'* the gas and air supply pipes; *n* the gas, or gas and air, governing valve, and *n'* the connecting rod to the governor for controlling the valve and the supply of gas, or gas and air, to the compression space *a'* of the working cylinder; and *q* the side shaft with two cams *q'* thereon which operate through connecting rods and links the valves *k'* and with cams *q<sup>2</sup>* which operate the exhaust valves *f*.

Having thus described my invention, what I claim is:—

35 1. A method of working internal combustion engines in which the main charge is drawn in on the suction stroke, which consists in admitting to the working cylinder a supplementary charge cooled to a temperature below the temperature of the usual charge at or near the end of the suction stroke when the load of the engine exceeds a predetermined amount.

40 2. A method of working internal combustion engines, which consists in drawing into the cylinder a charge of gas and air by suction, cooling a supplementary charge to a temperature below the temperature of the first-named charge admitting the supplementary charge at or near the end of the suction stroke, compressing the suction charge and the supplementary charge together, igniting the charge to move the piston on its working stroke, and permitting the products of combustion to be expelled on the exhaust stroke.

45 the cylinder a charge of gas and air by suction, cooling a supplementary charge to a temperature below the temperature of the first-named charge admitting the supplementary charge at or near the end of the suction stroke, compressing the suction charge and the supplementary charge together, igniting the charge to move the piston on its working stroke, and permitting the products of combustion to be expelled on the exhaust stroke.

3. A method of working internal combustion engines, which consists in drawing into the cylinder a charge of gas and air by suction, cooling a supplementary charge to a temperature below the temperature of the first-named charge admitting the supplementary charge at or near the end of the suction stroke, compressing the suction charge and the supplementary charge together, igniting the charge to move the piston on its working stroke, permitting the products of combustion to be expelled on the exhaust stroke, and simultaneously compressing the supplementary charge for the succeeding explosion.

4. The method of working internal combustion engines which consists in drawing into a cylinder a charge of gas and air by suction, compressing a supplementary charge in the engine, cooling said supplementary charge below the temperature of said first named charge, and admitting said supplementary charge at or near the end of the suction-stroke.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THOMAS RIGBY.

Witnesses:

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H. D. JAMESON.