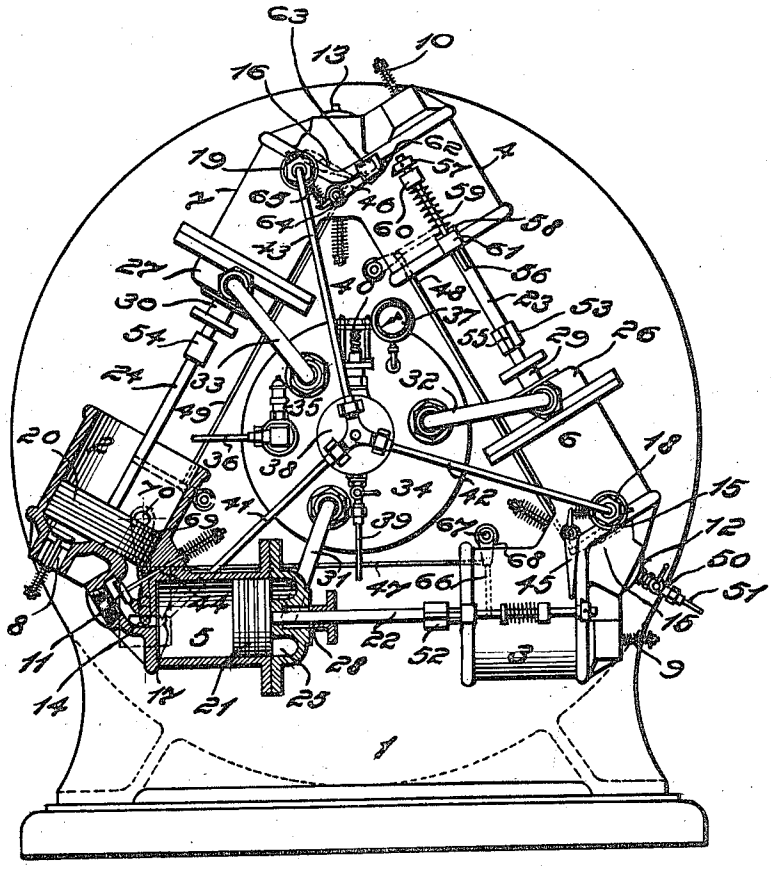
L. J. B. BLAKE.

GAS TURBINE.

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UNITED STATES PATENT OFFICE.

LIONEL JAMES BAKER BLAKE, OF CARLISLE, ENGLAND.

GAS-TURBINE.

1,148,653. Specification of Letters Patent. Patented Aug. 3, 1915.

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To all whom it may concern:

Be it known that I, LIONEL JAMES BAKER BLAKE, a subject of the King of England, and resident of Carlisle, in the county of Cumberland, England, have invented an Improved Gas-Turbine, of which the following is a specification.

This invention relates to improvements in or connected with gas turbines, more especially to gas turbines of the kind wherein provision is made of an arrangement of compression and explosion cylinders containing appropriate working pistons and provided with suction and delivery valves, in which arrangement an explosive mixture of gases or vapors is compressed in the compression cylinder and forced from these latter into the explosion cylinders where it is ignited and exploded by suitable igniting devices, the exploded gases being led to and caused to act upon the vanes of the turbine rotor so as to cause the same to revolve. In gas turbines of this kind arrangements are made of hydraulic accumulators connected with the explosion cylinders for the purpose on the one hand, of maintaining a constant or uniform pressure of the products of combustion escaping from the explosion cylinders to the turbine rotor and, on the other hand, to provide cooling water for cooling the explosion cylinders after each explosion.

According to one part of my present invention instead of the compression cylinders drawing in explosive mixture, compressing same and forcing it into the corresponding explosion cylinders where the compressed mixture is ignited and exploded, I cause the compression cylinders to draw in atmospheric air only, to compress that air and to force it, in its compressed condition, into the explosion cylinders, and then I inject by means of an auxiliary pump, or otherwise, a suitable quantity of oil or spirit into the compressed air in the explosion cylinders; thereby producing an explosive mixture of oil or spirit vapor and air, which is ignited and exploded by the heat produced in the air by its compression. By this means I am enabled to dispense with electric, incandescent tube or other igniting apparatus.

Another object of my present invention is to dispense with the said hydraulic accumulator and I employ instead thereof a receiver or reservoir of compressed air, the capacity of which is such that when the compressed air acting on the top of the pistons of the explosion cylinders is forced out into the said air receiver it makes no appreciable difference in the pressure prevailing in that receiver, so that the pressure exerted on those pistons remains practically constant, as when the hydraulic accumulator is employed.

In cases where it is found that the above described compressed air arrangement does not sufficiently cool the explosion cylinders, the latter may have water jackets or other known means applied to them in the usual way.

It may be an advantage to force a jet or spray of water into the explosion cylinder at or about the time when an explosion takes place. This water would be converted into steam by the heat of the exploded gases, thereby cooling those gases to some extent before they are delivered to the turbine rotor. The injection of water as above suggested is already well known in connection with explosion engines, and its use in my turbine forms no part of the invention claimed herein.

For these purposes I employ the construction and arrangement of apparatus such as is illustrated by way of example in the accompanying drawing, which is a part front and a part front sectional elevation.

The turbine 1 is of known construction, the stator being provided with facings for the cylinders, and passages or nozzles to enable the exploded mixture to impinge on the turbine blades.

The compression cylinders 2, 3 and 4 and the explosion cylinders 5, 6 and 7 are arranged in pairs as shown, and securely attached to the facings on the turbine stator arranged for them. The compression cylinders 2, 3 and 4 are fitted with suction valves 8, 9 and 10 respectively. Between the compressing cylinders 2, 3 and 4, and the explosion cylinders 5, 6 and 7, there are fitted delivery valves 11, 12 and 13 respectively. The explosion cylinders 5, 6 and 7 are fitted with delivery valves 14, 15 and 16 and oil or spirit valves 17, 18 and 19 respectively. The compression and explosion cylinders are all fitted with pistons similar to 20 and 21 respectively; each piston having suitable packing rings. The pistons of each pair of

compression and explosion cylinders are connected by means of piston rods 22, 23 and 24 respectively.

The outer ends of the explosion cylinders are fitted with suitable covers 25, 26 and 27, each cover having a suitable stuffing-box and gland 28, 29 and 30, arranged to take the piston rods 22, 23 and 24 respectively. The explosion cylinder covers 25, 26 and 27 are also provided with pipes 31, 32 and 33 connecting the said covers to the compressed air receiver or reservoir 34, so that the air in the said receiver is in direct communication with the side of the explosion pistons 21 remote from the explosion end of the cylinder, for controlling the motion of the said piston. The air receiver 34 is also provided with a relief valve 35, which is regulated to blow off, should the pressure in the said receiver at any time exceed the pressure at which the turbine has been designed to work. The relief valve 35 is also provided with a pipe 36 leading to a small auxiliary pump, not shown, which may be driven from the turbine shaft or otherwise. The object of this pump is to make good any leakage of air from the receiver and consequent reduction of pressure therein. A pressure gage 37 may also be fitted to the said receiver 34. The oil or spirit tank 38 is kept supplied with oil or spirit, under pressure, through the medium of an auxiliary pump, not shown, which may be driven from the turbine shaft or otherwise. The pump is connected to the said tank 38 by means of the pipe and valve 39. The tank is also provided with a small spring-loaded ram accumulator 40 or the like, to insure a regular supply of pressure oil or spirit through the pipes 41, 42 and 43 to the oil or spirit valves 17, 18 and 19 respectively. The oil or spirit valves 17, 18 and 19 are arranged to feed the explosion cylinders 5, 6 and 7 with a quantity of oil or spirit at a certain time, this time being regulated by means of the tappet levers 44, 45 and 46, these in turn being actuated by the motion of the cross-heads 52, 53 and 54 which are attached to the piston-rods 22, 23 and 24 respectively.

The construction of the operating gear connected with each of the tappet levers 44, 45 and 46 and the cross-heads 52, 53 and 54 is exactly the same for each set of compression and explosion cylinders; and a description of the construction and action of one complete set of tappet gear will suffice for all three sets. Taking as an example the tappet lever 46; the cross-head 53 has an arm or projection 55 which is adapted to strike the tappet rod 56 when the piston rod 23 moves outward. To the tappet rod 56 is fixed a striking piece 57, a fixed collar 58 and a suitable spring 59, the whole being supported in two suitable bearings 60 and 61. The tappet rod 56 is made of such a length that when the arm 55 on the cross-head 53 has made a large portion of its upward stroke, it strikes the tappet-rod 56 forcing it in an upward direction, and thereby compressing the spring 59 by means of the collar 58. When the cross-head 53 is on the inward stroke, the compressed spring 59 forces the tappet-rod 56 back into its original position by means of the collar 58. When the striking piece 57 moves in an upward direction it passes the lever 46 without altering its position in any way; but it forces the bell-crank shaped trip catch 62 aside and passes beyond it. When the striking piece 57 has passed, the trip catch 62 is forced back into its original position by means of the spring 63, so that the striking piece 57 engages the said catch on its return on the inward stroke of the piston rod 23 and thereby turns the lever 46 through an arc on the fulcrum 64. This in turn depresses the spindle of the oil or spirit valve 19, and allows a certain quantity of oil or spirit to be admitted to the explosion cylinder 7. When the striking piece 57 slips past the strip catch 62 through the lever 46 describing an arc, the said lever 46 is forced back into its original position through the action of the spring 65 on the spindle of the oil or spirit valve 19, at the same time closing the said valve.

The striking piece 57 can be adjusted so that the oil or spirit can be admitted through the valve 19 at any suitable point of the inward stroke of the piston rod 23.

The delivery valves 14, 15 and 16 on the explosion cylinders 5, 6 and 7 are operated by means of the rods 47, 48 and 49, these in turn being actuated by the motion of the cross heads 52, 53 and 54 connected with the piston rods 22, 23 and 24 respectively. The construction of the operating gear connected with each of the rods 47, 48 and 49 and cross heads 52, 53 and 54 is exactly the same for each set of compression and explosion cylinders; and a description of the construction and action of one complete set of tappet gear will suffice for all three sets. Taking as an example the rod 47, the cross head 52 has an arm or projection, not seen in the drawing because it is situated on the remote side of the cross head 52, which is adapted to strike tappets arranged on a tappet rod, also not shown in the drawing, the same being in line and parallel to the piston rod 22. This tappet rod is connected to the lever 66 adapted to oscillate on the fulcrum 67. A second lever 68 is also arranged on the fulcrum 67, and is made to turn in conjunction with lever 66. The lever 68 is connected to the lever 69 by means of the connecting rod 47, the lever 69 is adapted to oscillate on the fulcrum 70. On this fulcrum 70 is also arranged a suitable cam, not shown, which

works in conjunction with the lever 69, and is adapted to depress the spindle of the delivery valve 14 against the action of its supporting spring when the piston rod 22 moves in an outward direction, that is to say from left to right in the drawing, and the arm on the cross head 52 comes in contact with a tappet on the right hand side of the tappet rod connected to the lever 66, at about the end of the said outward stroke, and moves the said tappet in a right line. This also turns the lever 68 in the same direction and exerts a pull on the connecting rod 47 which in turn pulls the lever 69 over, so that the cam on the fulcrum 70 opens the delivery valve 14, allowing the gases to flow from the explosion cylinder 5 into the turbine, and preventing the piston 21 striking the cylinder cover 25. On the inward or return stroke of the piston rod 22 the arm on the cross head 52 comes in contact with a tappet on the left hand side of the aforesaid tappet rod connected to the lever 66, at about the end of the inward or return stroke and moves the same in a left to right direction. This turns the lever 68 in the same direction and creates a push on the connecting-rod 47 which in turn pushes the lever 69 over, so that the aforesaid cam on the fulcrum 70 turns and allows the spring to close the delivery valve 14, thereby retaining a certain amount of the exploded mixture in the explosion cylinder 5 for the piston 21 to bottom against and prevent the same striking the end of the cylinder.

In the example shown in the drawing the suction valves 8, 9 and 10 and the delivery valves 11, 12 and 13 are supposed to be automatically acting lift valves, but if preferred they may be operated and controlled by the piston rods.

The mechanism above described and illustrated in the drawing for operating the valves is only given by way of example, and any other suitable mechanism may be employed for that purpose without departing from the nature of my invention.

It will be understood that tappet gear similar to that above described in connection with the piston rod 23, for operating the oil or spirit valve 19, is employed in connection with each of the piston rods 24 and 22 for operating the oil or spirit valves 17 and 18 respectively; also that tappet gear similar to that above described in connection with the piston rod 22, for operating the delivery valve 14, is employed in connection with each of the piston rods 23 and 24 for operating the delivery valves 15 and 16 respectively; and that these tappet gears are not shown on the drawing in order to avoid confusion.

The plug or cover of the delivery valve 12 is fitted with an ordinary two-way valve 50 which is connected, by means of the pipe 51, to the auxiliary air pump before mentioned.

In operating the turbine, the air receiver 34 is fully charged with air, to the pressure at which the turbine has been designed to work, by the auxiliary pump before mentioned, which for this purpose can be manipulated independently of the rotor shaft. The oil or spirit tank 38 is also forced up to the pressure required for this vessel, by means of the auxiliary pump before mentioned, which can also be manipulated independently of the rotor shaft. A predetermined quantity of air is forced into the explosion cylinder 6, through the pipe 51 and the two-way valve 50 by the aid of the aforesaid auxiliary air pump. Having obtained this quantity of air in the explosion cylinder 6, the oil or spirit valve 18 is depressed, by hand, until a certain quantity of oil or spirit has been admitted to the said explosion cylinder 6. When the whole of this quantity of oil or spirit has been admitted, an explosion is caused by the heat generated in the compression of the air. Instead of this exploded mixture being retained at its explosion pressure it is allowed to expand, and in so doing it forces the pistons in the explosion cylinder 6 and the compression cylinder 4 in an outward direction, thereby forcing the air in the said compression cylinder 4 under the piston in the explosion cylinder 7, through the delivery valve 13. When the products of combustion have expanded to the full stroke of the piston in the explosion cylinder 6, the piston rod 23 actuates the tappet or cam gear connected with the rod 48 of the delivery valve 15 on this end cylinder in the same way as that described above in connection with delivery valve 14, thereby opening the said valve and admitting the products of combustion into the turbine 1, the said products of combustion being forced out of the cylinder at a more or less constant pressure through the action of the air pressure in the receiver 34 on the opposite side of the explosion piston. When the piston in the explosion cylinder 6 has just commenced the discharge stroke, the piston rod 23 actuates the tappet lever 46 in connection with the oil or spirit valve 19 as already described, thereby admitting a quantity of the oil or spirit into the explosion cylinder 7 and causing an explosion in this cylinder, the products of combustion being allowed to expand as in the case of cylinder 6. In like manner this will occur in each explosion cylinder successively, seeing that the conditions are the same it follows that the functions will likewise be the same, and these will take place through the respective valves, pipes and other gear in connection with each respective pair or sets of cylinders and pistons. When the explosion pistons are dis-

charging the products of combustion into the turbine, the piston rods of these pistons being also attached to the compression pistons, respectively, they therefore draw the same down, thereby drawing in a fresh supply of atmospheric air through the air suction valves 8, 9 and 10 respectively. The one pair of pistons in the cylinders in one set or pair will continue to alternate and synchronize with the pistons in the cylinders in the next set or pair. Further, in the arrangement as above set forth it will be seen that while one explosion cylinder has an expansive period going on, the second explosion cylinder will have a receiving period, while the third explosion cylinder will be discharging the products of combustion contained therein. In this way a perfect sequence is formed and the turbine will be supplied with a constant flow of gas at a certain pressure.

In the above description of mechanism suitable for carrying my invention into effect, I have described an arrangement consisting of three sets or pairs of cylinders, pistons, valves and other parts; but I desire to have it understood that I do not confine myself to any particular number of sets or pairs as the number may be varied, and the details of construction also, according to circumstances, without departing from the nature and scope of the invention, for example the drawing in and compression of air alone, its transference to the explosion cylinders, the injection thereinto of oil or spirit, and the ignition of the mixture of oil or spirit vapor and air by the heat generated in the compression of the air may be applied to the arrangement of two sets or pairs of cylinders.

Having now fully described my said invention what I claim and desire to secure by Letters Patent is:—

1. A gas turbine, comprising the combination with the turbine of a plurality of pairs of compression and explosion cylinders, a corresponding number of suction, delivery and spirit inlet valves fitted to said cylinders, pistons and piston rods in each of the cylinders, means controlled by the piston rods for the admission of atmospheric air and spirit successively into the several cylinders, and means for the ignition of the explosive mixture in the explosion cylinders, all substantially as described.

2. In a gas turbine, the combination with the turbine of a plurality of pairs of compression and explosion cylinders, suction valves fitted to said compression cylinders to admit atmospheric air, delivery valves mounted on the explosion cylinders, a piston and a piston rod in each of the cylinders, means for admitting air to the said compression cylinders, means for compressing the air in the compression cylinders, and means for delivering the said air from the compression cylinders through the delivery valves on the explosion cylinders, substantially as described.

3. In a gas turbine, the combination with the turbine of a plurality of pairs of explosion cylinders, delivery valves fitted thereon for the admission of air, a piston and piston rod in each of the said explosion cylinders, means for the admission of spirit to each of the said cylinders, means whereby the explosive mixture is ignited in each of the said cylinders, an air receiver mounted centrally of the several cylinders, covers on each of the said explosion cylinders having orifices and pipes for the admission and return of air to and from said air receiver, delivery valves communicating with the turbine nozzle, and means for operating the said delivery valves to connect each explosion cylinder in succession to the turbine nozzle during the reciprocating movement of the piston after expansion due to the ignition of the explosive mixture, substantially as described.

4. In a gas turbine, the combination with the turbine of a plurality of pairs of cylinders, each pair being composed of a compression and an explosion cylinder, arranged in tandem, a piston in each compression and explosion cylinder, and a piston rod connecting the said pistons, substantially as described.

5. In a gas turbine, the combination with the turbine of a plurality of pairs of compression and explosion cylinders, suction, delivery and spirit inlet valves fitted on said cylinders respectively, and means for operating the delivery valves on the explosion cylinders, by means of the reciprocating movement of the piston rods, to admit exploded and expanded mixture at a more or less constant pressure to the turbine nozzle, substantially as described.

6. In a gas turbine, the combination with the turbine, of a plurality of pairs of explosion cylinders, a device for maintaining a more or less constant pressure of air or gas on the side of the piston remote from that acted on by the exploded and expanded mixture, the said device consisting of an air receiver and means to connect the latter with the said explosion cylinders, all substantially as and for the purpose described.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

LIONEL JAMES BAKER BLAKE.

Witnesses:
J. H. Boyd,
Arthur M. Irwin.