No. 688,494. Patented Dec. 10, 1901.

P. K. STERN.

THERMO-ELECTRODYNAMIC TRANSFORMER.

(Application filed Feb. 15, 1901.)

(No Model.) 2 Sheets—Sheet 1.

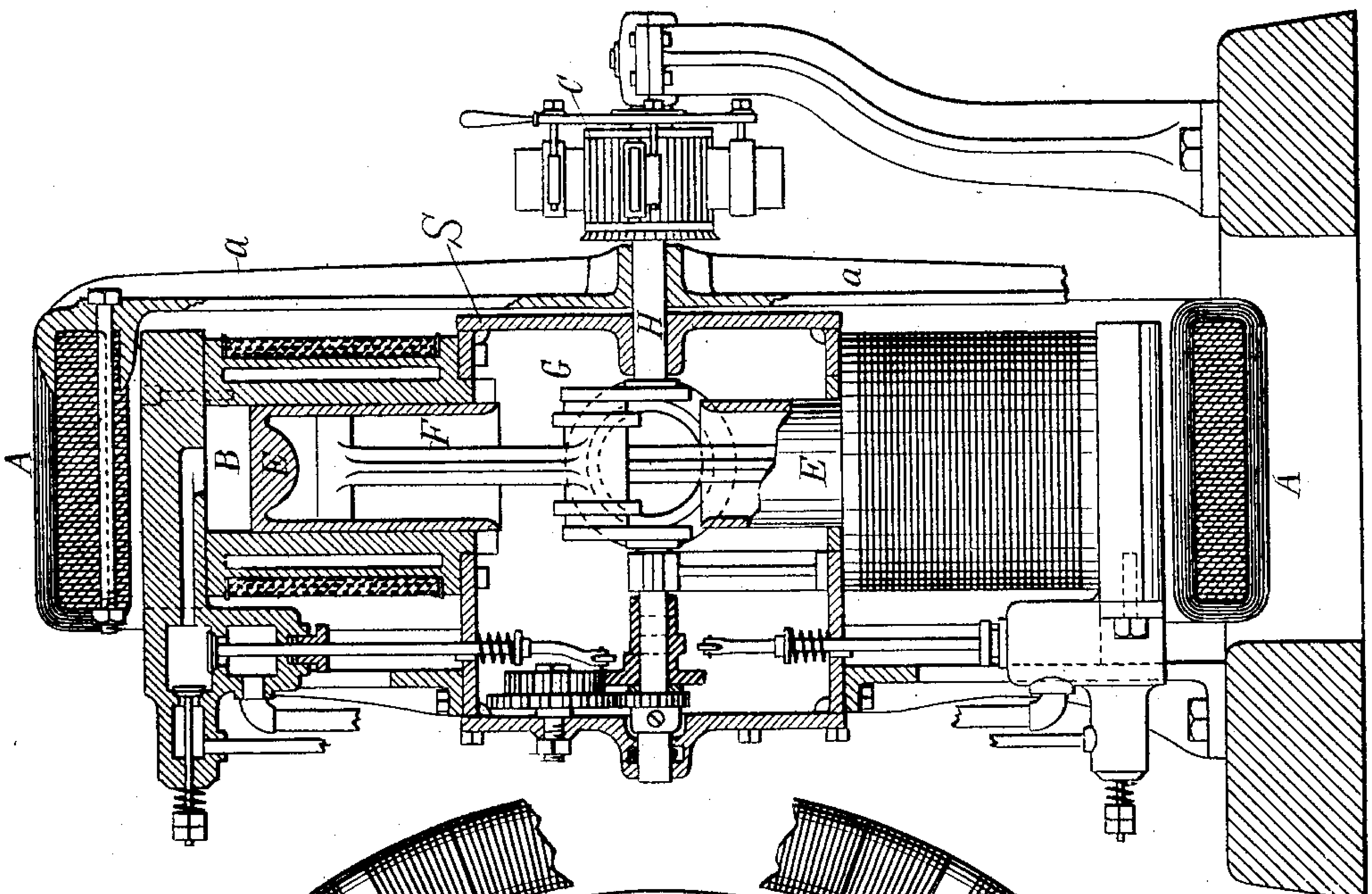

Fig. 2

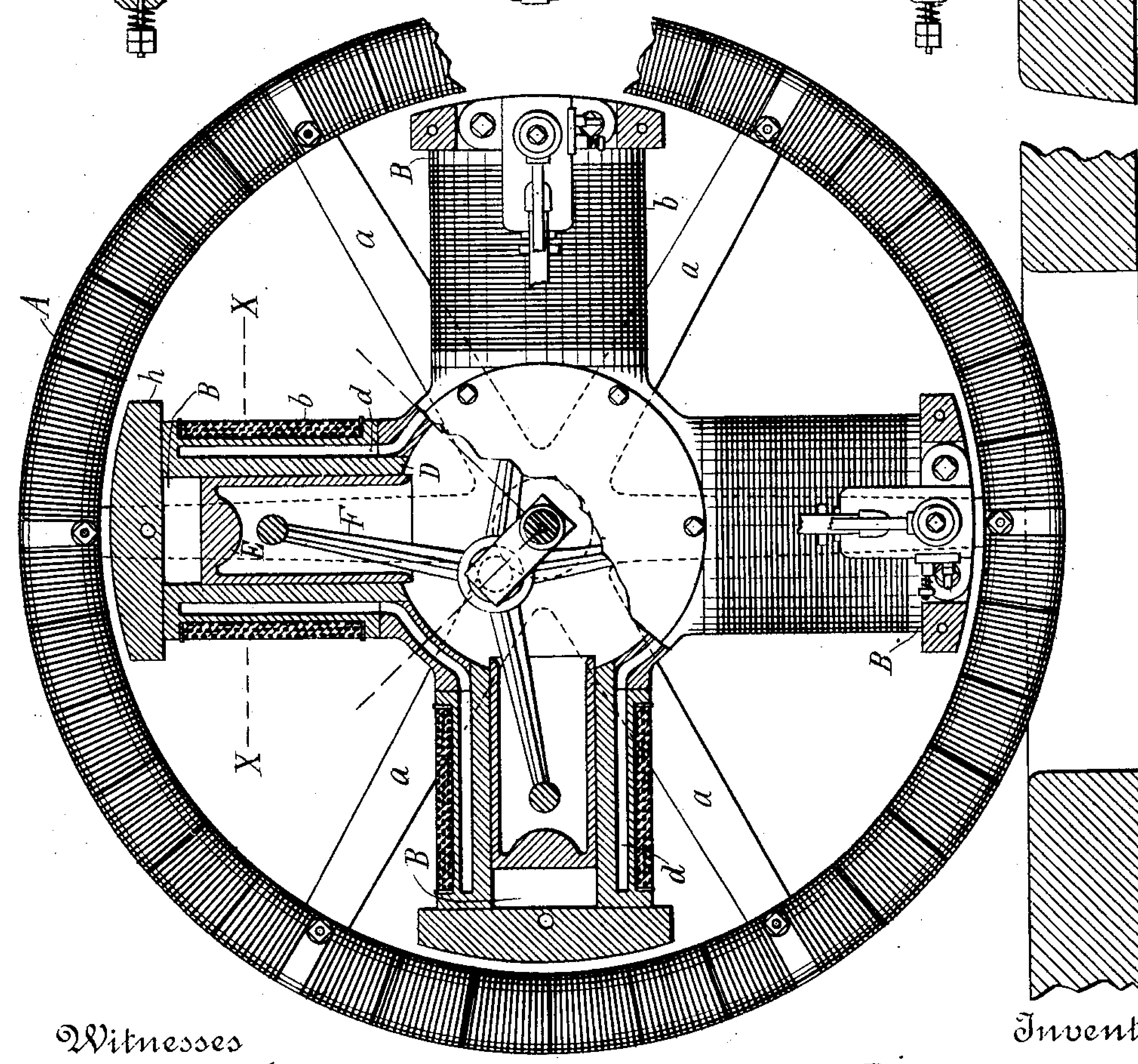

Fig. 1

Witnesses

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Marie Blumer

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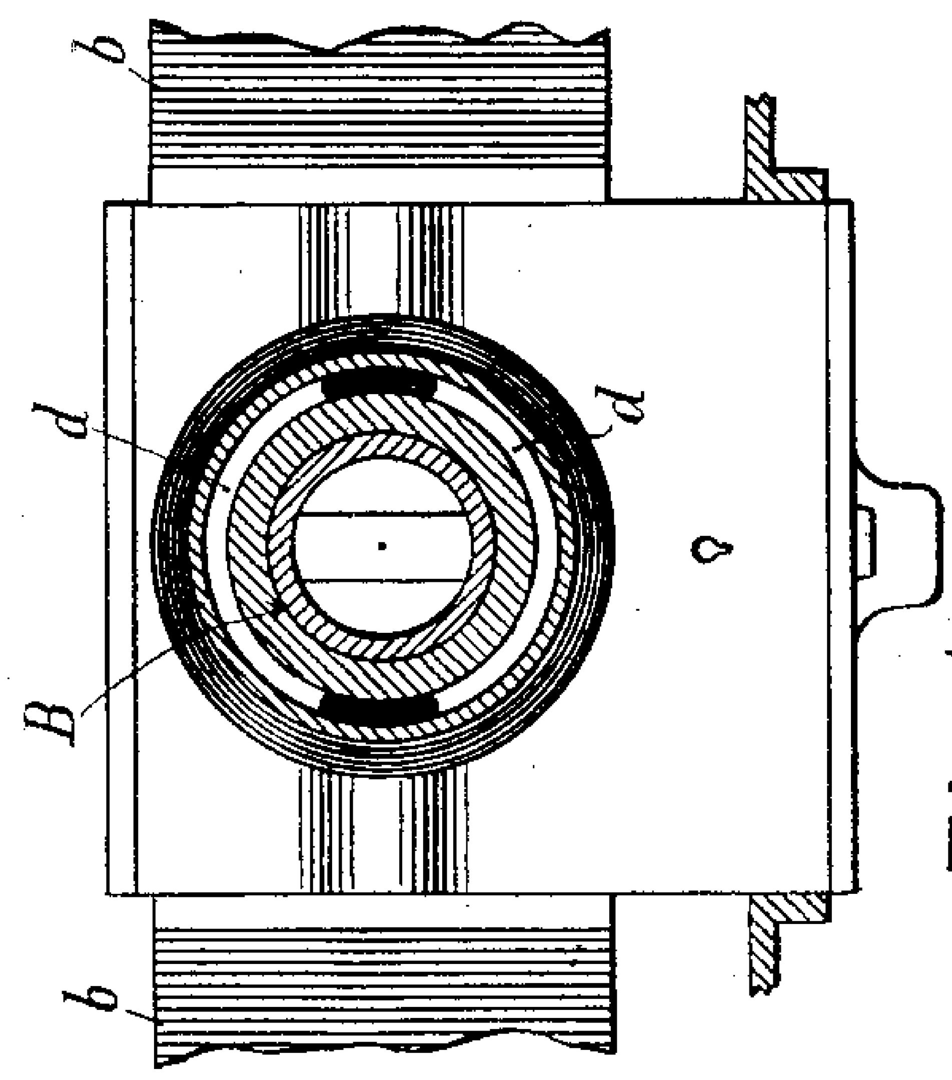

Fig 4

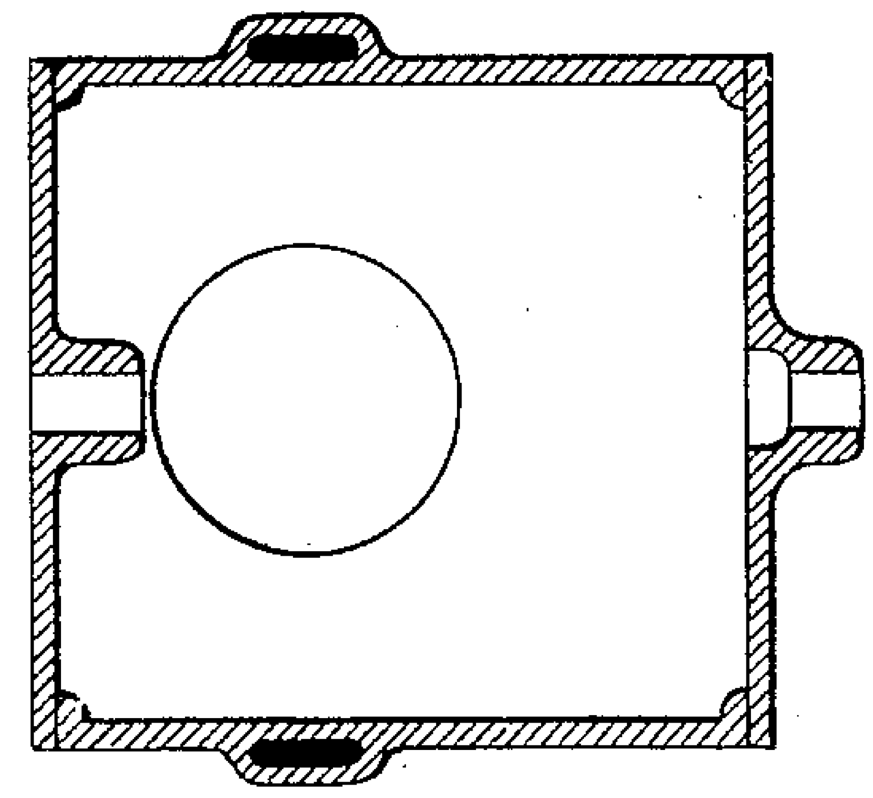

Fig. 5

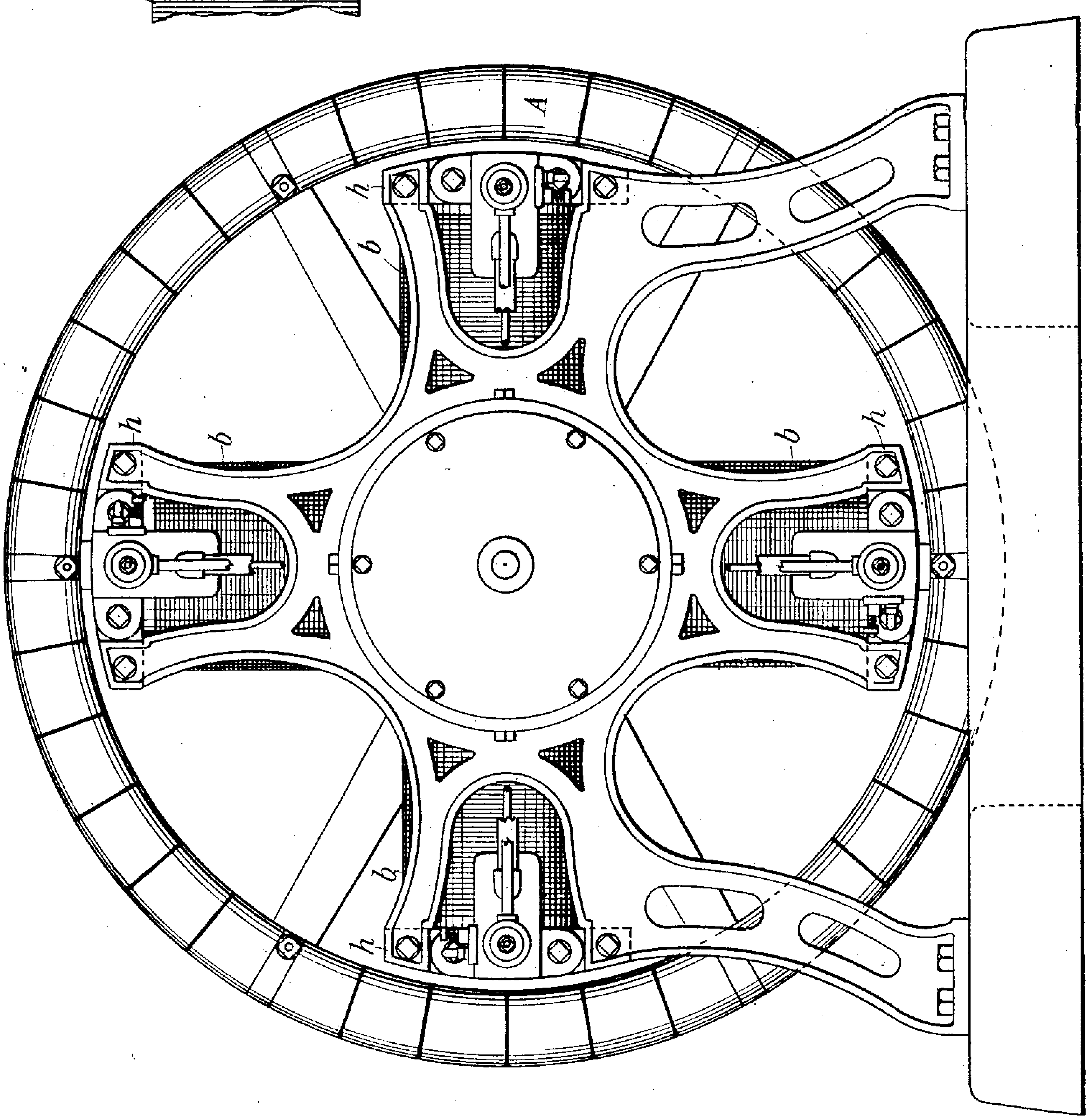

Fig. 3

Witnesses
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UNITED STATES PATENT OFFICE.

PHILIP K. STERN, OF NEW YORK, N. Y.

THERMO-ELECTRODYNAMIC TRANSFORMER.

SPECIFICATION forming part of Letters Patent No. 688,494, dated December 10, 1901.

Application filed February 15, 1901. Serial No. 47,468. (No model.)

To all whom it may concern:

Be it known that I, PHILIP K. STERN, a citizen of the United States, residing in the city of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Thermo-Electrodynamic Transformers, of which the following is a specification.

My invention in thermo-electrodynamic transformers relates to a combination of a thermodynamic machine and an electrodynamic machine so constituted and combined that the mass of material employed in the construction of the thermodynamic elements enters into the construction of the electrodynamic machine. It also has relation to certain economic features in the transformation of the potential energy of a fuel employed in thermodynamic transformation when further transformed into electrical energy.

In the transformation of heat into mechanical work and wherein the expansion of the power medium is employed, together with certain kinematic instrumentalities for translating the heat of a fuel, a certain mass of material is requisite to meet mechanical requirements. This mass, however, is quite independent of the translating effects developed during the combustion of the fuel. In transforming mechanical work into electrical energy by dynamic induction a mass of material in the inductive parts is demanded without regard to volume. Again, in the electrodynamic transformation of heat according to the present methods the dissipation of energy due to electrical or C^2R losses and magnetic losses is not recuperative, and, therefore, a part of the potential energy of the fuel is wasted.

It is the object of my invention, first, to recuperate to some extent these losses of the dissipated heat in the electrodynamic transformation process and turn it into useful work; second, to reduce the weight of the mechanism employed in thermodynamic electrical transformation; third, to combine the mechanism of all of the apparatus, used in such transformation, so as to simplify the construction of such transformers, and, fourth, to render the apparatus, as a whole, more compact, and, at the same time, more efficient than the electro-thermodynamic transforming apparatus which has been in vogue previous to my invention. In carrying out these objects I employ to a considerable extent the mass of material which enters into the construction of the thermodynamic machine, as the inductive masses for the electrodynamic machine, and by this adaptation I so combine the thermodynamic motor and the electrodynamic machine as to obtain the structural material for one of the two said machines, principally, from the material required for the other.

While reducing my invention to practice my attention was directed to certain advantages which the internal-combustion type of thermodynamic motor presented, contributory to the electrodynamic requirements of the transformer. The structural material of this type of motor, particularly that of the explosive-engine, contains a large quantity of iron, which may be disposed in a manner so as to meet the requirements for magnetic characteristics in the electrodynamic features of the apparatus when considered as a unit, and in describing my invention it will be observed in this connection that I have given preference to that class of thermodynamic motor which would best favor the multipolar type of continuous-current dynamo by adopting a four-cylinder explosive-engine, as will hereinafter be more fully explained.

The principle involved in the recuperation of the heat dissipated in the electrodynamic transformation of the energy of the thermodynamic machine I carry out in the application of a heat-absorbing medium to certain parts of the inductive masses in the electrodynamic section of the transformer and the combustion-chambers of the thermodynamic section of the said transformer by interposing the said heat-absorbing medium between them. This medium is adapted to take up the dissipated energy, of the electrical section, in the form of heat, so as to effect evaporization of the medium, which, in turn, yields its kinetic energy in thermodynamic transformation, to the translating devices of the thermodynamic section by the indirect (expansive) process, after which the vapor is consumed as a fuel in the presence of a sufficient quantity of an oxidizing agent in direct thermodynamic transformation, according to the internal-combustion (or direct) process to effect a further thermodynamic transformation. Thus the dissipation of the caloric energy in the double transformation of, first, heat into mechanical work, and, second, from mechanical work into electrical energy becomes mutually recuperative, and, as a consequence, the transformer will yield a higher efficiency when in operation than one constructed and coupled up according to the principles in vogue previous to my invention, according to the construction of which no provision was made for the absorption, by the thermodynamic machine, of the dissipated energy in electrodynamic transformation.

The principal embodiments of my invention and the manner in which I carry it out are more clearly defined in the specification and illustrated in the drawings, which form part thereof, and the special features of novelty are more particularly pointed out in the claims.

In Figure 1 of the drawings I have shown a front elevation of my invention with a portion of the framework removed and two of the cylinders of the motor and part of the crank-case in section. Fig. 2 is an end elevation taken partly in section so as to show the interior of one of the cylinders and its concomitants. Fig. 3 is a front elevation showing the manner by which the motor is supported by the framework. Fig. 4 is a sectional view taken on the line *x x* of Fig. 1, showing one of the cylinders in section and a top plan view of the crank-case. Fig. 5 is a sectional view in plan of the crank-case, showing the passages through which the water, or other cooling agent, circulates from one cooling-jacket to another.

In the several views similar characters of reference relate to the same parts.

The armature A, together with the four field-magnets B and the commutator C and the supporting-framework, mainly constitutes the electrical section of the transformer, while the cylinders D, pistons E, together with the piston-rods F, crank G, and crank-shaft H, together with the valve mechanism, (clearly shown in the drawings,) comprising an ordinary multiple-cylinder explosive type of engine, constitute the thermodynamic section of the transformer. It will be noticed that the armature A, which is of the external type and secured by the spiders *a* to the crank-shaft H, serves the purpose of a fly-wheel for the internal-combustion engine.

The supporting-framework of the machine includes an axial crank box or casing S, on which the cylinders D are radially disposed and which, being of iron, serves the purpose of a magnetic yoke for the field-magnets B, (or magnetically-disposed cylinders.)

The cylinder-heads *h*, which constitute the pole-pieces of the field-magnets B, are cored, or otherwise formed with the necessary passage-ways, (exhaust and intake ports,) as shown clearly in section in Fig. 2. To those familiar with the art to which gas-engines pertain and to those familiar with the design and construction of electrical machinery the drawings clearly show the construction of each of the respective parts which enter into the composition of the transformer. The field-magnet windings *b*, which are wound around the outside of the cooling-jackets *d*, are maintained at the temperature of the cooling medium which is kept circulating in the jackets *d*. The cooling medium, which I prefer to employ, is a light volatile hydrocarbon oil which will boil at a low temperature, preferably not over 100° Fahrenheit, and to this end I prefer to adopt some of the lighter distillations of petroleum-oil, such as naphtha. It will be observed by the passage-ways intercommunicating between the different cooling-jackets, as shown in Fig. 1 in section and in plan in Figs. 4 and 5, that a complete continuous circulation of the oil in the cooling-jackets *d* may be effected. To set up a circulation in the oil, any well-known means—such as a small pump, gravity circulation, or variations in density caused by differences of temperature—may be employed. I do not desire to claim any of the means by which the circulation of the oil is effected, the details of construction of the valve mechanism, the electrical features of the dynamo, or the details of construction of the gas-engine. I have therefore omitted describing these details of construction in the specification, they being well known and understood and, moreover, made sufficiently clear, by the drawings, as to enable those who are skilled in the art of dynamo and gas-engine construction to construct the apparatus herein shown from the illustrations in the two annexed sheets of drawings forming part of this specification. The cooling medium contained within the jackets *d*, which carries away the excessive cylinder heat of the combustion-engine, is admitted to its cylinders as a fuel in the usual manner. In the meanwhile, however, the heat may be taken out of the vapor by its performing useful work in operating an "expansion-engine," so called—namely, a steam-engine or such engines as are termed "naphtha-vapor" or "spirit" engines. After extracting heat from the naphtha-vapor thus energized by passing it through an engine, it may be taken into the cylinders of the internal-combustion engine through the intake-valve mechanism mixed with atmospheric air as customary and exploded behind the working piston. The continual consumption of the vapor, preceded by this loss of heat, will cause a rapid circulation of the fluid in the cooling-jackets *d*, which will have the effect of reducing the temperature of the mass of iron, which composes the cylinders of the engine and the electromagnets B of the dynamo, thus keeping down the temperature of the field-magnets due to eddy-currents in the iron and the C^2R losses in the windings, and as this carrier of heat takes up the C^2R losses, as well as the superfluous heat units of the working cylinders of the engine, the heat thus dissipated during the transformation of the energy of the fuel into electrical energy is recuperated in effecting a further transformation of thermic energy into that of electro dynamic. The value of Y or the magnetic permeability of the magnetic field may be augmented by a temperature coefficient, having a positive value for the iron, since within certain limits the value of Y will vary directly with the temperature of the iron, and the pole-pieces *h*, as well as the cylinder-heads, will necessarily attain a much higher temperature, during the combustion of the fuel within the cylinder, than the remaining mass of iron, contained in the field-magnets of the dynamo, which may be composed of a grade having the greatest permeability at that temperature which the pole-pieces *h* will attain during the normal working load of the engine. It will thus be seen that another object which I attain is met by the requirements of the electrical load by variations in the electromotive force through the temperature of the magnetic field. It should not be understood, however, that this is the only means of regulation, as a supplemental regulation may be obtained by varying the temperature of the iron in the field, as is well known and understood by electrical engineers and others skilled in the art of dynamo construction. Any increase in the electrical load necessarily increases the load on the engine, and therefore a greater number of heat units are developed within the working cylinder of the engine, during combustion, than when the engine is working on light loads. The temperature of the iron, therefore, will rise and, as previously stated, its magnetic reluctance will fall. On the other hand, the field-windings being located in close proximity to the cooling medium by a thin wall will be kept quite nearly at the temperature of the circulating liquid within the jackets *d*.

In carrying out my invention the pistons E of the movable elements in the cylinders may be composed of inductive material when it is desired to vary the electromotive force, of the machine, in quadrature during a revolution of the armature, so as to develop a periodic or pulsating electromotive force, which during a quarter-revolution of the armature will differ in phase by ninety degrees.

I construct the pistons E of inductive material, which during their movement in the magnetic field of force will vary the field-intensity of the latter as they move in and out, so as to include a greater or lesser number of magnetic lines of force.

Having fully described my invention, I claim as new and desire to secure by Letters Patent of the United States—

1. A thermic dynamo-electrical transformer, having structural parts of the thermodynamic translating mechanism disposed so as to constitute the magnetic inductive masses of both the fixed and movable members of the dynamo-electric translating means, and a heat-absorbing medium, interposed between the inductive mass constituting the fixed members and structural parts of the thermodynamic translating mechanism, adapted to carry off the surplus heat during the operation of the said transformer; substantially as described.

2. In a thermic dynamo-electrical transformer, wherein heat is first transformed into mechanical work and then transformed into electrical energy by dynamic induction, the combination of a thermodynamic transformer and a dynamo-electrical transformer having common structural material for the translating members of the thermodynamic transformer and inductive members of the dynamo-electrical transformer, and a heat-absorbing medium, interposed between the structural material constituting inductive members of the dynamo-electrical transformer and structural parts of the thermodynamic transformer, adapted to carry off the surplus heat during the operation of the said transformer; substantially as described.

3. A thermic dynamic dynamo-electrical machine having tubular field-magnets wherein working pistons are disposed, windings upon the said field-magnets and a heat-absorbing fluid interposed between the said windings and said pistons; substantially as described.

4. A dynamo-electrical generator having, as its field-magnets and pole-pieces, the working cylinders of an internal-combustion engine, and, as its armature, a fly-wheel of the said combustion-engine, and a heat-absorbing medium, interposed between the field-magnets of the dynamo and the cylinders of the combustion-engine, adapted to carry off the surplus heat; substantially as described.

5. A heat-engine having its cylinders electrically wound as field-magnets and its fly-wheel electrically wound as an armature, said electrically-wound fly-wheel disposed about the heads of the said electrically-wound cylinders so as to rotate about the same within inductive relation thereto, whereby the said field-magnets and the said armature will constitute the inductive members of a dynamo-electrical machine; substantially as described.

6. A multiple-cylinder explosive-engine having its cylinder-heads carry on their outer edges, the intake, the exhaust-valves and ignition-plugs, and its cooling-jackets electrically wound in the manner of, and so as to form, electromagnets and its fly-wheel disposed so as to encompass the said cylinder-heads said cylinder-heads magnetically disposed upon said electromagnets so as to form pole-pieces for the same; electrical windings upon the said fly-wheel so as to form an arma-

ture, whereby, upon the rotation of the latter, the same shall cut the magnetic lines of force of the field-magnets; substantially as described.

7. A combined dynamo-electrical and thermodynamic machine, the latter having a crank-box of iron, which constitutes the yoke for the field-magnets of the dynamo-electric member of said machine; substantially as described.

8. A combined dynamo-electrical and thermodynamic machine, having as a yoke for the field-magnets of the dynamo-electric member, an iron crank-box of the thermodynamic member, in which the said magnets are disposed radially to the said box; substantially as described.

9. A combined dynamo-electrical and thermodynamic machine, the latter having a crank-box, which constitutes a yoke for the field-magnets of the dynamo-electric member of said machine, and a fly-wheel electrically wound as an armature to coöperate inductively with said magnets; substantially as described.

10. In a thermodynamic dynamo-electrical machine, a multiple-cylinder explosive-engine, having, in combination, radial cylinders electrically wound as field-magnets, an axial crank-box constituting a yoke for said magnets, a piston in each of the cylinders, suitably connected to a crank on the engine-shaft, in said box, an intake-port, an exhaust-port, and an igniter for each of the cylinders, cylinder-heads forming the pole-pieces of said magnets, and a fly-wheel on said shaft, electrically wound as an armature to coöperate, inductively, with said magnets; substantially as described.

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

PHILIP K. STERN.

Witnesses:
MARIE BLUMER,
ABRAHAM I. SPIRO.