minor electromagnets of the stator, 120° apart, are energized during the hiatus. In the rotor the major electromagnets are energized during a hiatus step following two minor electromagnet energization steps. A total of 27 energizations are thus accomplished in the nine pairs of coils of the stator.

In Table I, the leftmost column depicts the location of each rotor arm **85, 86, 87** at an arbitrarily selected step No. **1** position. For example, in step **1** rotor arm **85** has a minor stator and minor rotor electromagnet in alignment for capacitors to discharge through them simultaneously at the 13⅓° position.

TABLE I

CAPACITOR DISCHARGE SEQUENCE FOR ONE REVOLUTION OF ROTOR IN SYSTEM OF FIGS. 5 AND 8

Step No. Rotor Arm 87	85	86	Rotor Angle	Rotor Electromagnet Minor	Major	Stator Electromagnet Minor	Major
10	1	19	13 1/3°	x		x	
11	2	20	26 2/3°		x		x
12	3	21	40°	x			x
13	4	22	53 1/3°	x		x	
14	5	23	66 2/3°		x		x
15	6	24	80°	x			x
16	7	25	93 1/3°	x		x	
17	8	26	106 2/3°		x		x
18	9	27	120°	x			x
19	10	1	133 1/3°	x		x	
20	11	2	146 2/3°		x		x
21	12	3	160°	x			x
22	13	4	173 1/3°	x		x	
23	14	5	186 2/3°		x		x
24	15	6	200°	x			x
25	16	7	213 1/3°	x		x	
26	17	8	226 2/3°		x		x
27	18	9	240°	x			x
1	19	10	253 1/3°	x		x	
2	20	11	266 2/3°		x		x
3	21	12	280°	x			x
4	22	13	293 1/3°	x		x	
5	23	14	306 2/3°		x		x
6	24	15	320°	x			x
7	25	16	333 1/3°	x		x	
8	26	17	346 2/3°		x		x
9	27	18	360°	x			x

Similarly, in step **1** rotor arm **86** is at the 133⅓° position with a minor rotor and minor stator electromagnet in alignment for discharge. Simultaneously, rotor arm **87** is at the 253⅓° position with a minor rotor and minor stator in alignment for capacitor discharge therethrough. The other steps of the sequence are apparent from Table I, for each position of the three rotor arms at any step and the juxtapositions of respective stator and rotor electromagnet elements at that position.

In the simplified motor arrangement shown in schematic form in FIG. **18**, with single electromagnet configuration the alignment is uniform and the discharge sequences follow sequentially.

As hereinbefore mentioned, a change in speed is effected by displacing the stator spark gap terminals on the rotor (shown at **236** in FIGS. **17** and **18**) either counter-clockwise or clockwise 6⅔° so that the discharge position of the stator electromagnets is displaced 6⅔° either clockwise or counter-clockwise of a rotor electromagnet at the time of discharge. Referring to FIGS. **11** to **15**, the simultaneous discharge of selected capacitors into the electromagnets so displaced results in a deceleration at the time the rotor electromagnet is just approaching the associated stator, or an acceleration if the rotor electromagnet is just leaving its associated stator electromagnet. In each event, there is a repulsive reaction between the stator and rotor electromagnets, so that if the rotor is approaching the stator, there is a slow-down and if the rotor is receding from the stator there is a speed-up.

Referring to FIG. **11**, clutch mechanism **304** about shaft **111** is operated electromagnetically in conventional manner to displace the spark-gap mechanism **236** which is operated normally in appropriate matching alignment with the rotor spark-gap discs **291, 292,** 293. Clutch **304** has a fixed drive element **311** containing an electromagnetic drive coil (not shown) and a motor element **310** which, when the electromagnetic drive coil is energized, can be operated by a direct current. The operation of motor element **310** brings into operation spark gap elements **224***r*, 223*r* or **223***f*, 224*f* of the system shown in FIGS. **4, 5** and **8**, as illustrated in FIG. **19.**

The fixed stator coil spark gap terminal pairs **223,** 224 and **266, 267** are arrayed about a cylindrical frame **322** which is fabricated in insulative material. In the illustrative example of FIGS. **17** and **18**, there are nine such spark gap terminal pairs about the periphery of cylinder frame **324.** In the engine of FIGS. **4** to **8**, a total of 27 such spark gap pairs are involved. In addition, although not shown in the drawing, there are also pairs of terminals, such as **223***r* or *f*, 224*r* or *f* and **266***r* or *f*, **267***r* or *f*, displaced 6⅔° on either side of the pairs **223, 224** or **266, 267** and all other pairs in the spark gap array, the letters *r* and *f* denoting "retard" and "faster." The latter displaced pairs of used in the control of speed of the engine rotor. The displaced pairs not shown are involved with the operation of cluth **304,** the speed changing control element.

Clutch **304** is associated with shaft **111** in that the movable element **310** draws clutch disc element **316** on shaft **111** away from clutch disc element **322** when energized by a voltage of appropriate polarity applied to its motor electromagnet **311.** Such clutch drives are well known in the art.

The clutch mechanism **304** of FIGS. **11** and **19,** when not energized is in the configuration shown in FIG. **11.** The energized configuration of clutch **304** is not specifically illustrated. Upon energization, spark-gap element **222** on disc **236** is displaced rightward, as viewed in FIG. **11,** by broken lines **236X,** into alignment with the positions of fixed spark-gap terminals **223***f*, 224*f* and **267***r*, 266*r*. When the disc is in position **236X**, the flattened edge **332** of pin **330** in disc **325** rides on surface **350** of disc **322.** Normally, the flattened edges **351** of pins **330** are engaged against the flat edge **352** in recess **331** of disc **322.** The displacement of disc **322** on shaft **111** is effected by the action of clutch **304** against spring **314** (FIG. **11**). An electric switch (not shown) of clutch mechanism **304** energizes it from a d-c power source, and has two positions, one for deceleration and one for acceleration. In either position, clutch **304** is engaged to pull clutch disc **322** from clutch disc **325,** momentarily. For the decelerate or the accelerate position, the displaced alignment of spark gap elements **222** is with the **224***f*, 223*f* and the **224***r*, 223*r* spark-gap terminal elements. However, only the **224***f*, 223*f* spark-gap elements are switched into operation with appropriate capacitors for the accelerate position, while in the decelerate position only the **223***r* and **224***r* spark-gap elements are switched into the circuit with their associated capacitors.

Of course, when insulative disc **236** is displaced by clutch **304,** its gap terminals **222, 225** and **228** (FIGS.

14 and 18) are all displaced into the alignment position of 236X so as to engage the *r* and *f* lines of fixed spark gap elements. Although the accelerate and decelerate positions of disc **236** are the same, it is the switching into operation of the **223, 224** or **266, 267** exemplary *r* or *f* pairs of terminals which determine whether speed up or slow down action of the rotor will occur.

The momentary displacement of clutch disc **322** from clutch disc **325** results in rotation of disc **325** about disc **322** through an angle of 120°. The detent ball and spring mechanism **320, 321** in disc **325** positions itself between one detent dimple **328** and a succeeding one **328** at a position 120° away on disc **325.** As stated, flat **332** of pin **330** rides on surface **350** of disc **322,** and pin **330** leaves the pin-holding groove **331**/352 along ramp **333** in disc **322** during the momentary lifting of disc **322** by clutch **304.** Pin **330** falls back into the next groove **331** at a point 120° further on about disc **322.** Pin **330** falls into place in groove **331** on ramp **334.** Pins **330** are rotatable in their sockets **353,** so that for either clockwise or counterclockwise rotation, the flat **351** will engage the flat **352** by the particular ramp it encounters.

The deceleration or acceleration due to the action of clutch **304** thus occurs within a 120° interval of rotation of disc **325.** Disc **322** during this interval may only move a fraction of this arc.

There has been described hereinabove an electromotive engine system wherein at least one electromagnet is in a fixed position and a second electromagnet of similar configuration is juxtaposed with it in a magnetic polarity relationship such that, when the cores of the electromagnets are energized, the juxtaposed core faces repel one another. One core being fixed and the second core being free to move, any attachments to the second electromagnet core will move with it. Hence, if a plurality of fixed cores are positioned about a circular confining housing, and, within the housing, cores on a shaft are free to move, the shaft is rotationally urged each time the juxtaposed fixed and rotatable cores are in alignment and energized. Both the fixed and the movable cores are connected to spark gap terminal elements, and the associated other terminal elements of the spark gaps are connected to capacitors which are changed to a high voltage from pulsed unipolar signal generators. These capacitors are discharged through the electromagnets across the spark gaps. By switching selected groups of capacitors into selected pairs of spark gap elements displaced from the normal uniformly positioned elements for discharge through the electromagnets, the rotor of the circular array systems is accelerated and decelerated.

By confining a fixed electromagnet array in a linear configuration with a linearly movable electromagnet to which a working tool is attached, exciting the juxtaposed pairs of electromagnets by capacitor discharge results in the generation of linear force for such tools as punch presses or for discharging projectiles with considerable energy.

The inventor claims:

1. An electric engine comprings:

a housing;

an array of electromagnets uniformly spaced in said housing to form a stator;

a rotor cage on a shaft journaled in and rotatable within said housing and within said stator, said rotor cage having thereon a spaced array of electromagnets similar to said stator electromagnets and in number comprising an integral fraction of the number of electromagnets in said stator array;

each of the electromagnets of said stator and of said rotor having a magnetizable core of particular configuration and each being wound with a coil such that a pulse of unidirectional electric current through said coil magnetizes the respective core thereof to a particular magnetic polarity, and the faces of rotor cores juxtaposing selected stator cores are magnetized to the same polarity, the juxtaposed cores thereby tending to repel one another, one lead of each of the stator and rotor coils being connected to a common terminal, the other lead of each of said coils being connected to a gap terminal, the gap terminals of said rotor coils being on the rotor and equal in number to the number of coils thereon and matching the positions of said rotor electromagnets thereon, the gap terminals of said stator being equal in number to the number of coils on the stator and disposed uniformly about said stator to match the positions of said stator electromagnets within said housing;

a first array of capacitors each having a terminal in common with the common coil terminal of said stator electromagnets, and each capacitor having its other terminal connected to a gap terminal arrayed adjacent the gap terminal of an electromagnet associated therewith;

a second array of capacitors, each having a terminal in common with said common terminal of said rotor electromagnet coils but equal in number to the number of capacitors in said stator array, the other terminals of said capacitors in said second array being connected to gap terminals arrayed about said housing so as to be in axial alignment with said stator gap terminal positions and being alignable with said rotor gap terminals as said rotor is rotated in said housing and respective gap terminals of said rotor coils pass each second array capacitor gap terminals at a predetermined gap distance;

gap coupling terminals on said rotor equal in number to the number of rotor electromagnet coils and positioned to match the rotor electromagnet positions on said rotor, the gap coupling terminals being rotatable with said rotor so as to pass said adjacent stator coil and associated stator capacitor gap terminal at a predetermined distance therefrom;

a plurality of capacitor charging circuits connected respectively across each of said capacitors in both said first and said second arrays of capacitors for charging each of said capacitors to a predetermined high d-c potential;

a first source of unidirectional electric potential connected to each of said capacitor charging circuits for energizing said charging circuits; and

a second unidirectional electric potential source connected to said electromagnets of said rotor and said stator of such polarity as to receive a charge from the inverse inductive discharge of the electromagnet coils as their fields collapse following the discharge of each capacitor through a rotor or stator electromagnet coil,

whereby whenever a rotor electromagnet is aligned opposite a stator electromagnet, the rotor coil gap terminal of that electromagnet is opposite an asso-

ciated second capacitor array gap terminal, and a gap coupling terminal of said rotor is aligned opposite the stator electromagnet coil gap terminal and associated first capacitor gap terminal, the capacitors discharge the charge thereon across the gaps through their associated electromagnet coils to magnetize their respective juxtaposed electromagnet cores to cause them to repel one another, thus aligning a succeeding pair of rotor and stator electromagnets for capacitor discharge across their respective gaps, to cause them to repel one another, alignments rotor rotation within the housing continuously bringing successive rotor-stator electromagnets into alignment for discharge of the capacitors therethrough to produce rotary motion of the rotor on said rotor shaft continuously so long as energy from said first source of unidirectional electric potential is applied to said charging circuits to recharge said capacitors after each discharge.

2. In an electric engine having a rotor comprising electromagnetic coil means rotatable within a stator comprising similar electromagnetic coil means, said electromagnetic coil means being polarized for magnetic repulsion;

capacitor means electrically coupled across successive spark gaps to selected ones of said coils of said stator and all of the coils of said rotor;

charging means connected to said capacitor means for charging said capacitor means to an electrical charge potential sufficient to cause arcing across said spark gaps to result in the discharge of said capacitor means through the electromagnetic coils so that the electromagnetic coil means repel one another; and

a unidirectional electric power source connected to said charging means to energize said charging means to continue charging said capacitor means following each discharge whereby the rotor of said engine is maintained in rotation by the successive discharges of said capacitor means across successive spark gaps into said electromagnetic coil means.

3. An electric engine according to claim **2,** wherein:

the charging means includes electronic square core oscillators connected to said unidirectional electric power source and includes step-up means and a rectifier to produce a substantial voltage step up from the voltage of said power source.

4. An electric engine according to claim **2,** wherein:

the charging means includes a vibrator connected to said power source, and step up transformer and rectifier means to provide a high voltage for charging said capacitor means.

5. A motive force producing means comprising:

at least a first electromagnet means including at least one coil wound about a core,

at least a second electromagnet means including at least one coil wound about a core similar to said first core,

the respective cores being positioned adjacent to one another so that the magnetic polarities of the adjacent core surfaces are the same when a unidirectional electric current is passed through the coils,

at least one capacitor means having one terminal thereof connected to one terminal of both of said electromagnet coils,

the other terminal of said capacitor means being connected to one terminal of a spark gap means, the other terminals of the coils of both said first and said second electromagnet means being connected to the other terminal of said spark gap means,

at least one unidirectional pulse charging means connected to said capacitor means to charge said capacitor means to a relatively high potential sufficient to arc across said spark gap means at predetermined spacing of said gap terminals, and

a source of unidirectional potential connected to said charging circuit to energize said charging means,

whereby upon application of current from said potential source to said charging means the successive pulses generated thereby charge said capacitor means to a voltage level sufficient to arc across said spark gap means to produce a discharge path for said capacitor means through said coils to cause said electromagnet means to repel one another with a substantial force.

6. A motive force producing means according to claim **5,** wherein:

said first electromagnet means is secured in a relatively stable housing, and said second electromagnet means is connected with and freely movable relative to said stable housing, and has utilization means connected thereto for performing work therewith when said capacitor means discharges through said coils of said electromagnet means.

7. A motive force producing means according to claim **6,** wherein said utilization means is a motor rotor coupled with said second electromagnet means and said first electromagnet means is a stator.

8. A motive force producing means according to claim **6,** wherein said utilization means is a piston attached to said second electromagnet means and is movable therewith to produce hammer-like blows when said capacitor means discharges through said electromagnet means.

9. In an electromotive force generating system as disclosed, means for accelerating or decelerating the motion of a force generating system, said means comprising:

at least two juxtaposed electromagnetic core elements, one fixed and one movable, including coils wound thereabout to provide a repulsion tendency when said cores are energized,

spark gap termimals connected with said coils,

capacitor means connected with said spark gap terminals to discharge across said spark gap terminals through said coils when a charge of sufficient voltage level appears across said capacitor means, thus to energize said juxtaposed electromagnets to induce said juxtaposed electromagnet cores to repel one another,

charging means connected to said capacitors for charging them to said sufficient voltage level, and

selective positioning means coupled with said spark gap terminals and with at least said movable electromagnet core to cause selective displacement of said movable core with respect to said fixed core to accelerate or decelerate the motion of the movable core relative to the fixed core.

10. An electromotive force generating system according to claim **9,** wherein:

said juxtaposed electromagnetic cores include a plurality of fixed cores and a smaller number of mov-

able cores, said smaller number being an integral fraction of the number of fixed cores, and

said selective positioning means is an electromagnetic clutch coupled with said smaller number of movable cores for movement therewith, and includes selective displacement means coupled with said spark gap terminals connected with selected capacitors in said capacitor means and selected combinations of coils in said plurality of fixed electromagnets.

11. The method of generating motive power comprising the steps of:

a. positioning similar electromagnets in juxtaposed relationship with their respective cores arranged for repulsion when said electromagnets are energized,

b. charging capacitors to a relatively high potential, and

c. discharging said capacitors simultaneously through said electromagnets across spark gaps set to break down at said relatively high potential,

thereby to cause said similar electromagnets to repel one another with considerable force.

12. The method of generating motive power defined in claim **11**, wherein in said positioning step at least one of said electromagnets is maintained in a fixed position and another electromagnet is free to move relative to said fixed electromagnet.

13. The method of generating motive power according to claim **11**, wherein:

the charging step includes the charging of capacitors to a relatively high potential from a pulsed unipolar source of electric energy.

14. In an electromagnetic capacitor discharge engine including movable electromagnets and fixed electromagnets, said movable electromagnets being movable into polar alignment with said fixed electromagnets, capacitor means, means for charging said capacitor means, and means for discharging said charged capacitor means through said fixed and movable electromagnets to polarize aligned fixed and polarized electromagnets for magnetic repulsion, an acceleration and deceleration control means comprising:

first selective means for momentarily delaying the discharge of the capacitors until the movable electromagnets in said engine have begun to recede from the fixed electromagnets, in order to accelerate the motion of said movable electromagnets by the added impetus of the repulsion, and

second selective means for momentarily accelerating the discharge of the capacitors to occur at a point in the motion of the movable electromagnets where said movable electromagnets are approaching said fixed electromagnets to decelerate the motion of said movable electromagnet by the tendency to repel the approaching electromagnet by the fixed electromagnet.

15. An electric engine, comprising:

fixed electromagnets;

movable electromagnets movable into alignment with said fixed electromagnets;

capacitor means;

means for charging said capacitor means; and

means for discharging said charged capacitor means through said fixed and movable electromagnets to polarize said aligned fixed and movable electromagnets for magnetic repulsion.

16. An electric engine as recited in claim **15**, wherein: said means for discharging said charged capacitor means comprises voltage breakdown switch means.

17. An electric engine as recited in claim **16**, wherein:

said voltage breakdown switch means includes at least one terminal movable with at least one of said movable electromagnets for breaking down when said at least one of said movable electromagnets is in alignment with a said fixed electromagnet.

18. An electric engine as recited in claim **17**, wherein:

said voltage breakdown switch means comprises a spark gap means.

* * * * *

FIG. 1.

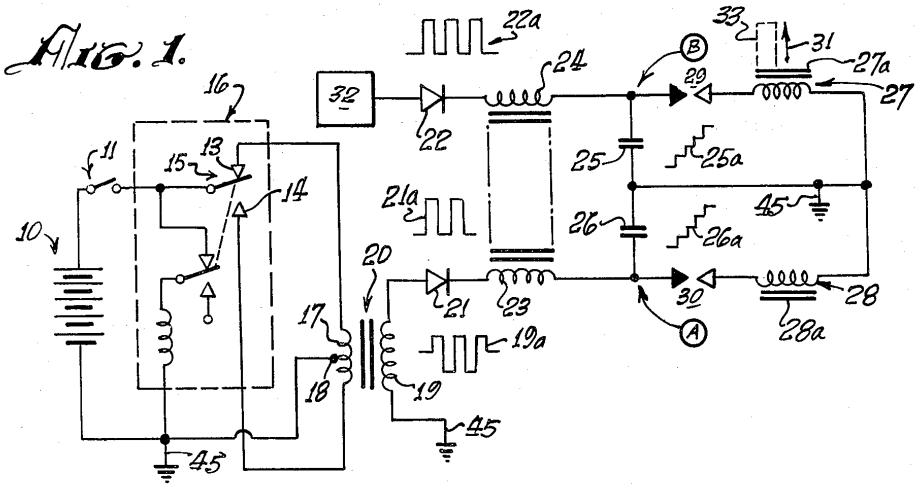
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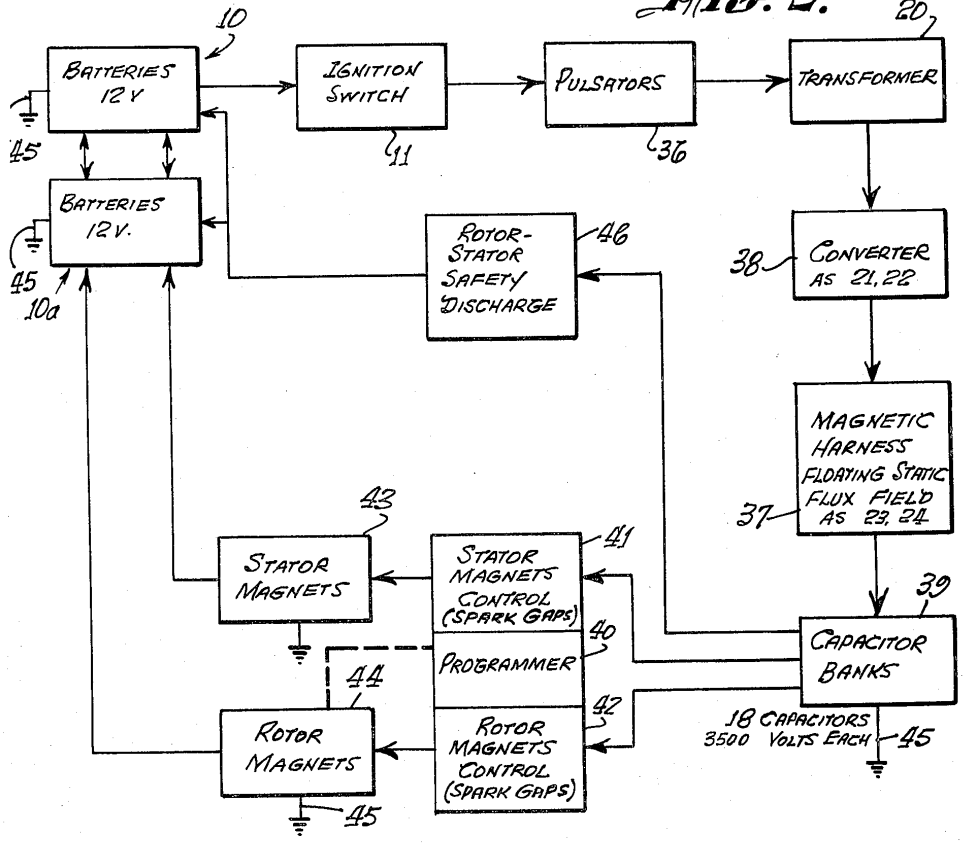
FIG. 2.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IGNITION SWITCH
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PULSATORS
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TRANSFORMER
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ROTOR-STATOR SAFETY DISCHARGE
46
38
CONVERTER AS 21, 22
MAGNETIC HARNESS FLOATING STATIC FLUX FIELD AS 23, 24
37
43
STATOR MAGNETS
STATOR MAGNETS CONTROL (SPARK GAPS)
41
39
CAPACITOR BANKS
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PROGRAMMER
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ROTOR MAGNETS
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ROTOR MAGNETS CONTROL (SPARK GAPS)
18 CAPACITORS 3500 VOLTS EACH
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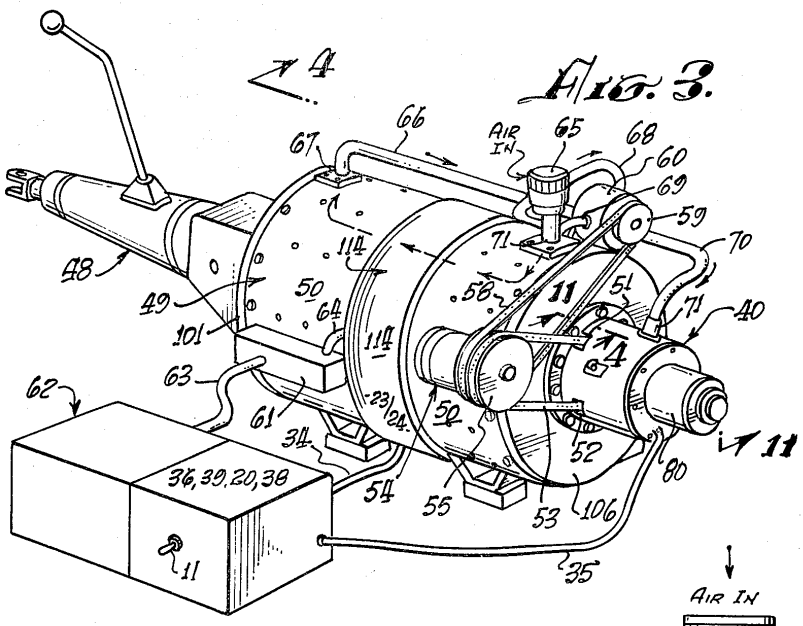
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Fig. 3.

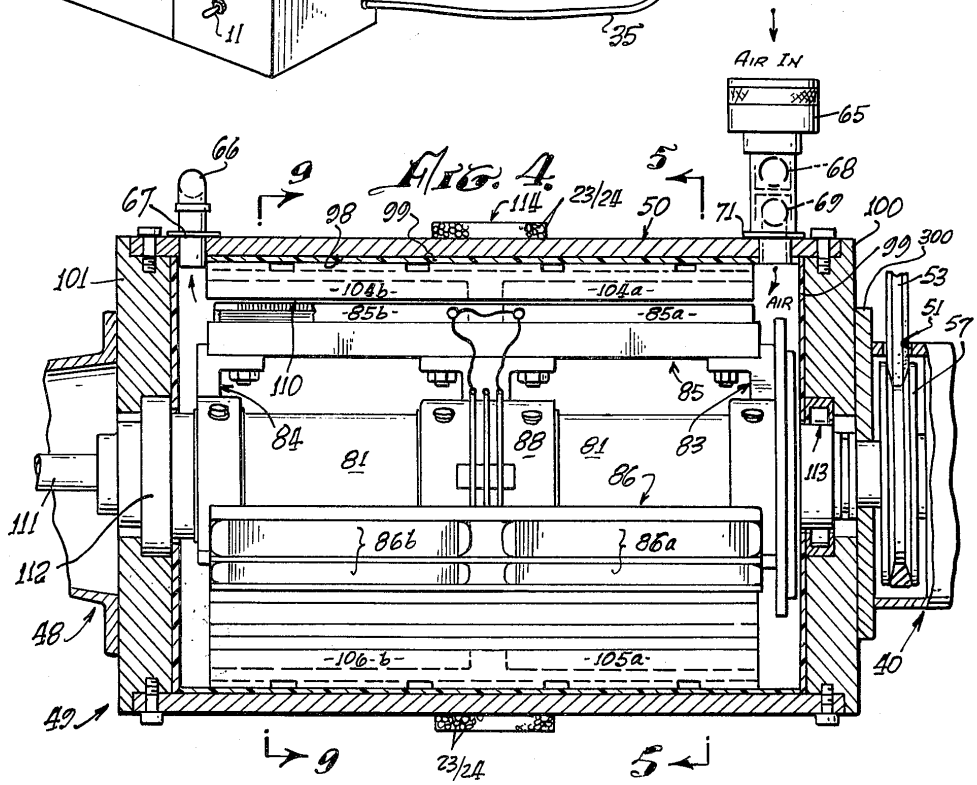
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Fig. 4.

Fig. 5.

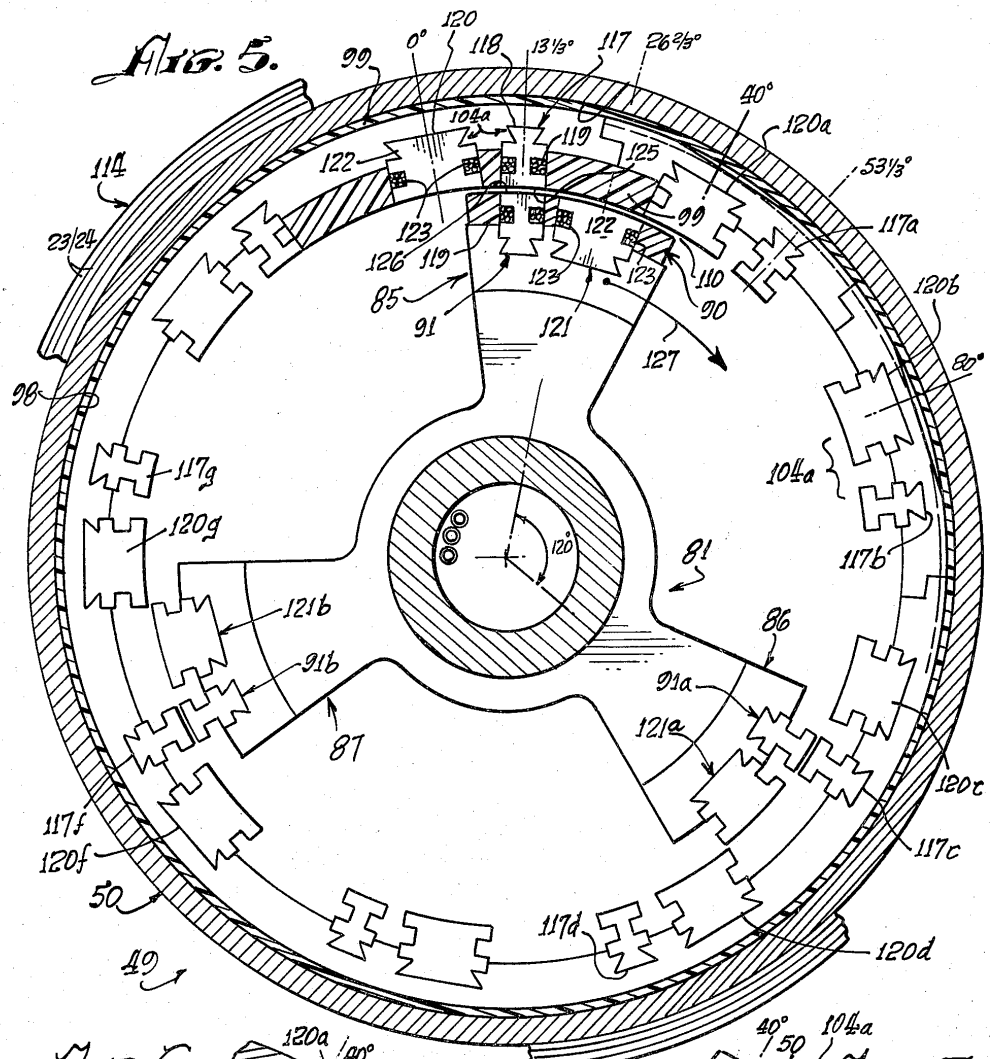


Fig. 6.

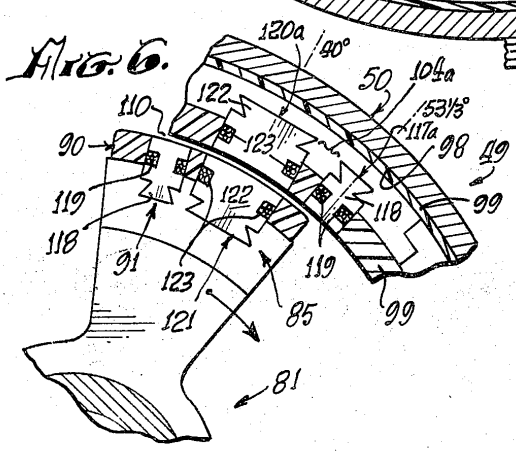


Fig. 7.

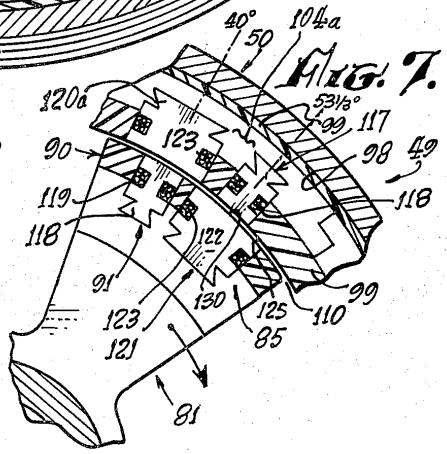


FIG. 8.

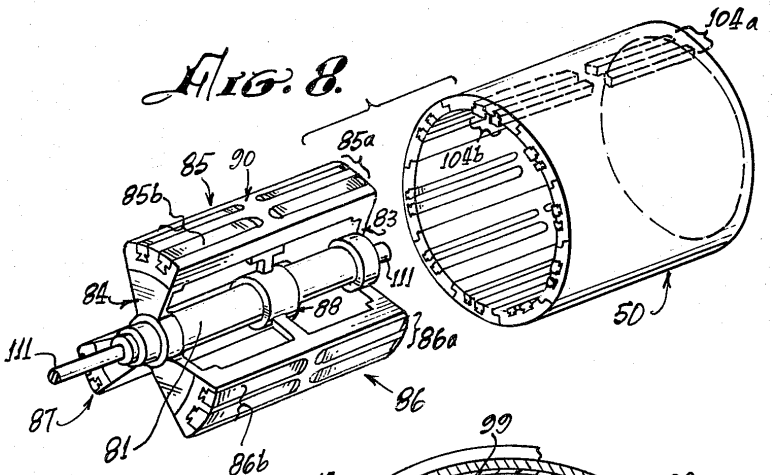
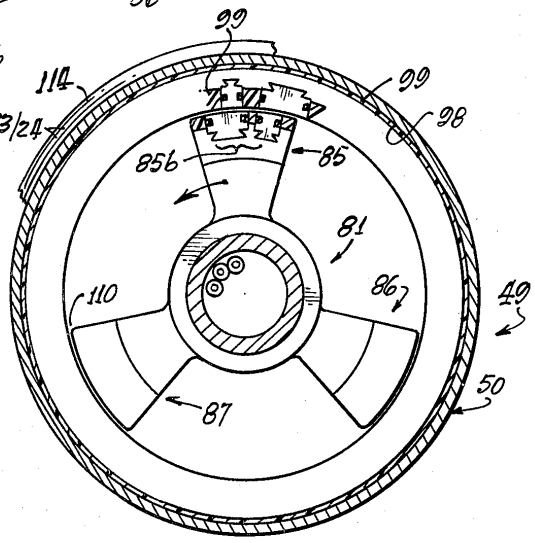


FIG. 9.



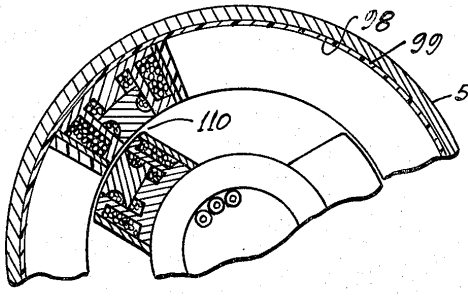
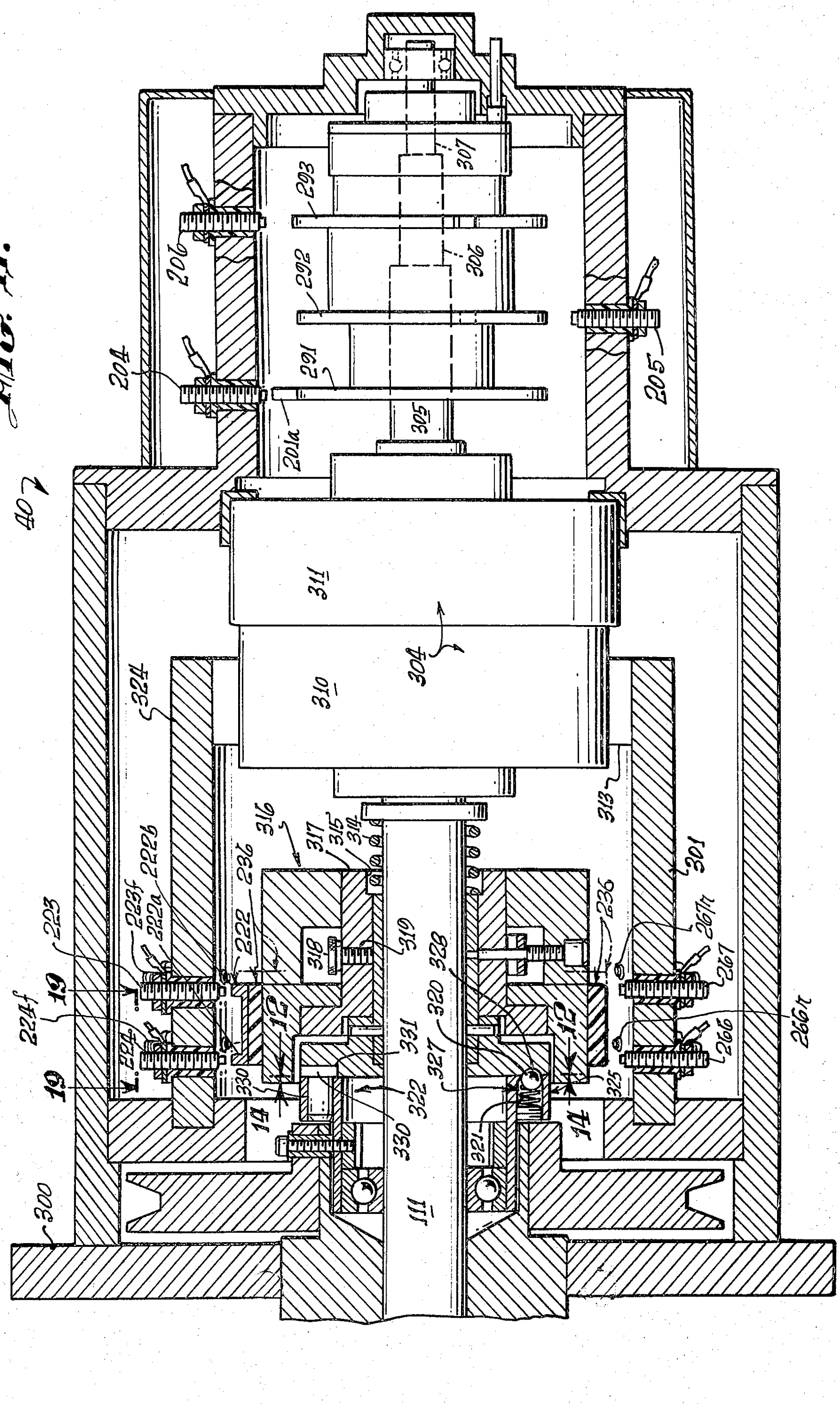


FIG. 10.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331
327
322
330
321
325
236
222
222a
222b
223
223f
224
224f
266
266r
267
267r
19
14
12
111
300

FIG. 11.

Fig. 12.

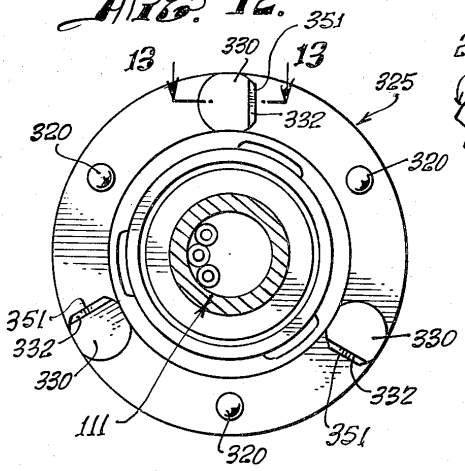


Fig. 14.

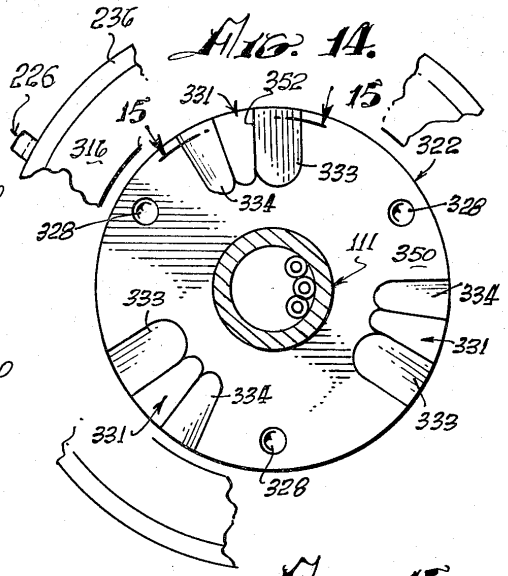


Fig. 13.

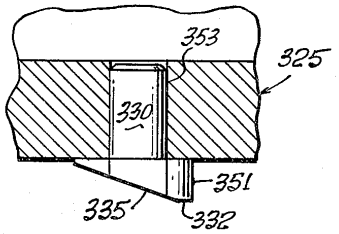


Fig. 15.

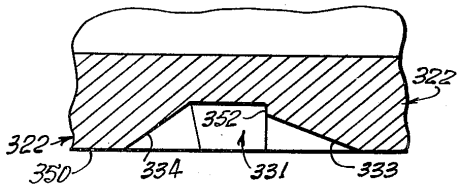


Fig. 16.

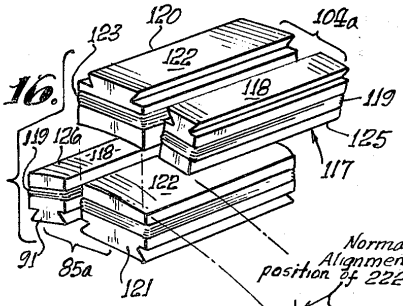
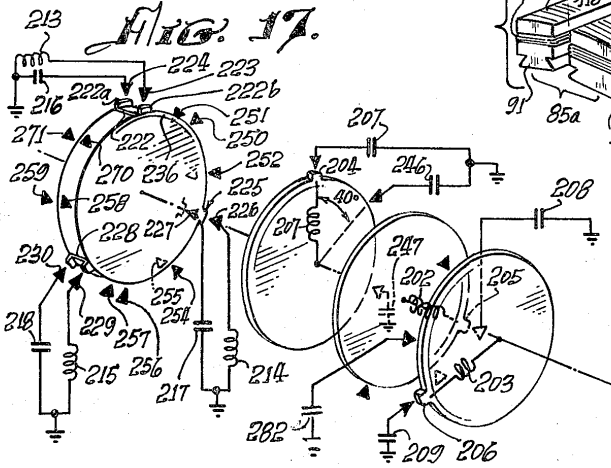
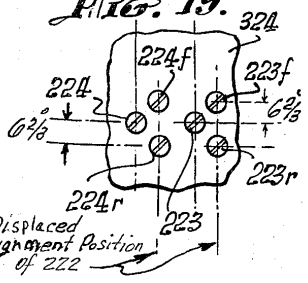


Fig. 17.



Normal Alignment position of 222

Fig. 19.



Displaced Alignment Position of 222

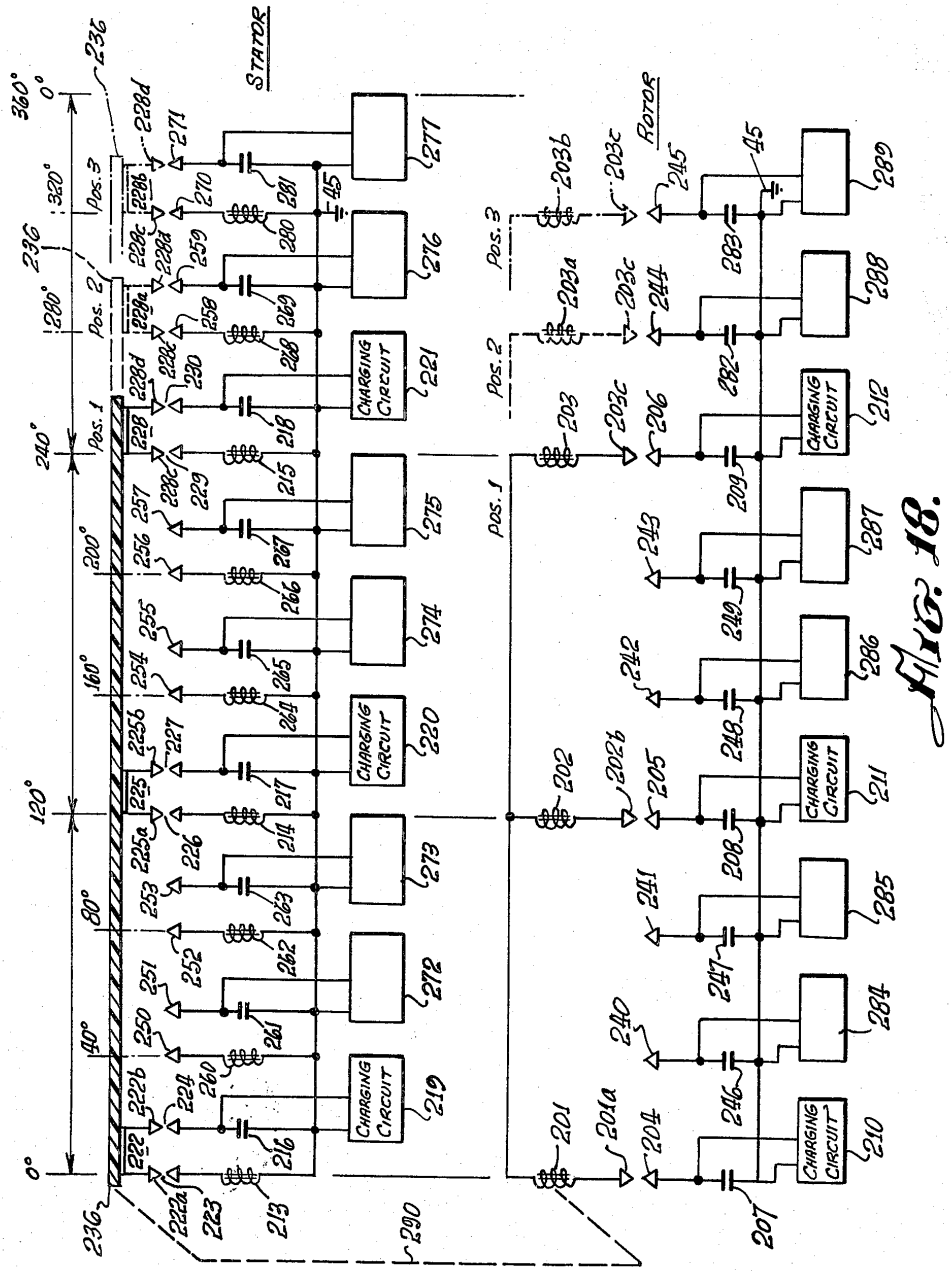

STATOR
ROTOR
Pos. 1
Pos. 2
Pos. 3
CHARGING CIRCUIT
0°
40°
80°
120°
160°
200°
240°
280°
320°
360°

Fig. 18.

United States Patent [19]

Gray

[11] **3,890,548**

[45] **June 17, 1975**

[54] **PULSED CAPACITOR DISCHARGE ELECTRIC ENGINE**

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[73] Assignee: **Evgray Enterprises, Inc.,** Van Nuys, Calif.

[22] Filed: **Nov. 2, 1973**

[21] Appl. No.: **412,415**

[52] **U.S. Cl.** **318/139;** 318/254; 318/439; 310/46

[51] **Int. Cl.** **H02p 5/00**

[58] **Field of Search** 310/46, 5, 6; 318/194, 318/439, 254, 139; 320/1; 307/110

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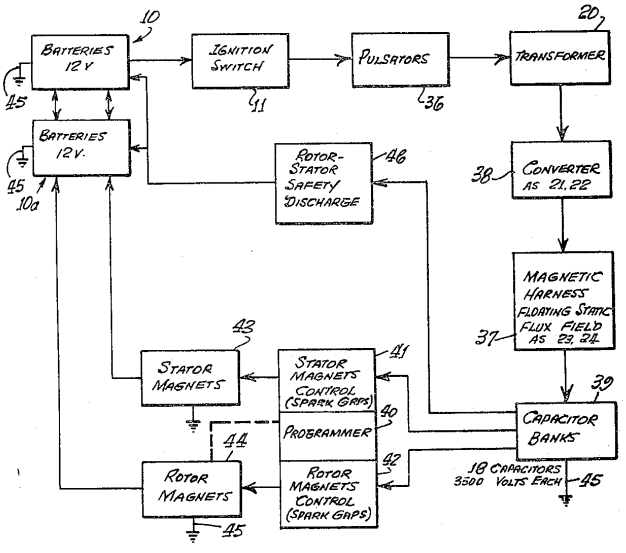
Primary Examiner—Robert K. Schaefer
Assistant Examiner—John J. Feldhaus
Attorney, Agent, or Firm—Gerald L. Price

[57] **ABSTRACT**

There is disclosed herein an electric machine or engine in which a rotor cage having an array of electromagnets is rotatable in an array of electromagnets, or fixed electromagnets are juxtaposed against movable ones. The coils of the electromagnets are connected in the discharge path of capacitors charged to relatively high voltage and discharged through the electromagnetic coils when selected rotor and stator elements are in alignment, or when the fixed electromagnets and movable electromagnets are juxtaposed. The discharge occurs across spark gaps disclosed in alignment with respect to the desired juxtaposition of the selected movable and stationary electromagnets. The capacitor discharges occur simultaneously through juxtaposed stationary movable electromagnets wound so that their respective cores are in magnetic repulsion polarity, thus resulting in the forced motion of movable electromagnetic elements away from the juxtaposed stationary electromagnetic elements at the discharge, thereby achieving motion. In an engine, the discharges occur successively across selected ones of the gaps to maintain continuous rotation. Capacitors are recharged between successive alignment positions of particular rotor and stator electromagnets of the engine.

18 Claims, 19 Drawing Figures



PULSED CAPACITOR DISCHARGE ELECTRIC ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

There is no known engine or motor operated on the principle of the present invention, that a capacitor charged to a relatively high voltage from a low-voltage d-c source is discharged across a spark gap to provide current through motor drive coils in the discharge path, these being solenoids which generate motion by magnetic repulsion of juxtaposed pairs of cores. The solenoids are preferably configured in motor and stator assemblies to effect motion of the rotor element with respect to the stator.

The present invention utilizes this principle to provide a rotary motion machine or engine which can develop considerable torque through the magnetic repulsion action of rotor and stator cores wound with coils through which capacitors are discharged synchronously with the positioning of the rotor coils opposite particular stator coils. Similarly, a linear action can be achieved with a stationary electromagnet juxtaposed against a movable electromagnet and the movable electromagnet can perform work with a tool or piston attached thereto.

A novel control mechanism is associated with the rotor is the engine to position discharge elements appropriately to create the desired discharge through the electromagnet coils when the juxtaposed rotor and stator electromagnets are in alignment. The electromagnets in the stator and rotor are so arranged that the control mechanism can advance or retard the discharge points relative to rotor-stator positions for control of rotational speed.

The discharge overshoot or back e.m.f. from the collapsing fields in the coils from the capacitor discharge is used to energize external batteries for conservation of power. The recovered energy thus stored may be used to operate equipment associated with the engine or motive force producing device.

The engine or rotary electric machine of the invention is believed to operate on the principle of conservation of energy, in that once rotation is achieved, current is needed only at the instant of a capacitor discharge in order to advance the rotor. The rotor moves to the next discharge point on the inertia of the repulsion action. The capacitor is recharged during the interval and stores the energy until discharge at the next rotor-stator coil coincidence. Thus, the new engine produces torque and stores the excess energy for subsequent use.

In a linear motion device according to the invention, only a single pulse discharge is needed to perform work.

The applications of the engine include use as an electric automotive engine which is economical and which can regenerate a part of the energy consumed to provide power for other loads in the automotive electric vehicle. As a linear actuator an economical use of power is possible because each stroke will result from a single discharge pulse of a capacitor through a coil.

2. Prior Art

Heretofore, electric engines or motors have operated on the principle that a conductor carrying a current in a magnetic field tends to move perpendicularly to that field; the electromagnetic torque developed by an armature or rotating portion of the motor is proportional to the magnetic flux in the stationary field and to the armature current.

In direct current motors the field is created by current through two or more field coils disposed in opposing magnetic relationship in the motor casing, while current through a rotatable armature positioned in the field is alternatingly reversed in polarity to provide continuous motion. The polarity reversing mechanism is a commutator. Some d-c motors have their field windings electrically in parallel with the rotor armature winding and are called "shunt-wound" motors. Other d-c motors have field and armature windings connected in series. In both series and shunt motors commutators are used for reversing the magnetic polarity of the armature to maintain rotation within the field.

A third type of d-c motor utilizes a permanent magnet field so that the operating current passes only through the armature winding. Such motors also use polarity reversing commutators to maintain direction of rotation. Reversal of direction of motion is effected by reversing the polarity of applied d-c potential.

Control of speed of d-c motors is accomplished basically by decrease or increase of magnetic field flux or the current through the armature. Either or both of these effects can be accomplished by raising or lowering the applied potential. In shunt motors, a series resistance may be varied to produce speed changes. In a permanent magnet motor or series motor, speed variation is best accomplished by voltage variation with a variable resistance in series with the motor d-c supply.

In alternating current motors, as is well known, a rotating magnetic field is created in the stator, and the rotor may be wound with as many poles as there are in the stator, with terminals connected with slip rings, or the rotor may consist of solid bars shorted by rings on each end to form a "squirrel cage" configuration. The speed of an a-c motor depends on the frequency of the applied a-c energy, if the motor is synchronous.

"Universal" motors are operable on either a-c or d-c energy.

In stepping motors, a rotor is moved from one pole to the next adjacent pole with each application of current, the rotor remaining at that position until a next application of current. This is accomplished by switching the current on and off or by pulsing the current. Examples of stepping motors are described in U.S. Pat. No. 3,467,902 to Shimizu, et al., U.S. Pat. No. 3,462,667 to Jackson, and U.S. Pat. No. 3,599,069 to Welch.

Operation of the a-c and d-c motors described above involves the consumption of substantial electric current. These motors can generate electric current when driven externally by a mechanical force. External energy to rotate the generator rotors can be provided by hydroelectric and steam sources or by other electric motors. In some of these systems, a d-c motor source drives an a-c generator for conversion of d-c energy to a-c energy or a d-c motor may drive a d-c generator which delivers a higher voltage than the source.

An extensive prior art search by the applicant uncovered no capacitor-discharge-operated motor resembling that of the present invention. All motors of the patents located in the search employed direct electrical connection between coils and electric power sources. Where selective switching is involved, semiconductor devices are employed, such as silicon-controlled rectifi-

ers. Capacitors are used only for starting and phasing purposes, and not for basic motor operation from the discharge thereof, as in this invention.

SUMMARY OF THE INVENTION

This invention relates to electric motors or engines, and more particularly to a new electric machine including electromagnetic poles in a stator configuration and electromagnetic poles in a rotor configuration wherein in one form thereof the rotor is rotatable within the stator configuration and where both are energized by capacitor discharges through rotor and stator electromagnets at the instant of the alignment of a rotor electromagnet with a stator electromagnet. The rotor electromagnet is repelled from the stator electromagnet by the discharge of the capacitor through the coils of both the stator and rotor electromagnets at the same instant.

In an exemplary rotary engine according to this invention, rotor electromagnets may be disposed 120° apart on a central shaft and major stator electromagnets may be disposed 40° apart in the motor housing about the stator periphery. Other combinations of rotor elements and stator elements may be utilized to increase torque or rotation rate.

In another form, a second electromagnet is positioned to one side of each of the major stator electromagnets on a center line 13⅓° from the center line of the stator magnet, and these are excited in a predetermined pattern or sequence. Similarly to one side of each major rotor electromagnet is a second electromagnet spaced on a 13⅓° center line from the major rotor electromagnet. Electromagnets in both the rotor and stator assemblies are identical, the individual electromagnets of each being aligned axially and the coils of each being wired so that each rotor electromagnetic pole will have the same magnetic polarity as the electromagnet in the stator with which it is aligned and which it is confronting at the time of discharge of the capacitor.

Charging of the discharge capacitor or capacitors is accomplished by an electrical switching circuit wherein electrical energy from a battery or other source of d-c potential may be applied in alternating polarity to ignition coils or other voltage step-up arrangements from which a high voltage d-c potential is derived through rectification by diodes.

The capacitor charging circuit comprises a pair of high frequency switchers which feed respective automotive-type ignition coils employed as step-up transformers. The "secondary" of each of the ignition coils provides a high voltage square wave to a half-wave rectifier to generate a high voltage output pulse of d-c energy with each switching alternation of the high frequency switcher. Only one polarity is used so that a unidirectional pulse is applied to the capacitor bank being charged.

Successive unidirectional pulses are accumulated on the capacitor or capacitor bank until discharged. Discharge of the bank of capacitors occurs across a spark gap by arc-over. The gap spacing determines the voltage at which discharge or arc-over occurs. An array of gaps is created by fixed elements in the engine housing and moving elements positioned on the rotor shaft. At the instant when the moving gap elements are positioned opposite fixed elements during the rotor rotation, a discharge occurs through the coils of the aligned rotor and stator electromagnets to produce the repulsion action between the stator and rotor electromagnet cores.

A plurality of fixed gap elements are arrayed in the motor housing to correspond to the locations of the stator electromagnets in the housing. The rotor gap elements correspond to the positions of the rotor electromagnets on the rotor so that at the instant of correct alignment of the gaps the capacitors are discharged to produce the necessary current through the stator and rotor coils to cause the electromagnets to repel one another.

The charging circuits are arranged in pairs, and are such that the discharge occurs through both rotor and stator windings of the electromagnets, which are opposite one another when the spark gap elements are aligned and arc-over.

The speed of the rotor can be changed by means of a clutch mechanism associated with the rotor. The clutch shifts the positions of the rotor gap elements so that the discharge will energize the stator coils in a manner to advance or retard the time of discharge with respect to the normal rotor/stator alignment positions. The discharge through the rotor and stator then occurs when the rotor has passed the stator 6⅔° for speed advance.

By causing the discharge to occur when the rotor position is approaching the stator, the repulsion pulse occurs 6⅔° before the alignment position of the rotor and stator electromagnets, thus slowing the speed.

The clutch mechanism for aligning capacitor discharge gaps for discharge is described as a control head. It may be likened to a firing control mechanism in an automotive combustion engine in that it "fires" the electromagnets and provides a return of any discharge overshoot potential back to the battery or other energy source.

The action of the control head is extremely fast. From the foregoing description, it can be anticipated that an increase in the speed or a decrease in speed of rotation can occur within the period in which the rotor electromagnet moves between any pair of adjacently located electromagnets in the stator assembly, which are 40° apart in the exemplary engine according to the invention. Thus, speed changes can be effected in a maximum of one-ninth of a revolution.

The rotor speed-changing action of the control head and its structure are believed to be further novel features of the invention, in that they maintain normal 120° firing positions during uniform speed or rotation conditions, but shift to ±6⅔° longer or shorter intervals for speed change by the novel shift mechanism in the rotor clutch assembly.

Accordingly, the preferred embodiment of this invention is an electric rotary engine wherein motor torque is developed by discharge of high potential from a bank of capacitors through stator and rotor electromagnet coils when the electromagnets are in alignment. The capacitors are charged from batteries by a switching mechanism, and are discharged across spark gaps set to achieve the discharge of the capacitor charge voltage through the electromagnetic coils when the gaps and predetermined rotor and stator electromagnet pairs are in alignment.

Exemplary embodiments of the invention are herein illustrated and described. These exemplary illustrations and description should not be construed as limiting the invention to the embodiments shown, because those

skilled in the arts appertaining to the invention may conceive of other embodiments in the light of the description within the ambit of the appended claims.

BREIF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an explanatory schematic diagram of a capacitor charging and discharging circuit utilized in the present invention;

FIG. 2 is a block diagram of an exemplary engine system according to the invention;

FIG. 3 is a perspective view of a typical engine system according to the invention, coupled to an automotive transmission;

FIG. 4 is an axial sectional view taken at line 4—4 in FIG. 3;

FIG. 5 is a sectional view taken at line 5—5 in FIG. 4;

FIGS. 6 and 7 are fragmentary sectional views, corresponding to a portion of FIG. 5, illustrating successive advanced positions of the engine rotor therein;

FIG. 8 is an exploded perspective view of the rotor and stator of the engine of FIGS. 3 and 4;

FIG. 9 is a cross-sectional view taken at line 9—9 of FIG. 4;

FIG. 10 is a partial sectional view, similar to the view of FIG. 9, illustrating a different configuration of electromagnets in another engine embodiment of the invention;

FIG. 11 is a sectional view taken at line 11—11 in FIG. 3, illustrating the control head or novel speed change controlling system of the engine;

FIG. 12 is a sectional view, taken at line 12—12 in FIG. 11, showing a clutch plate utilized in the speed change control system of FIG. 11;

FIG. 13 is a fragmentary view, taken at line 13—13 in FIG. 12;

FIG. 14 is a sectional view, taken at line 14—14 in FIG. 11, showing a clutch plate which cooperates with the clutch plate of FIG. 12;

FIG. 15 is a fragmentary sectional view taken at line 15—15 of FIG. 13;

FIG. 16 is a perspective view of electromagnets utilized in the present invention;

FIG. 17 is a schematic diagram showing cooperating mechanical and electrical features of the programmer portion of the invention;

FIG. 18 is an electrical schematic diagram of an engine according to the invention, showing the electrical relationships of the electromagnetic components embodying a new principle of the invention; and

FIG. 19 is a developed view, taken at line 19—19 of FIG. 11, showing the locations of displaced spark gap elements of the speed changing mechanism of an engine according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As hereinbefore mentioned, the basic principle of operation of the engine of the invention is the discharge of a capacitor, across a spark gap through an inductor. When a pair of inductors is used, and the respective magnetic cores thereof are arranged opposite and another in magnetic polarity repulsion relation, the discharge through them causes the cores to repel each other with considerable force.

Referring to the electrical schematic diagram of FIG. 1, a battery 10 energizes a pulse-producing vibrator mechanism 16, which may be of the magnetic type incorporating an armature 15 moving between contacts 13 and 14, or of the transistor type (not shown) with which a high frequency bipolar pulsed output is produced in primary 17 of transformer 20. The pulse amplitude is stepped-up in secondary 19 of transformer 20. Wave form 19*a* represents the bidirectional or bipolar pulsed output. A diode rectifier 21 produces a unidirectional pulse train, as indicated at 21*a*, to charge capacitor 26. A delay coil 23 is connected in series with the unipolar pulsed output to capacitor 26. Successive unidirectional pulses of wave 21*a* charge capacitor 26 to a high level, as indicated at 26*a*, until the voltage amplitude at point A reaches the breakdown potential of spark gap 30. At the breakdown of spark gap 30, capacitor 26 discharges across the arc created through the inductor coil 28. A current pulse is produced which magnetizes core 28*a*. Simultaneously, another substantially identical charging system 32 produces a discharge through inductor 27 across spark gap 29 to magnetize core 27*a*. Cores 28*a*, 27*a* are wound with coils 28, 27 so that their magnetic polarities are the same. As the cores 27*a*, 28*a* confront one another, they tend to fly apart when the discharge occurs through coils 27 and 28 because of repulsion of identical magnetic poles, as indicated by arrow 31. If core 28*a* is fixed or stationary and core 27*a* is movable, then core 27*a* may have tools 33 attached to it to perform work when the capacitor discharges.

Referring to FIGS. 1 and 2, a d-c electrical source or battery 10 energizes pulsators 36 (including at least two vibrators 16 as previously described) when switch 11 between the battery 10 and pulsator 36 is closed, to apply relatively high frequency pulses to the primaries of transformers 20. The secondaries of transformers 20 are step-up windings which apply bipolar pulses, such as pulses 19*a* (FIG. 1) to the diodes in converter 38. The rectified unidirectional pulsating output of each of the diodes in converter 38 is passed through delay coils 23, 24, thus forming a harness 37 wound about the case of the engine, as hereinafter described, which is believed to provide a static floating flux field. The outputs from delay lines 37 drive respective capacitors in banks 39 to charge the capacitors therein to a relatively high charge potential. A programmer and rotor and stator magnet control array 40, 41, 42 is formed by spark gaps positioned, as hereinafter described, so that at predetermined positions of the rotor during rotation of the engine, as hereinafter described, selected capacitors of capacitor banks 39 will discharge across the spark gaps through the rotor and stator electromagnets 43, 44. The converters 38, magnetic harness 37, capacitor banks 39, programmer 40, and controls 41, 42 from a series circuit path across the secondaries of transformers 20 to the ground, or point of reference potential, 45. The capacitor banks 39 are discharged across the spark gaps of programmer 40 (the rotor and stator magnet controls 41, 42). The discharge occurs through the coils of stator and rotor electromagnets 43, 44 to ground 45. Stator and rotor electromagnets are similar to those shown at 27, 27*a*, 28, 28*a* in FIG. 1.

The discharge through the coils of stator and rotor electromagnets 43, 44 is accompanied by a discharge overshoot or return pulse, the output of which is applied in an appropriate polarity to a secondary battery 10*a* to store this excess energy. The overshoot pulse returns to battery 10*a* because after discharge the only

path open is that to battery **10***a*, since the gaps in **40,** 41 and **42** have broken down, because the capacitors in banks **39** are discharged and have not yet recovered the high voltage charge from the high frequency pulsers **36** and converter rectifier units **38.**

In the event of a misfire in the programmer control circuits **40, 41, 42,** the capacitors are discharged through a rotor safety discharge circuit **46** and returned to batteries **10–10***a*, adding to their capacity. The circuit **46** is connected between the capacitor banks **39** and batteries **10, 10***a*.

Referring to FIG. **3,** a motor or engine **49** according to the present invention is shown connected with an automotive transmission **48.** The transmission **48** represents one of many forms of loads to which the engine may be applied. A motor housing **50** encases the operating mechanism hereinafter described. The programmer **40** is axially mounted at one end of this housing. Through apertures **51, 52** a belt **53** couples to a pulley **57** (not shown in this view) and to an alternator **54** attached to housing **50.** A pulley **55** on the alternator has two grooves, one for belt **53** to the drive pulley **58** on the shaft (not shown) of the engine **49,** and the other for a belt **58** coupled to a pulley **59** on a pump **60** attached to housing **50.** A terminal box **61** on the housing interconnects means between the battery assembly **62** and motor **49** via cables **63** and **64.**

An intake **65** for air is coupled to pump **60** via piping **68, 69** and from pump **60** via tubing or piping **66, 70** to the interior of housing **50** via coupling flanges **67** and **71.** The air flow tends to cool the engine, and the air may preferably be maintained at a constant temperature and humidity so that a constant spark gap discharge condition is maintained. A clutch mechanism **80** is provided on programmer **40.**

Referring to FIGS. **4, 5** and **9,** rotor **81** has spider assemblies **83, 84** with three electromagnet coil assembly sets mounted thereon, two of which are shown in FIG. **4,** on **85** at **85***a* and **85***b*, and on **86** at **86***a* and **86***b*. One of the third electromagnet coil assemblies, designated **87***a*, is shown in FIG. **5,** viewed from the shaft end. As more clearly shown in the perspective view of FIG. **8,** a third spider assembly **88** provides added rigidity and a central support for the rotor mechanism on shaft **81.**

The electromagnet sets **85***a* and **85***b*, 86*a* and **86***b*, **87***a* and **87***b*, disposed on rotor **81** and spiders **83, 84,** and **88** each comprise pairs of front units **85***a*, 86*a*, 87*a* and pairs of rear units **85***b*, 86*b*, 87*b*. Each pair consists of a major electromagnet and a minor electromagnet, as hereinafter described, which are embedded in an insulating material **90,** which insulates the electromagnet coil assemblies from one another and secures the electromagnets rigidly in place on the spider/rotor cage **81,** 83, 84, 88.

The interior wall **98** of housing **50** is coated with an electrically insulating material **99** in which are embedded electromagnet coils, as hereinafter described, and the interiors of end plates **100, 101** of the housing **50.** On the insulating surface **98** of housing **50** is mounted a series of stator electromagnet pairs **104***a*, identical with electromagnet pairs **85***a*, 86*a*, 87*a*, etc. Electromagnet pairs such as **104***a* or **105***a* are disposed every 40° about the interior of housing **50** to form a stator which cooperates with the rotor **81–88.** An air gap **110** of very close tolerance is defined between the rotor and stator electromagnets, and air from pump **65** flows through this gap.

As shown in FIG. **8,** the electromagnet assemblies, such as **85** through **87,** of the rotor and magnet assemblies, such as **104***a* in the stator are so embedded in their respective insulative plastic carriers (rotor and stator) that they are smoothly rounded in a concave contour for the stator, and in a convex contour on the rotor to permit smooth and continuous rotation of rotor **81** in stator housing **50.** The air gap **110** is uniform at all positions of any rotor element within the stator assembly, as is clearly shown in FIG. **16.**

The rotor **81** and spiders **83, 84, 88** are rigidly mounted on a shaft **111** journaled in bearing assemblies **112, 113** which are of conventional type, for easy rotation of the rotor on shaft **111** within housing **50.**

Around the central outer surface of housing **50** are wound a number of turns of wire **23, 24** to provide a static flux coil **114** as hereinbefore described, which is a delay line, as previously described.

FIGS. **5, 6, 7** and **9** are cross-sectional views of the rotor assembly **81–88,** arranged to show the positioning and alignment of the rotor and stator electromagnet coil assemblies at successive stages of the rotation of rotor **81–88** through a portion of a cycle of operation thereof. For example, in FIG. **5** the rotor assembly **81–88** is shown so positioned that a minor rotor electromagnet assembly **91** is aligned with a minor stator electromagnet assembly **117.**

As shown in further detail in FIG. **16,** minor electromagnet assembly **117** consists of an iron core **118,** grooved so that there may be wound thereabout a coil of wire **119.** Core **118** is the same in stator electromagnet **117** as it is in rotor electromagnet **91.**

As a position 13⅓° to the right of rotor electromagnet **91,** as viewed in FIGS. **5** and **16,** there is a second or major rotor electromagnet **121** which has a winding **123** about its core **122.** The electromagnets **91, 121** are the pair **85***a* of FIGS. **4** and **8.**

At a position 13⅓° to the left of stator electromagnet **117,** as viewed in FIG. **5,** there is a second or major stator electromagnet **120** whose core **122** is of the same configuration as core **122** of rotor electromagnet **121.** A winding **123** about core **122** of electromagnet **120** is of the same character as winding **123** on electromagnet **121.**

Electromagnet assembly pair **85***a* on the rotor is identical in configuration with that of the electromagnet stator assembly pair **104***a* except for the position reversal of the elements **117–120** and **91–121** of the respective pairs.

There are nine pairs of electromagnets **120–117** (**104***a*) disposed at 40° intervals about the interior of housing **50.** The center line of core **122** of electromagnet **120** is positioned 13⅓° to the left of the center line of the core **118** of electromagnet **117.** Three pairs of electromagnets **85***a*, 86*a*, 87*a* are provided on rotor assembly **81–88** as shown in FIG. **5.**

Other combinations are possible, but the number of electromagnets in the rotor should always be an integral fraction of the number of electromagnets in the stator. As shown in FIG. **8,** for the rotor assembly **85***a*, 85*b*, there are three of each of the front and back pairs of electromagnetic assemblies. Similarly, as shown in FIGS. **4** and **8,** there are nine front and back pairs of electromagnets in the stator such as **104***a* and **104***b*.

In order to best understand the operation of the rotor **81–88** rotating within the stator housing **50** of an engine according to this invention, the positions of rotor

electromagnets **91** and stator electromagnets **117** are initially exactly in line at the 13⅓° peripheral starting position marked on the vertical center line of FIG. **5.** The winding direction of the coils of these magnets is such that a d-c current through the coils **119** will produce a particular identical magnetic polarity on each of the juxtaposed surfaces **125** of magnet **117,** and **126** of magnet **91,** (FIG. **5**). FIGS. **16** and **6** illustrate the next step in the motion wherein the two major electromagnets, **120** in the stator and **121** in the rotor, are in alignment.

When the d-c discharges from the appropriate capacitors in banks **39** occur simultaneously across spark gaps through the coils **119** of electromagnets **117** and **91,** at the instant of their alignment, their cores **118** will repel one another to cause rotor assembly **81–88** to rotate clockwise in the direction indicated by arrow **127.** The system does not move in the reverse direction because it has been started in the clockwise direction by the alternator motor **54** shown in FIG. **3,** or by some other starter means. If started counterclockwise, the rotor will continue to move counterclockwise.

As hereinbefore noted, the discharge of any capacitor occurs over a very short interval across its associated spark gap, and the resulting magnetic repulsion action imparts motion to the rotor. The discharge event occurs when electromagnets **117** and **91** are in alignment. As shown in FIG. **5,** rotor electromagnet **91***a* is aligned with stator electromagnet **117***c*, and rotor electromagnet **91***b* is aligned with stator electromagnet **117***e* at the same time that similar electromagnets **117** and **91** are aligned. A discharge occurs through all six of these electromagnets simultaneously (that is, **117,** 91; **117***c*, 91*a*, 117*e* and **91***b*). A capacitor and a spark gap are required for each coil of each electromagnet. Where, as in the assembly shown in FIG. **8,** front and back pairs are used, both the axial in-line front and back coils are energized simultaneously by the discharge from a single capacitor or from a bank of paralleled capacitors such as **25, 26** (FIG. **1**). Although FIGS. **4** and **8** indicate the use of front and back electromagnets, it should be evident that only a single electromagnet in any stator position and a corresponding single electromagnet in the rotor position, may be utilized to accomplish the repulsion action of the rotor with respect to the stator. As stated, each electromagnet requires a discharge from a single capacitor or capacitor bank across a spark gap for it to be energized, and the magnetic polarity of the juxtaposed magnetic core faces must be the same, in order to effect the repulsive action to produce the rotary motion.

Referring to FIGS. **5** and **6,** the repulsion action causes the rotor to move 13⅓° clockwise, while electromagnets **91, 91***a* and **91***b* move away from electromagnets **117, 117***c* and **117***e* to bring electromagnets **121, 121***a* and **121***b* into respective alignment with electromagnets **120***a*, 120*d* and **120***f*. At this time, a capacitor discharge across a spark-gap into their coils **123** occurs, thus moving the rotor. Another 13⅓° ahead, as shown in FIG. **7,** major electromagnets **121, 121***a* and **121***b* come into alignment with minor electromagnets **117***a*, 117*d* and **117***f*, at which time a discharge occurs to repeat the repulsion action, this action continuing as long as d-c power is applied to the system to charge the capacitors in the capacitor banks.

FIG. **18** further illustrates the sequencing of the capacitor discharges across appropriate spark gap terminal pairs. Nine single stator coils and three single rotor coils are shown with their respective interconnections with the spark gaps and capacitors with which they are associated for discharge. When the appropriate spark gap terminals are aligned, at the points in the positioning of the rotor assembly for most effective repulsion action of juxtaposed electromagnet cores, the discharge of the appropriate charged capacitors across the associated spark gap occurs through the respective coils. The capacitors are discharged in sets of three through sets of three coils at each discharge position, as the rotor moves through the rotor positions. In FIG. **18,** the rotor electromagnets are positioned linearly, rather than on a circular base, to show the electrical action of an electric engine according to the invention. These motor electromagnets **201, 202,** and **203** are aligned with stator electromagnets **213, 214** and **215** at 0°, 120° and 450° respectively. The stator electromagnets are correspondingly shown in a linear schematic as if rolled out of the stator assembly and laid side by side. For clarity of description, the capacitors associated with the rotor operation **207, 208, 209** and **246, 247,** 248, 249, 282 and **283** are arranged in vertical alignment with the respective positions of the rotor coils **201, 202, 203** as they move from left to right, this corresponding to clockwise rotation of the rotor. The stator coils **213, 214, 215, 260, 261, 262, 263, 264, 265,** 266, etc. and capacitor combinations are arranged side by side, again to facilitate description.

An insulative disc **236** (shown in FIG. **17** as a disc, but opened out linearly in FIG. **18**) has mounted thereon three gap terminal blocks **222, 225** and **228.** Each block is rectangularly U-shaped, and each interconnects two terminals with the base of the U. Block **222** has terminals **222***a* and **222***b*, block **225** has terminals **225***a* and **225***b*, and block **228** has terminals **228***c* and **228***d*. When insulative disc **230** is part of the rotor, as indicated by mechanical linkage **290,** it can be seen that terminal U **222** creates a pair of gaps with gap terminals **223** and **224,** respectively. Thus, when the voltage on capacitor **216** from charging circuit **219** is of a value which will arc over the air spaces between **222***a* and **223,** and between **222***b* and **224,** the capacitor **216** will discharge into the coil of electromagnet **213** to ground. Similarly gap terminal U **225** forms a dual spark gap with gap terminals **226** and **227** to result in arc-over when the voltage on capacitor **217,** charged by charging circuit **220,** discharges into the coil of electromagnet **214.** Also, U-gap terminal **228** with terminals **228***c* and **228***d*, creates a spark gap with terminals **229** and **230** to discharge capacitor **218,** charged by charging circuit **221,** into coil **215.** At the same time, rotor coils, **201, 202** and **203** across gaps **201***a*–**204,** 202*b*–**205** and **203***c*–**206** each receives a discharge from respective capacitors **207, 208,** and **209.**

When the electromagnet coils **213, 214, 215** and **201, 202, 203** are energized, the repulsion action causes the rotor assembly to move to position **2** where a new simultaneous group of discharges occurs into rotor coils **201, 202,** and **203** from capacitors **246, 248,** and **282** across gaps **201***a*–**240, 202***b*–**242** and **203***c*–**244.** Simultaneously, because gap-U-elements **222, 225** and **228** have also moved to position **2** with the rotor assembly, capacitor **261** is discharged through electromagnet coil **260,** capacitor **265** is discharged through electromagnet coil **264,** and capacitor **269** is discharged through electromagnet coil **268** in align-

ment with position **2** of the rotor electromagnet coils, thus to cause the rotor electromagnets to move to position **3** where the discharge pattern is repeated now with capacitors **247, 249** and **283** discharging through the rotor electromagnet coils **201, 202, 203,** and the capacitors **263, 267** and **281** discharging respectively through stator electromagnet coils **262, 266** and **280.**

After each discharge the charging circuits **219–221** and **272–277** for the stator capacitors, and **210–212** and **284–289** for the rotor capacitors, are operated continuously from a battery source, as described earlier with reference to FIG. **1,** to constantly recharge the capacitors to which each is connected. Those versed in the art will appreciate that, as each capacitor discharges across an associated spark gap, the resulting drop in potential across the gap renders the gap an open circuit until such time as the capacitor can recharge to the arc-over level of the gap. This recharge to a discharge potential occurs before a rotor element arrives at the next position in question.

The mechanical schematic diagram of FIG. **17** further clarifies the operation of the spark-gap discharge programming system. A forward disc **236** of an electrically insulative material, has thereon the set of U-shaped gap terminal connectors previously described. These are positioned at 0°, 120° and 240° respectively. In FIG. **17,** schematic representations of the position of the coil and capacitor arrangements at the start of a cycle are shown to correspond to the description hereinabove with reference to FIG. **18.** Accordingly, the coil and capacitor combinations **213**/216, 214/217, and **215**/218 are shown connected with their gap terminals, respectively, **223**/224, 226/227 and **229**/230. On the rotor coil and capacitor connection three separate discs **291, 292** and **293** are shown, each with a single gap terminal. The discs **291–293** are rotated so as to position their respective gap terminals **201***a*, 202*b* and **203***c* at 120° increments, with the 0° position corresponding to the 0° position of U-gap terminal **222** on disc **230.**

Representative gap terminals are shown about the peripheries of discs **230, 291–293** to clearly indicate how, as the discs turn in unison, the gap alignments correspond so that three rotor coil/capacitor positions always line up with three stator coil/capacitors at 120° intervals about the rotary path, producing an alignment every 40°, there being nine stator coils. Thus there are three simultaneous discharges into stator coils and three into rotor coils at each 40° position. Nine positions displaced 40° apart provide a total of 27 discharge points for capacitors into the rotor coils and 27 discharge points for capacitors into the stator coils in one revolution.

It will be understood that, as illustrated in FIGS. **17** and **18,** nine individual electromagnet coils are shown in the stator and three in the rotor, in order to show in its simplest form how the three rotor electromagnets are stepped forward from alignment with three of the stator electromagnets, when the appropriate spark gaps are in alignment, to effect the discharge of capacitors through juxtaposed pairs of rotor/stator electromagnets. The repulsion moves the rotor electromagnet from the stator electromagnet to the next alignment position advanced at an arc of 40° from the preceding alignment position. In the interval until another rotor electromagnet, 120° removed, is aligned with the stator electromagnet that had just been excited, the associated capacitor is recharged to a potential which will cause the spark gap to break down to produce another discharge of this capacitor on the next revolution. Thus the rotor moves from one position to the next, with capacitor discharges occurring each 40° of rotation, a total of nine per revolution. It should be obvious that, with other rotor/stator combinations, the number of electromagnet coincidences and spark-gap discharges will vary. For example, with the coil pairs shown in FIGS. **4** through **8,** a total of 27 discharges will occur. Although there are 18 stator electromagnets and three rotor electromagnets, the discharge pattern is determined by the specific spark gap arrangement.

The rotor/stator configuration of FIGS. **5** and **8,** involving the major and minor pairs of electromagnets such as **85***a* and **104***a* (the terms "minor" and "major" referring to the difference in size of the elements), include nine pairs of electromagnets in the stator, such as **104***a*, with three electromagnet pairs of the rotor, such as **85***a*. Because of the 13⅓° separation between the major and minor electromagnets in the rotor pair **85***a*, with the same separation of minor and major electromagnets of the stator pair **104***a*, the sequence of rotation and discharge described above, with respect to the illustrative example of FIG. **5,** involves the following:

1. A minor element **117** of stator pair **104***a* is aligned with the minor element **91** of rotor pair **85***a*. On the discharge, this moves the rotor ahead 13⅓°.

2. The major rotor element **122** of the pair **85***a* now is aligned with the major stator element **120***b* of the next stator electromagnet pair, in the stator array as shown in FIG. **6.** On the discharge, the rotor moves ahead 13⅓°.

3. This brings the minor rotor electromagnet **91** into alignment with the major stator electromagnet **120***b* of pair **104***d*, and the major electromagnet **122** (just discharged) of pair **85***a* into alignment with minor electromagnet **117***b* of pair **104***d*, and the rotor spark gap ements into alignment with a different position of gap elements connected with capacitors not discharged in the previous position of the rotor. It should be remembered at this point that it is the positioning of a rotatable spark gap array, similar to that illustrated in FIGS. **17** and **18,** which controls the time of discharge of capacitors connected to these gap terminals. Therefore, any electromagnet can be energized twice successively from separate capacitors as the rotor brings appropriate gap terminals into alignment with the coil terminals of a particular electromagnet.

Thus, although major electromagnet **120***b* of pair **104***d* has just been energized as described above, it can now be energized again along with minor rotor electromagnet **91** in step **3,** because the rotor moved to a new set of terminals of the spark gap arrays connected with capacitors not yet discharged. These capacitors now discharge through rotor electromagnet **91** and stator electromagnet **120***b*, causing rotor to move ahead another 13⅓°, thus again aligning two minor electromagnets again, these being **117***b* of stator pair **104***d* and **91** of rotor pair **85***a*. The rotor has now moved 40° since step **1** above. The sequence is repeated, and it is to be noted that at each 13⅓° step, the discharges rotate the rotor another 13⅓°. There are 27 steps per revolution with nine stator coil pairs. The discharge sequence is not uniform, as is shown in Table I. In the stator, three major electromagnets 120° apart are energized twice in sequence followed by a hiatus of one step while three

minor electromagnets of the stator, 120° apart, are energized during the hiatus. In the rotor the major electromagnets are energized during a hiatus step following two minor electromagnet energization steps. A total of 27 energizations are thus accomplished in the nine pairs of coils of the stator.

In Table I, the leftmost column depicts the location of each rotor arm **85, 86, 87** at an arbitrarily selected step No. **1** position. For example, in step **1** rotor arm **85** has a minor stator and minor rotor electromagnet in alignment for capacitors to discharge through them simultaneously at the 13⅓° position.

TABLE I

CAPACITOR DISCHARGE SEQUENCE FOR ONE REVOLUTION OF ROTOR IN SYSTEM OF FIGS. 5 AND 8

Step No. Rotor Arm 87	85	86	Rotor Angle	Rotor Electromagnet Minor	Major	Stator Electromagnet Minor	Major
10	1	19	13 1/3°	x		x	
11	2	20	26 2/3°		x		x
12	3	21	40°	x			x
13	4	22	53 1/3°	x		x	
14	5	23	66 2/3°		x		x
15	6	24	80°	x			x
16	7	25	93 1/3°	x		x	
17	8	26	106 2/3°		x		x
18	9	27	120°	x			x
19	10	1	133 1/3°	x		x	
20	11	2	146 2/3°		x		x
21	12	3	160°	x			x
22	13	4	173 1/3°	x		x	
23	14	5	186 2/3°		x		x
24	15	6	200°	x			x
25	16	7	213 1/3°	x		x	
26	17	8	226 2/3°		x		x
27	18	9	240°	x			x
1	19	10	253 1/3°	x		x	
2	20	11	266 2/3°		x		x
3	21	12	280°	x			x
4	22	13	293 1/3°	x		x	
5	23	14	306 2/3°		x		x
6	24	15	320°	x			x
7	25	16	333 1/3°	x		x	
8	26	17	346 2/3°		x		x
9	27	18	360°	x			x

Similarly, in step **1** rotor arm **86** is at the 133⅓° position with a minor rotor and minor stator electromagnet in alignment for discharge. Simultaneously, rotor arm **87** is at the 253⅓° position with a minor rotor and minor stator in alignment for capacitor discharge therethrough. The other steps of the sequence are apparent from Table I, for each position of the three rotor arms at any step and the juxtapositions of respective stator and rotor electromagnet elements at that position.

In the simplified motor arrangement shown in schematic form in FIG. **18**, with single electromagnet configuration the alignment is uniform and the discharge sequences follow sequentially.

As hereinbefore mentioned, a change in speed is effected by displacing the stator spark gap terminals on the rotor (shown at **236** in FIGS. **17** and **18**) either counter-clockwise or clockwise 6⅔° so that the discharge position of the stator electromagnets is displaced 6⅔° either clockwise or counter-clockwise of a rotor electromagnet at the time of discharge. Referring to FIGS. **11** to **15**, the simultaneous discharge of selected capacitors into the electromagnets so displaced results in a deceleration at the time the rotor electromagnet is just approaching the associated stator, or an acceleration if the rotor electromagnet is just leaving its associated stator electromagnet. In each event, there is a repulsive reaction between the stator and rotor electromagnets, so that if the rotor is approaching the stator, there is a slow-down and if the rotor is receding from the stator there is a speed-up.

Referring to FIG. **11**, clutch mechanism **304** about shaft **111** is operated electromagnetically in conventional manner to displace the spark-gap mechanism **236** which is operated normally in appropriate matching alignment with the rotor spark-gap discs **291, 292,** 293. Clutch **304** has a fixed drive element **311** containing an electromagnetic drive coil (not shown) and a motor element **310** which, when the electromagnetic drive coil is energized, can be operated by a direct current. The operation of motor element **310** brings into operation spark gap elements **224***r*, 223*r* or **223***f*, 224*f* of the system shown in FIGS. **4, 5** and **8**, as illustrated in FIG. **19.**

The fixed stator coil spark gap terminal pairs **223,** 224 and **266, 267** are arrayed about a cylindrical frame **322** which is fabricated in insulative material. In the illustrative example of FIGS. **17** and **18**, there are nine such spark gap terminal pairs about the periphery of cylinder frame **324.** In the engine of FIGS. **4** to **8**, a total of 27 such spark gap pairs are involved. In addition, although not shown in the drawing, there are also pairs of terminals, such as **223***r* or *f*, 224*r* or *f* and **266***r* or *f*, **267***r* or *f*, displaced 6⅔° on either side of the pairs **223, 224** or **266, 267** and all other pairs in the spark gap array, the letters *r* and *f* denoting "retard" and "faster." The latter displaced pairs of used in the control of speed of the engine rotor. The displaced pairs not shown are involved with the operation of cluth **304,** the speed changing control element.

Clutch **304** is associated with shaft **111** in that the movable element **310** draws clutch disc element **316** on shaft **111** away from clutch disc element **322** when energized by a voltage of appropriate polarity applied to its motor electromagnet **311.** Such clutch drives are well known in the art.

The clutch mechanism **304** of FIGS. **11** and **19,** when not energized is in the configuration shown in FIG. **11.** The energized configuration of clutch **304** is not specifically illustrated. Upon energization, spark-gap element **222** on disc **236** is displaced rightward, as viewed in FIG. **11,** by broken lines **236X,** into alignment with the positions of fixed spark-gap terminals **223***f*, 224*f* and **267***r*, 266*r*. When the disc is in position **236X**, the flattened edge **332** of pin **330** in disc **325** rides on surface **350** of disc **322.** Normally, the flattened edges **351** of pins **330** are engaged against the flat edge **352** in recess **331** of disc **322.** The displacement of disc **322** on shaft **111** is effected by the action of clutch **304** against spring **314** (FIG. **11**). An electric switch (not shown) of clutch mechanism **304** energizes it from a d-c power source, and has two positions, one for deceleration and one for acceleration. In either position, clutch **304** is engaged to pull clutch disc **322** from clutch disc **325,** momentarily. For the decelerate or the accelerate position, the displaced alignment of spark gap elements **222** is with the **224***f*, 223*f* and the **224***r*, 223*r* spark-gap terminal elements. However, only the **224***f*, 223*f* spark-gap elements are switched into operation with appropriate capacitors for the accelerate position, while in the decelerate position only the **223***r* and **224***r* spark-gap elements are switched into the circuit with their associated capacitors.

Of course, when insulative disc **236** is displaced by clutch **304,** its gap terminals **222, 225** and **228** (FIGS.

14 and 18) are all displaced into the alignment position of 236X so as to engage the *r* and *f* lines of fixed spark gap elements. Although the accelerate and decelerate positions of disc **236** are the same, it is the switching into operation of the **223, 224** or **266, 267** exemplary *r* or *f* pairs of terminals which determine whether speed up or slow down action of the rotor will occur.

The momentary displacement of clutch disc **322** from clutch disc **325** results in rotation of disc **325** about disc **322** through an angle of 120°. The detent ball and spring mechanism **320, 321** in disc **325** positions itself between one detent dimple **328** and a succeeding one **328** at a position 120° away on disc **325.** As stated, flat **332** of pin **330** rides on surface **350** of disc **322,** and pin **330** leaves the pin-holding groove **331**/352 along ramp **333** in disc **322** during the momentary lifting of disc **322** by clutch **304.** Pin **330** falls back into the next groove **331** at a point 120° further on about disc **322.** Pin **330** falls into place in groove **331** on ramp **334.** Pins **330** are rotatable in their sockets **353,** so that for either clockwise or counterclockwise rotation, the flat **351** will engage the flat **352** by the particular ramp it encounters.

The deceleration or acceleration due to the action of clutch **304** thus occurs within a 120° interval of rotation of disc **325.** Disc **322** during this interval may only move a fraction of this arc.

There has been described hereinabove an electromotive engine system wherein at least one electromagnet is in a fixed position and a second electromagnet of similar configuration is juxtaposed with it in a magnetic polarity relationship such that, when the cores of the electromagnets are energized, the juxtaposed core faces repel one another. One core being fixed and the second core being free to move, any attachments to the second electromagnet core will move with it. Hence, if a plurality of fixed cores are positioned about a circular confining housing, and, within the housing, cores on a shaft are free to move, the shaft is rotationally urged each time the juxtaposed fixed and rotatable cores are in alignment and energized. Both the fixed and the movable cores are connected to spark gap terminal elements, and the associated other terminal elements of the spark gaps are connected to capacitors which are changed to a high voltage from pulsed unipolar signal generators. These capacitors are discharged through the electromagnets across the spark gaps. By switching selected groups of capacitors into selected pairs of spark gap elements displaced from the normal uniformly positioned elements for discharge through the electromagnets, the rotor of the circular array systems is accelerated and decelerated.

By confining a fixed electromagnet array in a linear configuration with a linearly movable electromagnet to which a working tool is attached, exciting the juxtaposed pairs of electromagnets by capacitor discharge results in the generation of linear force for such tools as punch presses or for discharging projectiles with considerable energy.

The inventor claims:

1. An electric engine comprings:

a housing;

an array of electromagnets uniformly spaced in said housing to form a stator;

a rotor cage on a shaft journaled in and rotatable within said housing and within said stator, said rotor cage having thereon a spaced array of electromagnets similar to said stator electromagnets and in number comprising an integral fraction of the number of electromagnets in said stator array;

each of the electromagnets of said stator and of said rotor having a magnetizable core of particular configuration and each being wound with a coil such that a pulse of unidirectional electric current through said coil magnetizes the respective core thereof to a particular magnetic polarity, and the faces of rotor cores juxtaposing selected stator cores are magnetized to the same polarity, the juxtaposed cores thereby tending to repel one another, one lead of each of the stator and rotor coils being connected to a common terminal, the other lead of each of said coils being connected to a gap terminal, the gap terminals of said rotor coils being on the rotor and equal in number to the number of coils thereon and matching the positions of said rotor electromagnets thereon, the gap terminals of said stator being equal in number to the number of coils on the stator and disposed uniformly about said stator to match the positions of said stator electromagnets within said housing;

a first array of capacitors each having a terminal in common with the common coil terminal of said stator electromagnets, and each capacitor having its other terminal connected to a gap terminal arrayed adjacent the gap terminal of an electromagnet associated therewith;

a second array of capacitors, each having a terminal in common with said common terminal of said rotor electromagnet coils but equal in number to the number of capacitors in said stator array, the other terminals of said capacitors in said second array being connected to gap terminals arrayed about said housing so as to be in axial alignment with said stator gap terminal positions and being alignable with said rotor gap terminals as said rotor is rotated in said housing and respective gap terminals of said rotor coils pass each second array capacitor gap terminals at a predetermined gap distance;

gap coupling terminals on said rotor equal in number to the number of rotor electromagnet coils and positioned to match the rotor electromagnet positions on said rotor, the gap coupling terminals being rotatable with said rotor so as to pass said adjacent stator coil and associated stator capacitor gap terminal at a predetermined distance therefrom;

a plurality of capacitor charging circuits connected respectively across each of said capacitors in both said first and said second arrays of capacitors for charging each of said capacitors to a predetermined high d-c potential;

a first source of unidirectional electric potential connected to each of said capacitor charging circuits for energizing said charging circuits; and

a second unidirectional electric potential source connected to said electromagnets of said rotor and said stator of such polarity as to receive a charge from the inverse inductive discharge of the electromagnet coils as their fields collapse following the discharge of each capacitor through a rotor or stator electromagnet coil,

whereby whenever a rotor electromagnet is aligned opposite a stator electromagnet, the rotor coil gap terminal of that electromagnet is opposite an asso-

ciated second capacitor array gap terminal, and a gap coupling terminal of said rotor is aligned opposite the stator electromagnet coil gap terminal and associated first capacitor gap terminal, the capacitors discharge the charge thereon across the gaps through their associated electromagnet coils to magnetize their respective juxtaposed electromagnet cores to cause them to repel one another, thus aligning a succeeding pair of rotor and stator electromagnets for capacitor discharge across their respective gaps, to cause them to repel one another, alignments rotor rotation within the housing continuously bringing successive rotor-stator electromagnets into alignment for discharge of the capacitors therethrough to produce rotary motion of the rotor on said rotor shaft continuously so long as energy from said first source of unidirectional electric potential is applied to said charging circuits to recharge said capacitors after each discharge.

2. In an electric engine having a rotor comprising electromagnetic coil means rotatable within a stator comprising similar electromagnetic coil means, said electromagnetic coil means being polarized for magnetic repulsion;

capacitor means electrically coupled across successive spark gaps to selected ones of said coils of said stator and all of the coils of said rotor;

charging means connected to said capacitor means for charging said capacitor means to an electrical charge potential sufficient to cause arcing across said spark gaps to result in the discharge of said capacitor means through the electromagnetic coils so that the electromagnetic coil means repel one another; and

a unidirectional electric power source connected to said charging means to energize said charging means to continue charging said capacitor means following each discharge whereby the rotor of said engine is maintained in rotation by the successive discharges of said capacitor means across successive spark gaps into said electromagnetic coil means.

3. An electric engine according to claim **2,** wherein:

the charging means includes electronic square core oscillators connected to said unidirectional electric power source and includes step-up means and a rectifier to produce a substantial voltage step up from the voltage of said power source.

4. An electric engine according to claim **2,** wherein:

the charging means includes a vibrator connected to said power source, and step up transformer and rectifier means to provide a high voltage for charging said capacitor means.

5. A motive force producing means comprising:

at least a first electromagnet means including at least one coil wound about a core,

at least a second electromagnet means including at least one coil wound about a core similar to said first core,

the respective cores being positioned adjacent to one another so that the magnetic polarities of the adjacent core surfaces are the same when a unidirectional electric current is passed through the coils,

at least one capacitor means having one terminal thereof connected to one terminal of both of said electromagnet coils,

the other terminal of said capacitor means being connected to one terminal of a spark gap means, the other terminals of the coils of both said first and said second electromagnet means being connected to the other terminal of said spark gap means,

at least one unidirectional pulse charging means connected to said capacitor means to charge said capacitor means to a relatively high potential sufficient to arc across said spark gap means at predetermined spacing of said gap terminals, and

a source of unidirectional potential connected to said charging circuit to energize said charging means,

whereby upon application of current from said potential source to said charging means the successive pulses generated thereby charge said capacitor means to a voltage level sufficient to arc across said spark gap means to produce a discharge path for said capacitor means through said coils to cause said electromagnet means to repel one another with a substantial force.

6. A motive force producing means according to claim **5,** wherein:

said first electromagnet means is secured in a relatively stable housing, and said second electromagnet means is connected with and freely movable relative to said stable housing, and has utilization means connected thereto for performing work therewith when said capacitor means discharges through said coils of said electromagnet means.

7. A motive force producing means according to claim **6,** wherein said utilization means is a motor rotor coupled with said second electromagnet means and said first electromagnet means is a stator.

8. A motive force producing means according to claim **6,** wherein said utilization means is a piston attached to said second electromagnet means and is movable therewith to produce hammer-like blows when said capacitor means discharges through said electromagnet means.

9. In an electromotive force generating system as disclosed, means for accelerating or decelerating the motion of a force generating system, said means comprising:

at least two juxtaposed electromagnetic core elements, one fixed and one movable, including coils wound thereabout to provide a repulsion tendency when said cores are energized,

spark gap termimals connected with said coils,

capacitor means connected with said spark gap terminals to discharge across said spark gap terminals through said coils when a charge of sufficient voltage level appears across said capacitor means, thus to energize said juxtaposed electromagnets to induce said juxtaposed electromagnet cores to repel one another,

charging means connected to said capacitors for charging them to said sufficient voltage level, and

selective positioning means coupled with said spark gap terminals and with at least said movable electromagnet core to cause selective displacement of said movable core with respect to said fixed core to accelerate or decelerate the motion of the movable core relative to the fixed core.

10. An electromotive force generating system according to claim **9,** wherein:

said juxtaposed electromagnetic cores include a plurality of fixed cores and a smaller number of mov-

able cores, said smaller number being an integral fraction of the number of fixed cores, and

said selective positioning means is an electromagnetic clutch coupled with said smaller number of movable cores for movement therewith, and includes selective displacement means coupled with said spark gap terminals connected with selected capacitors in said capacitor means and selected combinations of coils in said plurality of fixed electromagnets.

11. The method of generating motive power comprising the steps of:

a. positioning similar electromagnets in juxtaposed relationship with their respective cores arranged for repulsion when said electromagnets are energized,

b. charging capacitors to a relatively high potential, and

c. discharging said capacitors simultaneously through said electromagnets across spark gaps set to break down at said relatively high potential,

thereby to cause said similar electromagnets to repel one another with considerable force.

12. The method of generating motive power defined in claim **11**, wherein in said positioning step at least one of said electromagnets is maintained in a fixed position and another electromagnet is free to move relative to said fixed electromagnet.

13. The method of generating motive power according to claim **11**, wherein:

the charging step includes the charging of capacitors to a relatively high potential from a pulsed unipolar source of electric energy.

14. In an electromagnetic capacitor discharge engine including movable electromagnets and fixed electromagnets, said movable electromagnets being movable into polar alignment with said fixed electromagnets, capacitor means, means for charging said capacitor means, and means for discharging said charged capacitor means through said fixed and movable electromagnets to polarize aligned fixed and polarized electromagnets for magnetic repulsion, an acceleration and deceleration control means comprising:

first selective means for momentarily delaying the discharge of the capacitors until the movable electromagnets in said engine have begun to recede from the fixed electromagnets, in order to accelerate the motion of said movable electromagnets by the added impetus of the repulsion, and

second selective means for momentarily accelerating the discharge of the capacitors to occur at a point in the motion of the movable electromagnets where said movable electromagnets are approaching said fixed electromagnets to decelerate the motion of said movable electromagnet by the tendency to repel the approaching electromagnet by the fixed electromagnet.

15. An electric engine, comprising:

fixed electromagnets;

movable electromagnets movable into alignment with said fixed electromagnets;

capacitor means;

means for charging said capacitor means; and

means for discharging said charged capacitor means through said fixed and movable electromagnets to polarize said aligned fixed and movable electromagnets for magnetic repulsion.

16. An electric engine as recited in claim **15**, wherein: said means for discharging said charged capacitor means comprises voltage breakdown switch means.

17. An electric engine as recited in claim **16**, wherein:

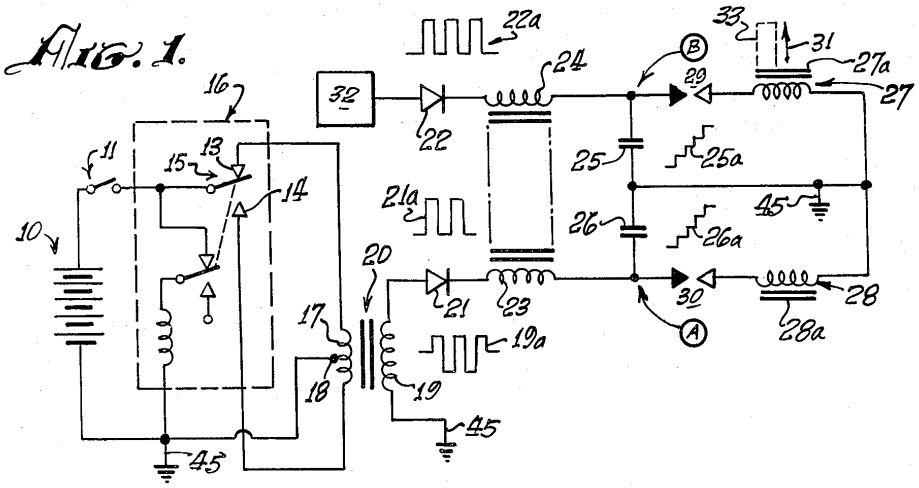
said voltage breakdown switch means includes at least one terminal movable with at least one of said movable electromagnets for breaking down when said at least one of said movable electromagnets is in alignment with a said fixed electromagnet.

18. An electric engine as recited in claim **17**, wherein:

said voltage breakdown switch means comprises a spark gap means.

* * * * *

FIG. 1.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31
27a
27
B
29
25
25a
21a
45
26
26a
10
20
21
23
28
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28a
A
17
19a
18
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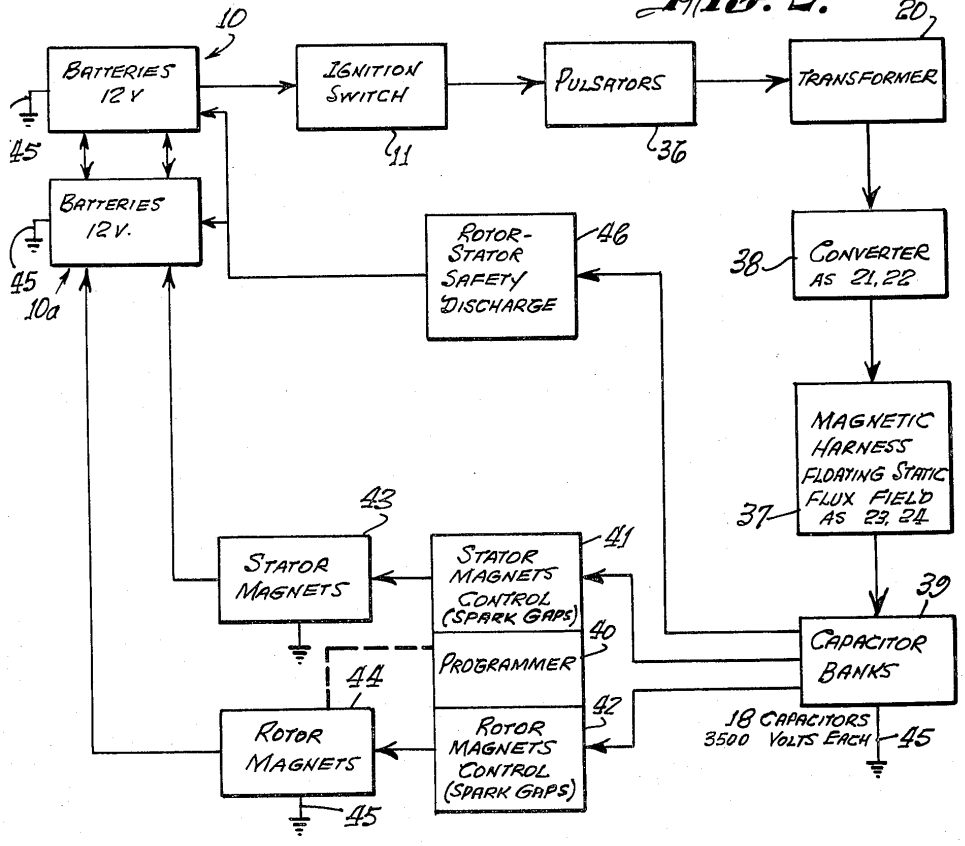
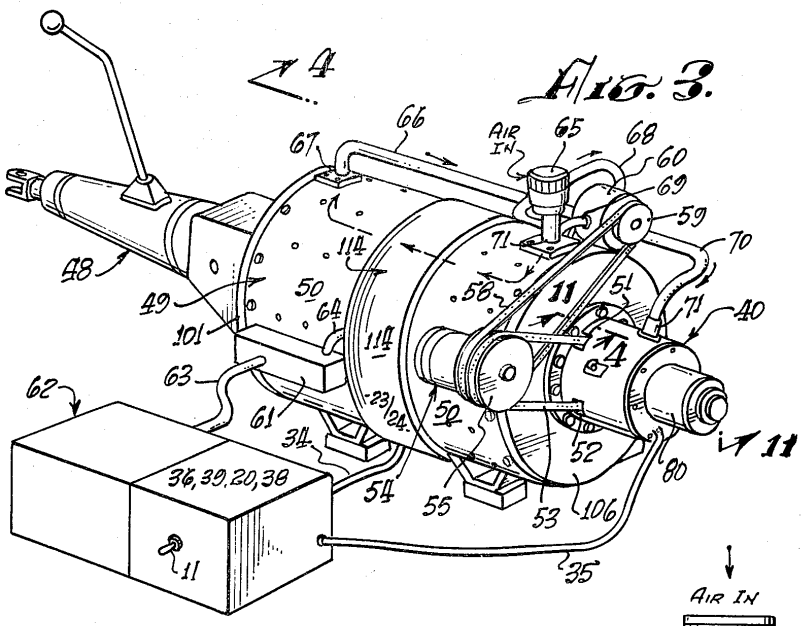
45

FIG. 2.


10
BATTERIES 12 V
IGNITION SWITCH
11
PULSATORS
36
20
TRANSFORMER
45
BATTERIES 12 V.
45
10a
ROTOR-STATOR SAFETY DISCHARGE
46
38
CONVERTER AS 21, 22
MAGNETIC HARNESS FLOATING STATIC FLUX FIELD AS 23, 24
37
43
STATOR MAGNETS
STATOR MAGNETS CONTROL (SPARK GAPS)
41
39
CAPACITOR BANKS
40
PROGRAMMER
44
ROTOR MAGNETS
42
ROTOR MAGNETS CONTROL (SPARK GAPS)
18 CAPACITORS 3500 VOLTS EACH
45
45


4
AIR IN
65
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101
114
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11
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23/24
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36,39,20,38
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55
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106
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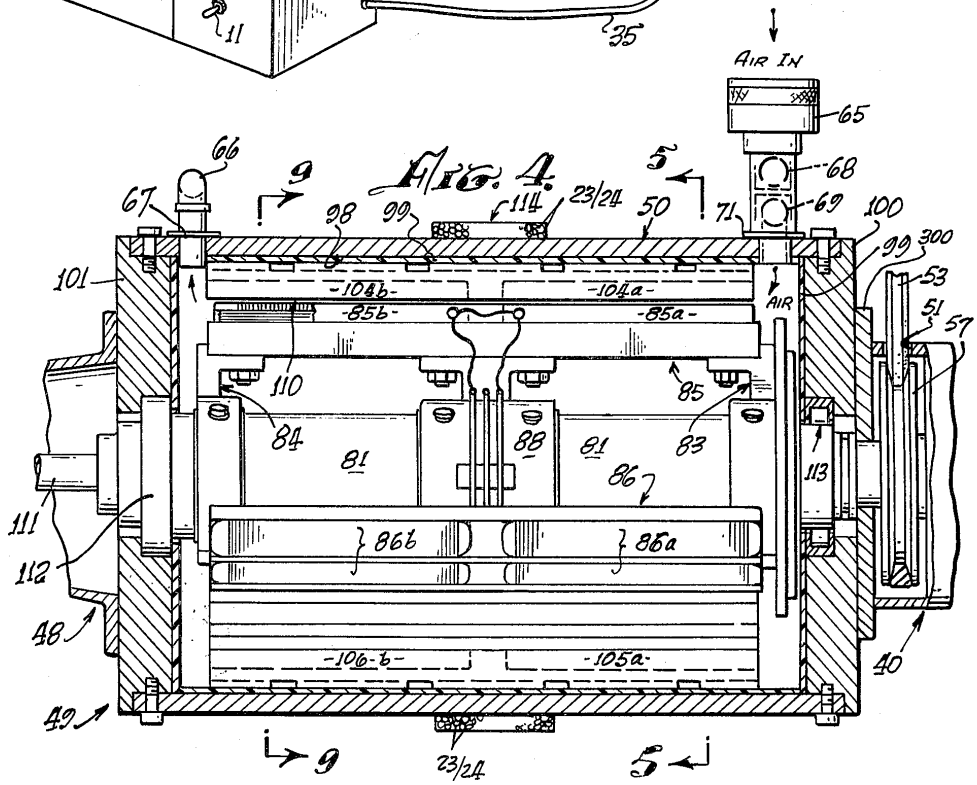
80
35

Fig. 3.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300
101
104b
104a
85b
85a
AIR
53
51
57
110
84
85
83
81
88
86
113
111
112
86b
85a
48
106-b
105a
40
49
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23/24
5

Fig. 4.

Fig. 5.

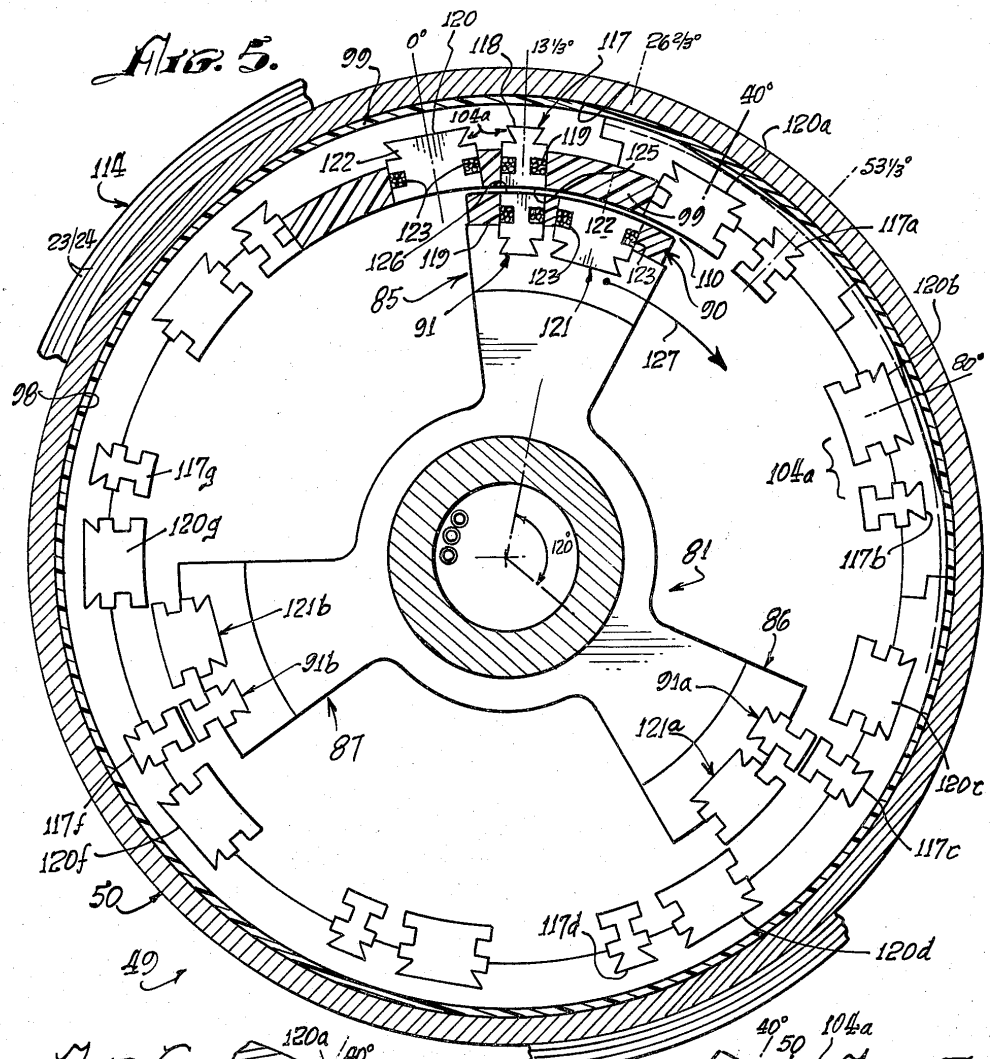


Fig. 6.

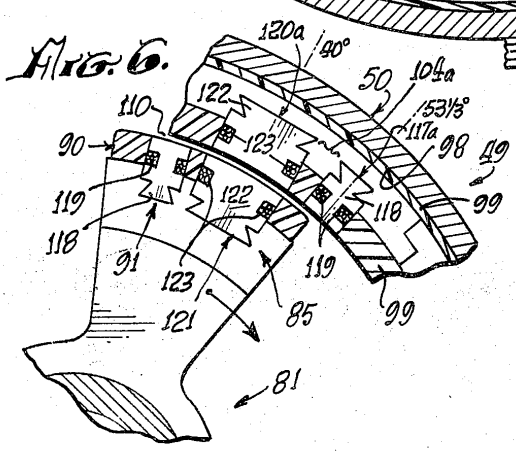


Fig. 7.

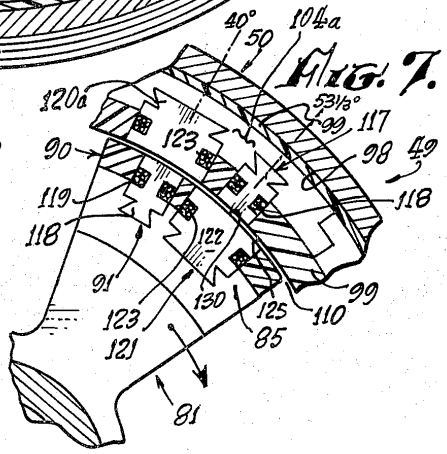


FIG. 8.

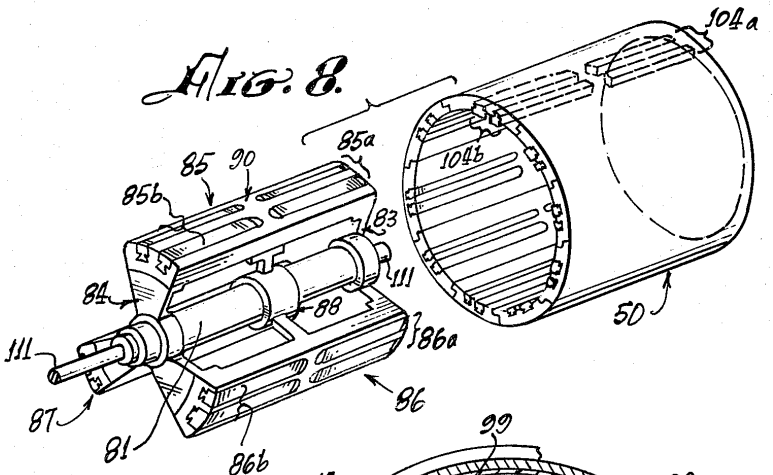
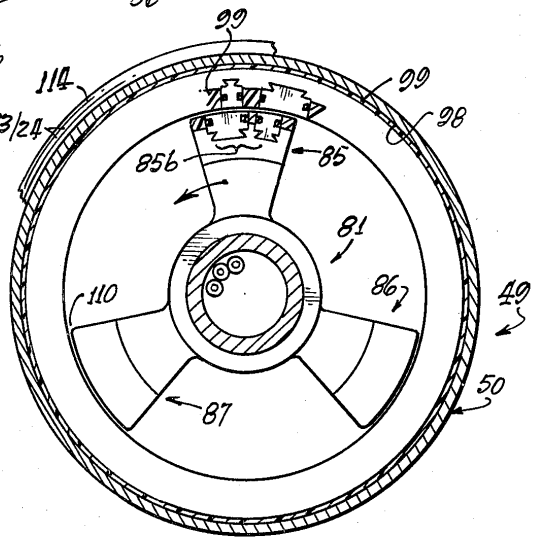


FIG. 9.



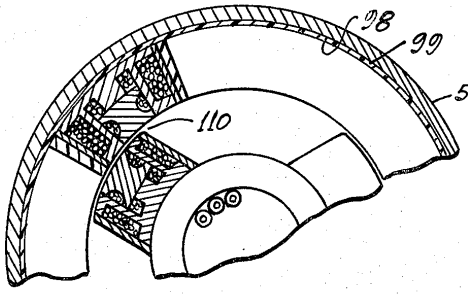
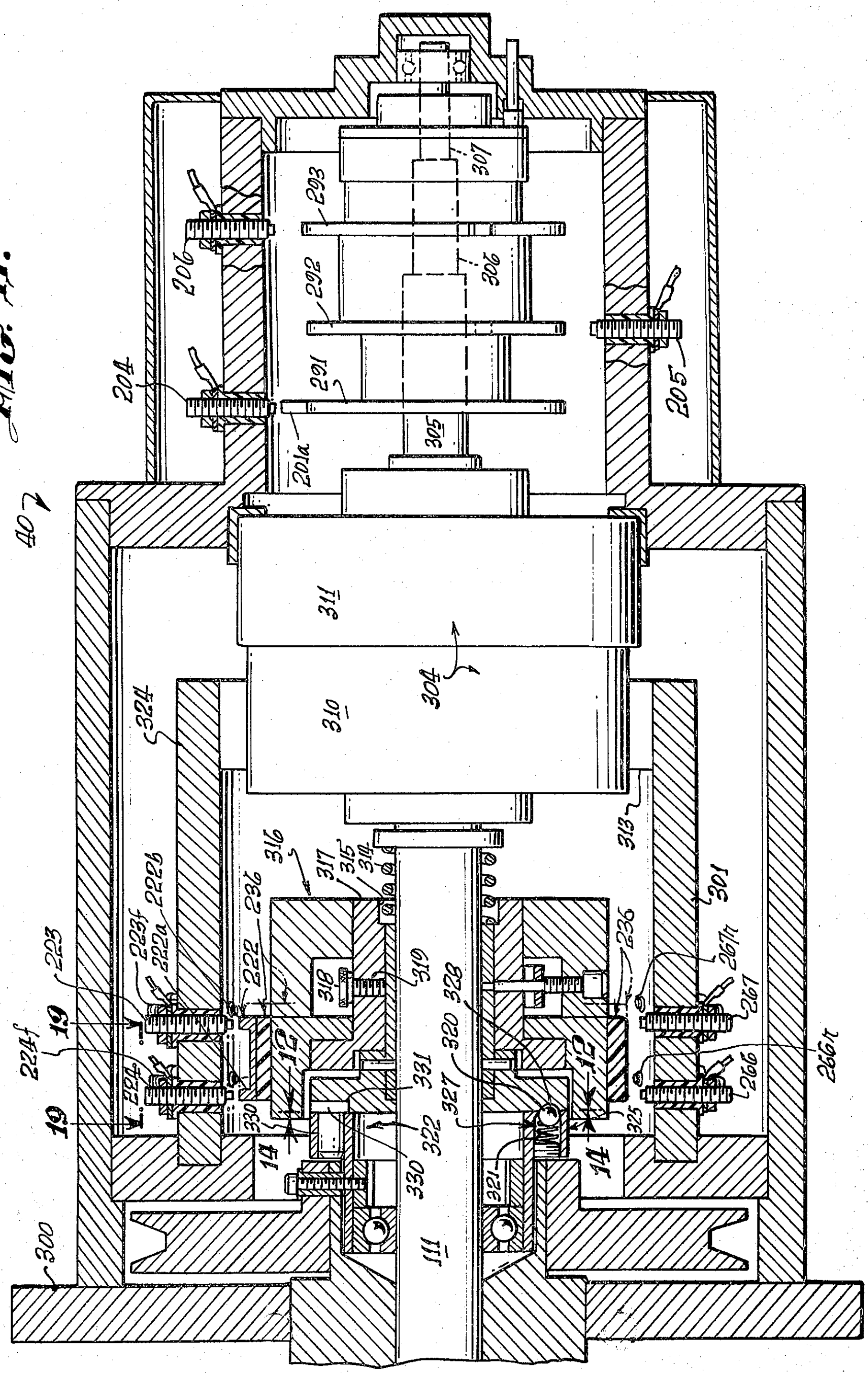


FIG. 10.

FIG. 11.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318
319
236
222
222a
222b
223
223f
224
224f
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330
331
322
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328
327
321
325
266
266h
267
267h
300
111

Fig. 12.

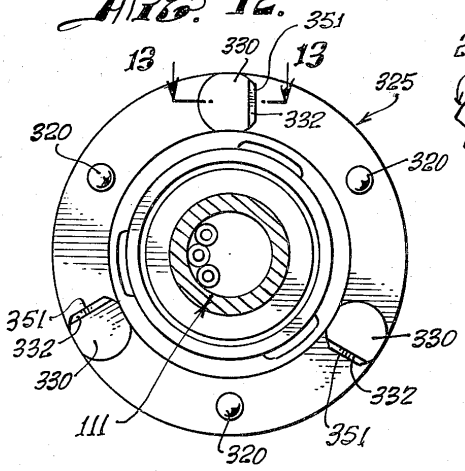


Fig. 14.

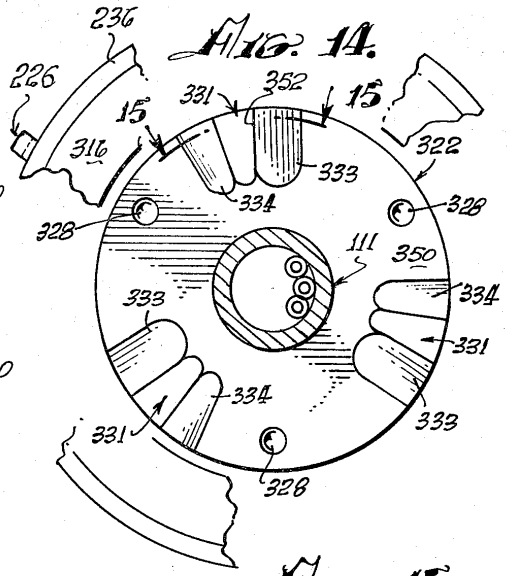


Fig. 13.

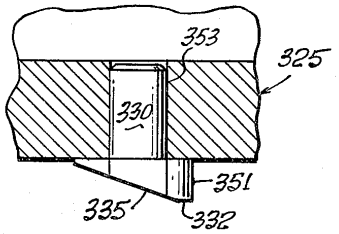


Fig. 15.

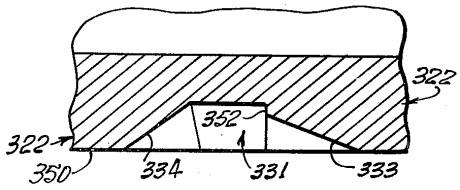


Fig. 16.

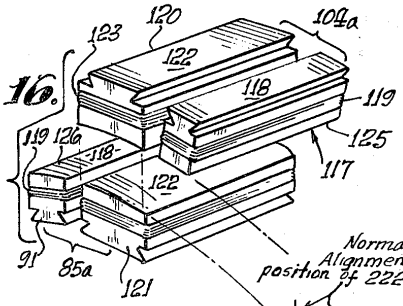
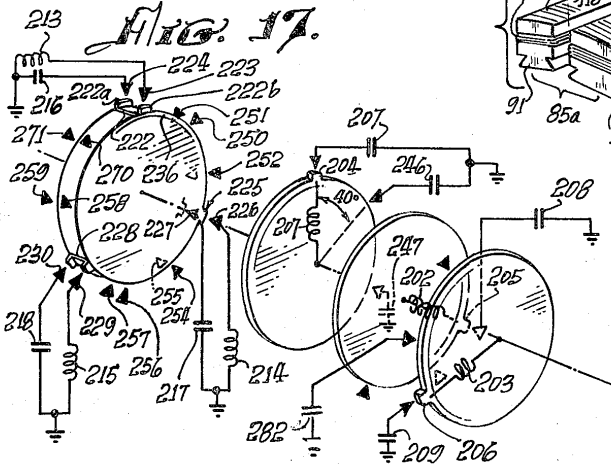
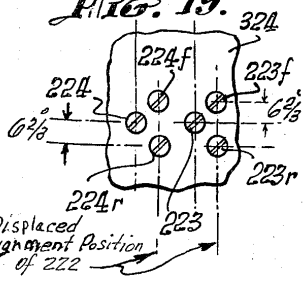


Fig. 17.



Normal Alignment position of 222

Fig. 19.



Displaced Alignment Position of 222

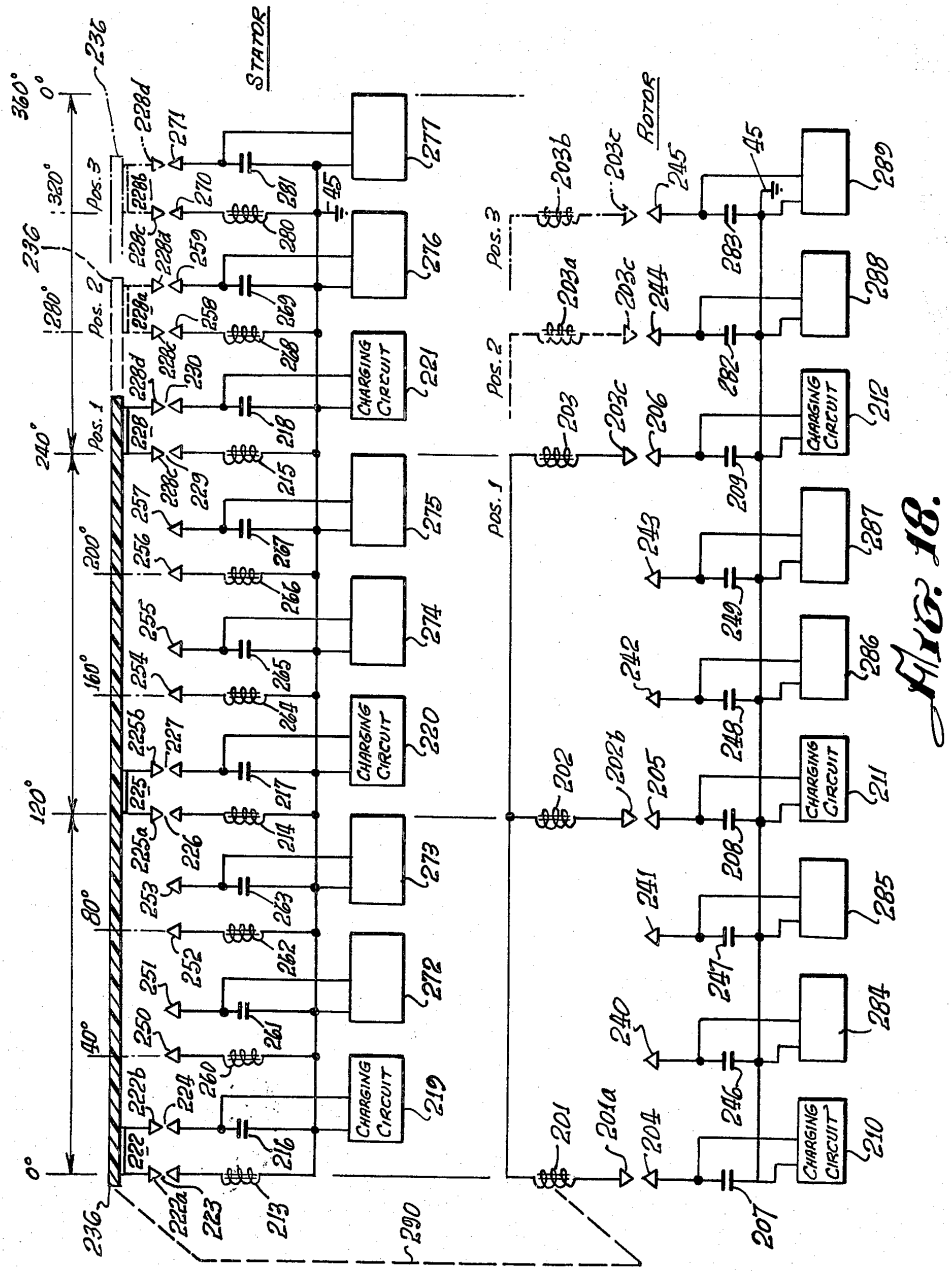

STATOR
ROTOR
Pos. 1
Pos. 2
Pos. 3
CHARGING CIRCUIT
0°
40°
80°
120°
160°
200°
240°
280°
320°
360°

Fig. 18.

United States Patent [19]

Gray, Sr.

[11] **Patent Number: 4,595,975**

[45] **Date of Patent: Jun. 17, 1986**

[54] **EFFICIENT POWER SUPPLY SUITABLE FOR INDUCTIVE LOADS**

[76] Inventor: **Edwin V. Gray, Sr.**, P.O. Box 362, Council, Id. 83612

[21] Appl. No.: **662,339**

[22] Filed: **Oct. 18, 1984**

[51] **Int. Cl.**[4] **H02M 3/42**

[52] **U.S. Cl.** **363/33**; 363/94; 363/110; 323/207; 323/228; 323/291

[58] **Field of Search** ..... 315/33 S; 363/32, 33, 363/76, 94, 109, 110; 323/207, 227, 228, 291

[56] **References Cited**

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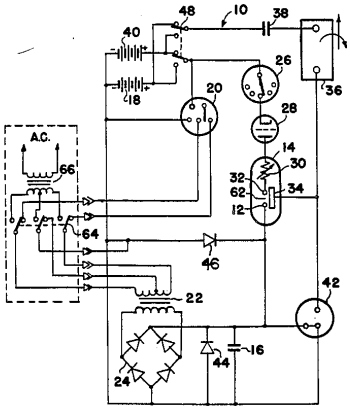
2030801 3/1983 United Kingdom .

Primary Examiner—William H. Beha, Jr.
Assistant Examiner—Jeffrey Sterrett
Attorney, Agent, or Firm—Nixon and Vanderhye

[57] **ABSTRACT**

Disclosed is an Electrical Driving and Recovery System for a High Frequency environment. The recovery system can be applied to drive present day direct-current or alternating-current loads for better efficiency. It has a low-voltage source coupled to a vibrator, a transformer and a bridge-type rectifier to provide a high voltage pulsating signal to a first capacitor. Where a high-voltage source is otherwise available, it may be coupled directly to a bridge-type rectifier, causing a pulsating signal to the first capacitor. The first capacitor in turn is coupled to a high voltage anode of an electrical conversion switching element tube. The switching element tube also includes a low voltage anode which is connected to a voltage source by a commutator and a switching element tube. Mounted around the high voltage anode is a charge receiving plate which is coupled to an inductive load to transmit a high voltage discharge from the switching element tube to the load. Also coupled to the load is a second capacitor for storing the back EMF created by the collapsing electrical field of the load when the current to the load is blocked. The second capacitor is coupled to the voltage source. When adapted to present day direct-current or alternating-current devices the load could be a battery or capacitor to enhance the productivity of electrical energy.

8 Claims, 5 Drawing Figures



EFFICIENT POWER SUPPLY SUITABLE FOR INDUCTIVE LOADS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electrical driving system and a conversion element, and more particularly, to a system for driving an inductive load in a greatly improved and efficient manner.

2. Description of the Prior Act

In the opinion of the inventor, there is no known device which provides the conversion of energy from a direct-current electric source or an alternating-current electric source to a mechanical force based on the principle of this invention. EXAMPLE: A portable energy source, (1) such as a battery, (2) such as alternating-current, (3) such as the combination of battery and alternating-current, may be used with highly improved efficiency to operate a mechanical device, whose output is a linear or rotary force, with an attendant increase in the useful productive period between external applications of energy restoration for the energy source.

SUMMARY OF THE INVENTION

The present invention provides a more efficient driving system comprising a source of electrical voltage; a vibrator connected to the low-voltage source for forming a pulsating signal; a transformer connected to the vibrator for receiving the pulsating signal; a high-voltage source, where available, connected to a bridge-type rectifier; or the bridge-type rectifier connected to the high voltage pulse output of the transformer; a capacitor for receiving the voltage pulse output; a conversion element having first and second anodes, electrically conductive means for receiving a charge positioned about the second anode and an output terminal connected to the charge receiving means, the second anode being connected to the capacitor; a commutator connected to the source of electrical voltage and to the first anode; and an inductive load connected to the output terminal whereby a high energy discharge between the first and second anodes is transferred to the charge receiving means and then to the inductive load.

As a sub-combination, the present invention also includes a conversion element comprising a housing; a first low voltage anode mounted to the housing, the first anode adapted to be connected to a voltage source; a second high voltage anode mounted to the housing, the second anode adapted to be connected to a voltage source; electrically conductive means positioned about the second anode and spaced therefrom for receiving a charge, the charge receiving means being mounted to the housing; and an output terminal communicating with the charge receiving means, said terminal adapted to be connected to an inductive load.

The invention also includes a method for providing power to an inductive load comprising the steps of providing a voltage source, pulsating a signal from said cource; increasing the voltage of said signal; rectifying said signal; storing and increasing the signal; conducting said signal to a high voltage anode; providing a low voltage to a second anode to form a high energy discharge; electrostatically coupling the discharge to a charge receiving element; conducting the discharge to an inductive load; coupling a second capacitor to the load; and coupling the second capacitor to the source.

It is an aim of the present invention to provide a system for driving an inductive load which system is substantially more efficient than any now existing.

Another object of the present invention is to provide a system for driving an inductive load which is reliable, is inexpensive and simply constructed.

The foregoing objects of the present invention together with various other objects, advantages, features and results thereof which will be evident to those skilled in the art in light of this disclosure may be achieved with the exemplary embodiment of the invention described in detail hereinafter and illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic circuit diagram of the electrical driving system.

FIG. **2** is an elevational sectional view of the electrical conversion element.

FIG. **3** is a plan sectional view taken along line **3—3** of FIG. **2**.

FIG. **4** is a plan sectional view taken along line **4—4** of FIG. **2**.

FIG. **5** is a schematic circuit diagram of the alternating-current input circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While the present invention is susceptible of various modifications and alternative constructions, an embodiment is shown in the drawings and will herein be described in detail. It should be understood however that it is not the intention to limit the invention to the particular form disclosed; but, on the contrary, the invention is to cover all modifications, equivalents and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

There is disclosed herein an electrical driving system which, on theory, will convert low voltage electric energy from a source such as an electric storage battery to a high potential, high current energy pulse that is capable of developing a working force at the inductive output of the device that is more efficient than that which is capable of being developed directly from the energy source. The improvement in efficiency is further enhanced by the capability of the device to return that portion of the initial energy developed, and not used by the inductive load in the production of mechanical energy, to the same or second energy reservoir or source for use elsewhere, or for storage.

This system accomplishes the results stated above by harnessing the "electrostatic" or "impulse" energy created by a high-intensity spark generated within a specially constructed electrical conversion switching element tube. This element utilizes a low-voltage anode, a high-voltage anode, and one or more "electrostatic" or charge receiving grids. These grids are of a physical size, and appropriately positioned, as to be compatible with the size of the tube, and therefore, directly related to the amount of energy to be anticipated when the device is operating.

The low-voltage anode may incorporate a resistive device to aid in controlling the amount of current drawn from the energy source. This low-voltage anode is connected to the energy source through a mechanical commutator or a solid-state pulser that controls the timing and duration of the energy spark within the element. The high-voltage anode is connected to a high-

voltage potential developed by the associated circuits. An energy discharge occurs within the element when the external control circuits permit. This short duration, high-voltage, high-current energy pulse is captured by the "electrostatic" grids within the tube, stored momentarily, then transferred to the inductive output load.

The increase in efficiency anticipated in converting the electrical energy to mechanical energy within the inductive load is attributed to the utilization of the most optimum timing in introducing the electrical energy to the load device, for the optimum period of time.

Further enhancement of energy conservation is accomplished by capturing a significant portion of the energy generated by the inductive load when the useful energy field is collapsing. This energy is normally dissipated in load losses that are contrary to the desired energy utilization, and have heretofore been accepted because no suitable means had been developed to harness this energy and restore it to a suitable energy storage device.

The present invention is concerned with two concepts or characteristics. The first of these characteristics is observed with the introduction of an energizing current through the inductor. The inductor creates a contrary force (counter-electromotive force or CEMF) that opposes the energy introduced into the inductor. This CEMF increases throughout the time the introduced energy is increasing.

In normal applications of an alternating-current to an inductive load for mechanical applications, the useful work of the inductor is accomplished prior to terminating the application of energy. The excess energy applied is thereby wasted.

Previous attempts to provide energy inputs to an inductor of time durations limited to that period when the optimum transfer of inductive energy to mechanical energy is occuring, have been limited by the ability of any such device to handle the high current required to optimize the energy transfer.

The second characteristic is observed when the energizing current is removed from the inductor. As the current is decreased, the inductor generates an EMF that opposes the removal of current or, in other words, produces an energy source at the output of the inductor that simulates the original energy source, reduced by the actual energy removed from the circuit by the mechanical load. This "regenerated", or excess, energy has previously been lost due to a failure to provide a storage capability for this energy.

In this invention, a high-voltage, high-current, short duration energy pulse is applied to the inductive load by the conversion element. This element makes possible the use of certain of that energy impressed within an arc across a spark-gap, without the resultant deterioration of circuit elements normally associated with high energy electrical arcs.

This invention also provides for capture of a certain portion of the energy induced by the high inductive kick produced by the abrupt withdrawal of the introduced current. This abrupt withdrawal of current is attendant upon the termination of the stimulating arc. The voltage spike so created is imposed upon a capacitor that couples the attendant current to a secondary energy storage device.

A novel, but not essential, circuit arrangement provides for switching the energy source and the energy storage device. This switching may be so arranged as to actuate automatically at predetermined times. The switching may be at specified periods determined by experimentation with a particular device, or may be actuated by some control device that measures the relative energy content of the two energy reservoirs.

Referring now to FIG. **1**, the system **10** will be described in additional detail. The potential for the high-voltage anode, **12** of the conversion element **14** is developed across the capacitor **16**. This voltage is produced by drawing a low current from a battery source **18** through the vibrator **20**. The effect of the vibrator is to create a pulsating input to the transformer **22**. The turns ratio of the transformer is chosen to optimize the voltage applied to a bridge-type rectifier **24**. The output of the rectifier is then a series of high-voltage pulses of modest current. When the available source is already of the high voltage, AC type, it may be coupled directly to the bridge-type rectifier.

By repetitious application of these output pulses from the bridge-type recrifier to the capacitor **16**, a high-voltage, high-level charge is built up on the capacitor.

Control of the conversion switching element tube is maintained by a commutator **26**. A series of contacts mounted radially about a shaft, or a solid-state switching device sensitive to time or other variable may be used for this control element. A switching element tube type one-way energy path **28** is introduced between the commutator device and the conversion switching element tube to prevent high energy arcing at the commutator current path. When the switching element tube is closed, current from the voltage source **18** is routed through a resistive element **30** and a low voltage anode **32**. This causes a high energy discharge between the anodes within the conversion switching element tube **14**.

The energy content of the high energy pulse is electrostatically coupled to the conversion grids **34** of the conversion element. This electrostatic charge is applied through an output terminal **60** (FIG. **2**) across the load inductance **36**, inducing a strong electromagnetic field about the inductive load. The intensity of this electromagnetic field is determined by the high electromotive potential developed upon the electrostatic grids and the very short time duration required to develop the energy pulse.

If the inductive load is coupled magnetically to a mechanical load, a strong initial torque is developed that may be efficiently utilized to produce physical work.

Upon cessation of the energy pulse (arc) within the conversion switching element tube the inductive load is decoupled, allowing the electromagnetic field about the inductive load to collapse. The collapse of this energy field induces within the inductive load a counter EMF. This counter EMF creates a high positive potential across a second capacitor which, in turn, is induced into the second energy storage device or battery **40** as a charging current. The amount of charging current available to the battery **40** is dependent upon the initial conditions within the circuit at the time of discharge within the conversion switching element tube and the amount of mechanical energy consumed by the work load.

A spark-gap protection device **42** is included in the circuit to protect the inductive load and the rectifier elements from unduly large discharge currents. Should the potentials within the circuit exceed predetermined values, fixed by the mechanical size and spacing of the elements within the protective device, the excess en-

ergy is dissipated (bypassed) by the protective device to the circuit common (electrical ground).

Diodes **44** and **46** bypass the excess overshoot generated when the "Energy Conversion Switching Element Tube" is triggered. A switching element **48** allows either energy storage source to be used as the primary energy source, while the other battery is used as the energy retrieval unit. The switch facilitates interchanging the source and the retrieval unit at optimum intervals to be determined by the utilization of the conversion switching element tube. This switching may be accomplished manually or automatically, as determined by the choice of switching element from among a large variety readily available for the purpose.

FIGS. **2**, **3**, and **4** show the mechanical structure of the conversion switching element tube **14**. An outer housing **50** may be of any insulative material such as glass. The anodes **12** and **22** and grids **34***a* and **34***b* are firmly secured by nonconductive spacer material **54**, and **56**. The resistive element **30** may be introduced into the low-voltage anode path to control the peak currents through the conversion switching element tube. The resistive element may be of a piece, or it may be built of one or more resistive elements to achieve the desired result.

The anode material may be identical for each anode, or may be of differing materials for each anode, as dictated by the most efficient utilization of the device, as determined by appropriate research at the time of production for the intended use.

The shape and spacing of the electrostatic grids is also susceptible to variation with application (voltage, current, and energy requirements).

It is the contention of the inventor that by judicious mating of the elements of the conversion switching element tube, and the proper selection of the components of the circuit elements of the system, the desired theoretical results may be achieved. It is the inventor's contention that this mating and selection process is well within the capabilities of intensive research and development technique.

Let it be stated here that substituting a source of electric alternating-current subject to the required current and/or voltage shaping and/or timing, either prior to being considered a primary energy source, or thereafter, should not be construed to change the described utilization or application of primary energy in any way. Such energy conversion is readily achieved by any of a multitude of well established principles. The preferred embodiment of this invention merely assumes optimum utilization and optimum benefit from this invention when used with portable energy devices similar in principle to the wet-cell or dry-cell battery.

This invention proposes to utilize the energy contained in an internally generated high-voltage electric spike (energy pulse) to electrically energize an inductive load; this inductive load being then capable of converting the energy so supplied into a usefu1 electrical or mechanical output.

In operation the high-voltage, short-duration electric spike is generated by discharging the capacitor **16** across the spark-gap in the conversion switching element tube. The necessary high-voltage potential is stored on the capacitor in incremental, additive steps from the bridge-type rectifier **24**.

When the energy source is a direct-current electric energy storage device, such as the battery **12**, the input to the bridge rectifier is provided by the voltage step-up transformer **22**, that is in turn energized from the vibrator **20**, or solid-state chopper, or similar device to properly drive the transformer and rectifier circuits.

When the energy source is an alternating-current, switches **64** disconnect transformer **22** and the input to the bridge-type rectifier **24** is provided by the voltage step-up transformer **66**, that is in turn energized from the vibrator **20**, or solid-state chopper, or similar device to properly drive the transformer and rectifier circuits.

The repetitions output of the bridge rectifier incrementally increases the capacitor charge toward its maximum. This charge is electrically connected directly to the high-voltage anode **12** of the conversion switching element tube.

When the low-voltage anode **32** is connected to a source of current, an arc is created in the spark-gap designated **62** of the conversion switching element tube equivalent to the potential stored on the high-voltage anode, and the current available from the low-voltage anode. Because the duration of the arc is very short, the instantaneous voltage, and instantaneous current may both be very high. The instantaneous peak apparent power is therefore, also very high. Within the conversion switching element tube, this energy is absorbed by the grids **34***a* and **34***b* mounted circumferentially about the interior of the tube.

Control of the energy spike within the conversion switching element tube is accomplished by a mechanical, or solid-state commutator, that closes the circuit path from the low-voltage anode to the current source at that moment when the delivery of energy to the output load is most auspicious. Any number of standard high-accuracy, variable setting devices are available for this purpose. When control of the repetitive rate of the system's output is required, it is accomplished by controllihg the time of connection at the low-voltage anode.

Thus there can be provided an electrical driving system having a low-voltage source coupled to a vibrator, a transformer and a bridge-type rectifier to provide a high voltage pulsating signal to a first capacitor. Where a high-voltage source is otherwise available, it may be coupled direct to a bridge-type rectifier, causing a pulsating signal to a first capacitor. The capacitor in turn is coupled to a high-voltage anode of an electrical conversion switching element tube. The element also includes a low-voltage anode which in turn is connected to a voltage source by a commutator, a switching element tube, and a variable resistor. Mounted around the high-voltage anode is a charge receiving plate which in turn is coupled to an inductive load to transmit a high-voltage discharge from the element to the load. Also coupled to the load is a second capacitor for storing the back EMF created by the collapsing electrical field of the load when the current to the load is blocked. The second capacitor in turn is coupled to the voltage source.

What is claimed is:

1. An electrical driving system comprising:

a source of electrical voltage;

a vibrator connected to said source for forming a pulsating signal;

a transformer connected to said vibrator for receiving said pulsating signal;

a rectifier connected to said transformer having a high-voltage pulse output;

a capacitor for receiving said voltage pulse output;

a conversion switching element tube having first and second anodes, electrically conductive means for receiving a charge positioned about said second anode and an output terminal connected to said charge receiving means, said second anode being connected to said capacitor;

a commutator connected to said source of electrical voltage and to said first anode; and

an inductive load connected to said output terminal whereby a high energy discharge between said first and second anodes is transferred to said charge receiving means and then to said inductive load.

2. A system as claimed in claim **1**, including

a second capacitor for receiving a charge from said load.

3. A system as claimed in claim **2**, including

a switching element tube positioned in series between said commutator and said first anode.

4. A system as claimed in claim **3**, including

a second source of voltage and a switch for receiving a signal from said second capacitor.

5. A system as claimed in claim **4** wherein:

said conversion switching element tube includes a resistive element in series with said first anode; and

said charge receiving means is tubularly shaped.

6. A system as in claim **1** wherein said source comprises a direct current source and wherein said system further comprises:

a source of alternating current; and

a switch means for selecting said direct-current or said alternating-current power source as input to said rectifier.

7. A system as in claim **1** wherein said rectifier comprises a bridge-type rectifier.

8. A method for providing power to an inductive load comprising the steps of

providing a voltage source;

pulsating a signal from said source;

increasing the voltage of said signal;

rectifying said signal;

storing and increasing said signal;

conducting said signal to a high-voltage anode;

providing a low-voltage to a second anode to form a high energy discharge;

electrostatically coupling said discharge to a charge receiving element;

conducting said discharge to an inductive load;

coupling a second capacitor to said load; and

coupling said capacitor to said source.

* * * * *

FIG. 1

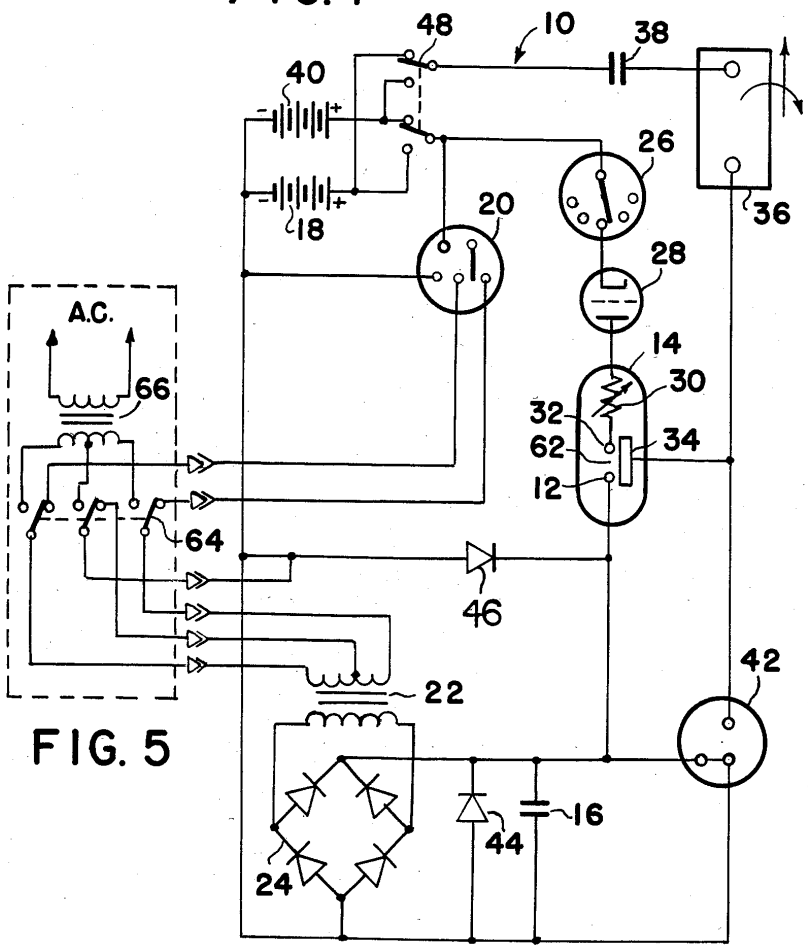


FIG. 5

FIG. 2

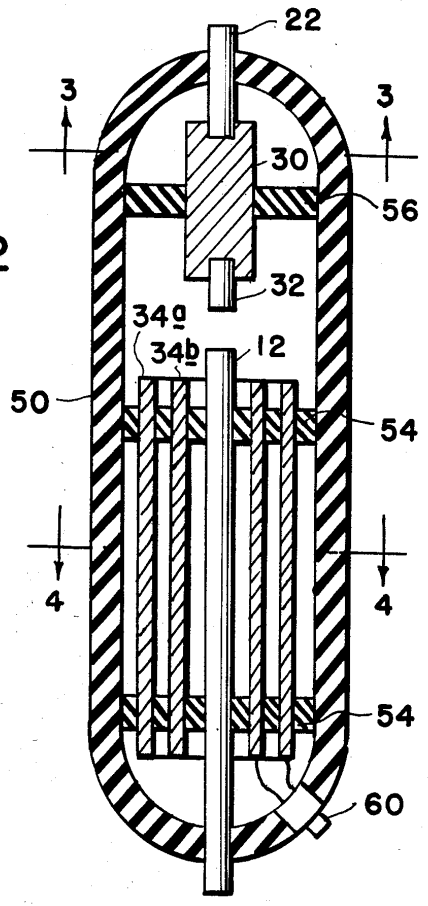


FIG. 3

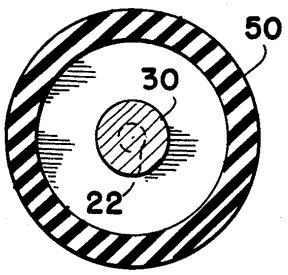
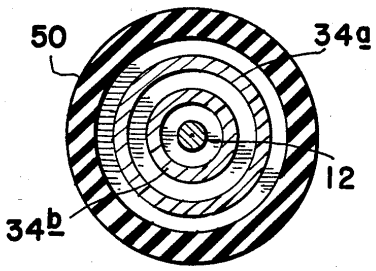


FIG. 4



United States Patent [19]

Gray, Sr.

[11] **Patent Number: 4,661,747**

[45] **Date of Patent: Apr. 28, 1987**

[54] **EFFICIENT ELECTRICAL CONVERSION SWITCHING TUBE SUITABLE FOR INDUCTIVE LOADS**

[76] Inventor: **Edwin V. Gray, Sr.**, P.O. Box 362, Council, Id. 83612

[21] Appl. No.: **791,508**

[22] Filed: **Oct. 25, 1985**

Related U.S. Application Data

[62] Division of Ser. No. 662,339, Oct. 18, 1984, Pat. No. 4,595,975.

[30] **Foreign Application Priority Data**

Dec. 16, 1983 [GR] Greece 124388

[51] **Int. Cl.**[4] **H01J 11/04;** H01J 13/48; H05B 37/00; H05B 39/00

[52] **U.S. Cl.** **315/330;** 313/601; 313/602; 313/604; 315/261; 315/335

[58] **Field of Search** 315/57, 58, 60, 36, 315/334, 335, 330, 336, 261; 313/595, 601, 602, 603

[56] **References Cited**

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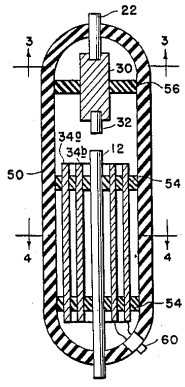
Primary Examiner—Saxfield Chatmon

[57] **ABSTRACT**

Disclosed is an electrical driving and recovery system for a high frequency environment. The recovery system can be applied to drive present day direct-current or alternating-current loads for better efficiency. It has a low-voltage source coupled to a vibrator, a transformer and a bridge-type rectifier to provide a high voltage pulsating signal to a first capacitor. Where a high-voltage source is otherwise available, it may be coupled directly to a bridge-type rectifier, causing a pulsating signal to the first capacitor. The first capacitor in turn is coupled to a high voltage anode of an electrical conversion switching element tube. The switching element tube also includes a low voltage anode which is connected to a voltage source by a commutator and a switching element tube. Mounted around the high voltage anode is a charge receiving plate which is coupled to an inductive load to transmit a high voltage discharge from the switching element tube to the load. Also coupled to the load is a second capacitor for storing the back EMF created by the collapsing electrical field of the load when the current to the load is blocked. The second capacitor is coupled to the voltage source. When adapted to present day direct-current or alternating-current devices the load could be a battery or capacitor to enhance the productivity of electrical energy.

4 Claims, 5 Drawing Figures



EFFICIENT ELECTRICAL CONVERSION SWITCHING TUBE SUITABLE FOR INDUCTIVE LOADS

This is a division of application Ser. No. 662,339, filed Oct. 18, 1984, now U.S. Pat. No. 4,595,975.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electrical driving system and a conversion element, and more particularly, to a system for driving an inductive load in a greatly improved and efficient manner.

2. Description of the Prior Act

In the opinion of the inventor, there is no known device which provides the conversion of energy from a direct-current electric source or an alternating-current electric source to a mechanical force based on the principle of this invention. EXAMPLE: A portable energy source, (1) such as a battery, (2) such as alternating-current, (3) such as the combination of battery and alternating-current, may be used with highly improved efficiency to operate a mechanical device, whose output is a linear or rotary force, with an attendant increase in the useful productive period between external applications of energy restoration for the energy source.

SUMMARY OF THE INVENTION

The present invention provides a more efficient driving system comprising a source of electrical voltage; a vibrator connected to the low-voltage source for forming a pulsating signal; a transformer connected to the vibrator for receiving the pulsating signal; a high-voltage source, where available, connected to a bridge-type rectifier; or the bridge-type rectifier connected to the high voltage pulse output of the transformer; a capacitor for receiving the voltage pulse output; a conversion element having first and second anodes, electrically conductive means for receiving a charge positioned about the second anode and an output terminal connected to the charge receiving means, the second anode being connected to the capacitor; a commutator connected to the source of electrical voltage and to the first anode; and an inductive load connected to the output terminal whereby a high energy discharge between the first and second anodes is transferred to the charge receiving means and then to the inductive load.

As a sub-combination, the present invention also includes a conversion element comprising a housing; a first low voltage anode mounted to the housing, the first anode adapted to be connected to a voltage source; a second high voltage anode mounted to the housing, the second anode adapted to be connected to a voltage source; electrically conductive means positioned about the second anode and spaced therefrom for receiving a charge, the charge receiving means being mounted to the housing; and an output terminal communicating with the charge receiving means, said terminal adapted to be connected to an inductive load.

The invention also includes a method for providing power to an inductive load comprising the steps of providing a voltage source, pulsating a signal from said source; increasing the voltage of said signal; rectifying said signal; storing and increasing the signal; conducting said signal to a high voltage anode; providing a low voltage to a second anode to form a high energy discharge; electrostatically coupling the discharge to a charge receiving element; conducting the discharge to an inductive load; coupling a second capacitor to the load; and coupling the second capacitor to the source.

It is an aim of the present invention to provide a system for driving an inductive load which system is substantially more efficient than any now existing.

Another object of the present invention is to provide a system for driving an inductive load which is reliable, is inexpensive and simply constructed.

The foregoing objects of the present invention together with various other objects, advantages, features and results thereof which will be evident to those skilled in the art in light of this disclosure may be achieved with the exemplary embodiment of the invention described in detail hereinafter and illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic circuit diagram of the electrical driving system.

FIG. **2** is an elevational sectional view of the electrical conversion element.

FIG. **3** is a plan sectional view taken along line **3—3** of FIG. **2**.

FIG. **4** is a plan sectional view taken along line **4—4** of FIG. **2**.

FIG. **5** is a schematic circuit diagram of the alternating-current input circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While the present invention is susceptible of various modifications and alternative constructions, an embodiment is shown in the drawings and will herein be described in detail. It should be understood however that it is not the intention to limit the invention to the particular form disclosed; but, on the contrary, the invention is to cover all modifications, equivalents and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

There is disclosed herein an electrical driving system which, on theory, will convert low voltage electric energy from a source such as an electric storage battery to a high potential, high current energy pulse that is capable of developing a working force at the inductive output of the device that is more efficient than that which is capable of being developed directly from the energy source. The improvement in efficiency is further enhanced by the capability of the device to return that portion of the initial energy developed, and not used by the inductive load in the production of mechanical energy, to the same or second energy reservoir or source for use elsewhere, or for storage.

This system accomplishes the results stated above by harnessing the "electrostatic" or "impulse" energy created by a high-intensity spark generated within a specially constructed electrical conversion switching element tube. This element utilizes a low-voltage anode, a high-voltage anode, and one or more "electrostatic" or charge receiving grids. These grids are of a physical size, and appropriately positioned, as to be compatible with the size of the tube, and therefore, directly related to the amount of energy to be anticipated when the device is operating.

The low-voltage anode may incorporate a resistive device to aid in controlling the amount of current drawn from the energy source. This low-voltage anode is connected to the energy source through a mechanical

commutator or a solid-state pulser that controls the timing and duration of the energy spark within the element. The high-voltage anode is connected to a high-voltage potential developed by the associated circuits. An energy discharge occurs within the element when the external control circuits permit. This short duration, high-voltage, high-current energy pulse is captured by the "electrostatic" grids within the tube, stored momentarily, then transferred to the inductive output load.

The increase in efficiency anticipated in converting the electrical energy to mechanical energy within the inductive load is attributed to the utilization of the most optimum timing in introducing the electrical energy to the load device, for the optimum period of time.

Further enhancement of energy conservation is accomplished by capturing a significant portion of the energy generated by the inductive load when the useful energy field is collapsing. This energy is normally dissipated in load losses that are contrary to the desired energy utilization, and have heretofore been accepted because no suitable means had been developed to harness this energy and restore it to a suitable energy storage device.

The present invention is concerned with two concepts or characteristics. The first of these characteristics is observed with the introduction of an energizing current through the inductor. The inductor creates a contrary force (counter-electromotive force or CEMF) that opposes the energy introduced into the inductor. This CEMF increases throughout the time the introduced energy is increasing.

In normal applications of an alternating-current to an inductive load for mechanical applications, the useful work of the inductor is accomplished prior to terminating the application of energy. The excess energy applied is thereby wasted.

Previous attempts to provide energy inputs to an inductor of time durations limited to that period when the optimum transfer of inductive energy to mechanical energy is occuring, have been limited by the ability of any such device to handle the high current required to optimize the energy transfer.

The second characteristic is observed when the energizing current is removed from the inductor. As the current is decreased, the inductor generates an EMF that opposes the removal of current or, in other words, produces an energy source at the output of the inductor that simulates the original energy source, reduced by the actual energy removed from the circuit by the mechanical load. This "regenerated", or excess, energy has previously been lost due to a failure to provide a storage capability for this energy.

In this invention, a high-voltage, high-current, short duration energy pulse is applied to the inductive load by the conversion element. This element makes possible the use of certain of that energy impressed within an arc across a spark-gap, without the resultant deterioration of circuit elements normally associated with high energy electrical arcs.

This invention also provides for capture of a certain portion of the energy induced by the high inductive kick produced by the abrupt withdrawal of the introduced current. This abrupt withdrawal of current is attendant upon the termination of the stimulating arc. The voltage spike so created is imposed upon a capacitor that couples the attendant current to a secondary energy storage device.

A novel, but not essential, circuit arrangement provides for switching the energy source and the energy storage device. This switching may be so arranged as to actuate automatically at predetermined times. The switching may be at specified periods determined by experimentation with a particular device, or may be actuated by some control device that measures the relative energy content of the two energy reservoirs.

Referring now to FIG. **1**, the system **10** will be described in additional detail. The potential for the high-voltage anode **12** of the conversion element **14** is developed across the capacitor **16**. This voltage is produced by drawing a low current from a battery source **18** through the vibrator **20**. The effect of the vibrator is to create a pulsating input to the transformer **22**. The turns ratio of the transformer is chosen to optimize the voltage applied to a bridge-type rectifier **24**. The output of the rectifier is then a series of high-voltage pulses of modest current. When the available source is already of the high voltage AC type, it may be coupled directly to the bridge-type rectifier.

By repetitious application of these output pulses from the bridge-type recrifier to the capacitor **16**, a high-voltage high-level charge is built up on the capacitor.

Control of the conversion switching element tube is maintained by a commutator **26**. A series of contacts mounted radially about a shaft, or a solid-state switching device sensitive to time or other variable may be used for this control element. A switching element tube type one-way energy path **28** is introduced between the commutator device and the conversion switching element tube to prevent high energy arcing at the commutator current path. When the switching element tube is closed, current from the voltage source **18** is routed through a resistive element **30** and a low voltage anode **32**. This causes a high energy discharge between the anodes within the conversion switching element tube **14**.

The energy content of the high energy pulse is electrostatically coupled to the conversion grids **34** of the conversion element. This electrostatic charge is applied through an output terminal **60** (FIG. **2**) across the load inductance **36**, inducing a strong electromagnetic field about the inductive load. The intensity of this electromagnetic field is determined by the high electromotive potential developed upon the electrostatic grids and the very short time duration required to develop the energy pulse.

If the inductive load is coupled magnetically to a mechanical load, a strong initial torque is developed that may be efficiently utilized to produce physical work.

Upon cessation of the energy pulse (arc) within the conversion switching element tube the inductive load is decoupled, allowing the electromagnetic field about the inductive load to collapse. The collapse of this energy field induces within the inductive load a counter EMF. This counter EMF creates a high positive potential across a second capacitor **38** which, in turn, is induced into the second energy storage device or battery **40** as a charging current. The amount of charging current available to the battery **40** is dependent upon the initial conditions within the circuit at the time of discharge within the conversion switching element tube and the amount of mechanical energy consumed by the work load.

A spark-gap protection device **42** is included in the circuit to protect the inductive load and the rectifier

elements from unduly large discharge currents. Should the potentials within the circuit exceed predetermined values, fixed by the mechanical size and spacing of the elements within the protective device, the excess energy is dissipated (bypassed) by the protective device to the circuit common (electrical ground).

Diodes **44** and **46** bypass the excess overshoot generated when the "Energy Conversion Switching Element Tube" is triggered. A switching element **48** allows either energy storage source to be used as the primary energy source, while the other battery is used as the energy retrieval unit. The switch facilitates interchanging the source and the retrieval unit at optimum intervals to be determined by the utilization of the conversion switching element tube. This switching may be accomplished manually or automatically, as determined by the choice of switching element from among a large variety readily available for the purpose.

FIGS. **2**, **3**, and **4** show the mechanical structure of the conversion switching element tube **14**. An outer housing **50** may be of any insulative material such as glass. The anodes **12** and **32** and grids **34***a* and **34***b* are firmly secured by nonconductive spacer material **54**, and **56**. The resistive element **30** may be introduced into the low-voltage anode path to control the peak currents through the conversion switching element tube. The resistive element may be of a piece, or it may be built of one or more resistive elements to achieve the desired result.

The anode material may be identical for each anode, or may be of differing materials for each anode, as dictated by the most efficient utilization of the device, as determined by appropriate research at the time of production for the intended use.

The shape and spacing of the electrostatic grids is also susceptible to variation with application (voltage, current, and energy requirements).

It is the contention of the inventor that by judicious mating of the elements of the conversion switching element tube, and the proper selection of the components of the circuit elements of the system, the desired theoretical results may be achieved. It is the inventor's contention that this mating and selection process is well within the capabilities of intensive research and development technique.

Let it be stated here that substituting a source of electric alternating-current subject to the required current and/or voltage shaping and/or timing, either prior to being considered a primary energy source, or thereafter, should not be construed to change the described utilization or application of primary energy in any way. Such energy conversion is readily achieved by any of a multitude of well established principles. The preferred embodiment of this invention merely assumes optimum utilization and optimum benefit from this invention when used with portable energy devices similar in principle to the wet-cell or dry-cell battery.

This invention proposes to utilize the energy contained in an internally generated high-voltage electric spike (energy pulse) to electrically energize an inductive load; this inductive load being then capable of converting the energy so supplied into a useful electrical or mechanical output

In operation the high-voltage, short-duration electric spike is generated by discharging the capacitor **16** across the spark-gap in the conversion switching element tube. The necessary high-voltage potential is stored on the capacitor in incremental, additive steps from the bridge-type rectifier **24**.

When the energy source is a direct-current electric energy storage device, such as the battery **12**, the input to the bridge rectifier is provided by the voltage step-up transformer **22**, that is in turn energized from the vibrator **20**, or solid-state chopper, or similar device to properly drive the transformer and rectifier circuits.

When the energy source is an alternating-current, switches **64** disconnect transformer **22** and the input to the bridge-type rectifier **24** is provided by the voltage step-up transformer **66**, that is in turn energized from the vibrator **20**, or solid-state chopper, or similar device to properly drive the transformer and rectifier circuits.

The repetitious output of the bridge rectifier incrementally increases the capacitor charge toward its maximum. This charge is electrically connected directly to the high-voltage anode **12** of the conversion switching element tube.

When the low-voltage anode **32** is connected to a source of current, an arc is created in the spark-gap designated **62** of the conversion switching element tube equivalent to the potential stored on the high-voltage anode, and the current available from the low-voltage anode. Because the duration of the arc is very short, the instantaneous voltage, and instantaneous current may both be very high. The instantaneous peak apparent power is therefore, also very high. Within the conversion switching element tube, this energy is absorbed by the grids **34***a* and **34***b* mounted circumferentially about the interior of the tube.

Control of the energy spike within the conversion switching element tube is accomplished by a mechanical, or solid-state commutator, that closes the circuit path from the low-voltage anode to the current source at that moment when the delivery of energy to the output load is most auspicious. Any number of standard high-accuracy, variable setting devices are available for this purpose. When control of the repetitive rate of the system's output is required, it is accomplished by controlling the time of connection at the low-voltage anode.

Thus there can be provided an electrical driving system having a low-voltage source coupled to a vibrator, a transformer and a bridge-type rectifier to provide a high voltage pulsating signal to a first capacitor. Where a high-voltage source is otherwise available, it may be coupled direct to a bridge-type rectifier, causing a pulsating signal to a first capacitor. The capacitor in turn is coupled to a high-voltage anode of an electrical conversion switching element tube. The element also includes a low-voltage anode which in turn is connected to a voltage source by a commutator, a switching element tube, and a variable resistor. Mounted around the high-voltage anode is a charge receiving plate which in turn is coupled to an inductive load to transmit a high-voltage discharge from the element to the load. Also coupled to the load is a second capacitor for storing the back EMF created by the collapsing electrical field of the load when the current to the load is blocked. The second capacitor in turn is coupled to the voltage source.

What is claimed is:

1. An electrical conversion switching element tube comprising:

a closed insulative housing (**50**);

a first low-voltage anode (**32**) mounted internally to said housing and extending internally to an electri-

cal discharge area (62), said first anode adapted to be connected to a voltage source external to the housing;

a second high-voltage anode (12) mounted internally to said housing and extending internally to said electrical discharge area (62), said second anode also being adapted to be connected to a voltage source external to the housing;

electrically conductive means (34*b*) positioned internally within said housing and extending circumferentially about said second anode while being directly exposed thereto but not conductively connected thereto but, rather, spaced therefrom for receiving an electrostatic charge from the second anode when a discharge current is triggered across said discharge area between said first and second anodes, said charge receiving electrically conductive means also being internally mounted to said housing; and

an output terminal (60) communicating with said charge receiving electrically conductive means, said terminal adapted to be connected to an inductive load externally of said housing.

2. An electrical conversion switching element tube as claimed in claim 1, including a resistive element (30) in series with said first anode.

3. An electrical conversion switching element tube as claimed in claim 1 wherein:

said charge receiving electrically conductive means is tubularly shaped.

4. An electrical conversion switching element tube as claimed in claim 3, including

a second tubularly shaped charge receiving electrically conductive means (34*a*) positioned circumferentially about said first mentioned charge receiving electrically conductive means.

* * * * *

FIG. 1

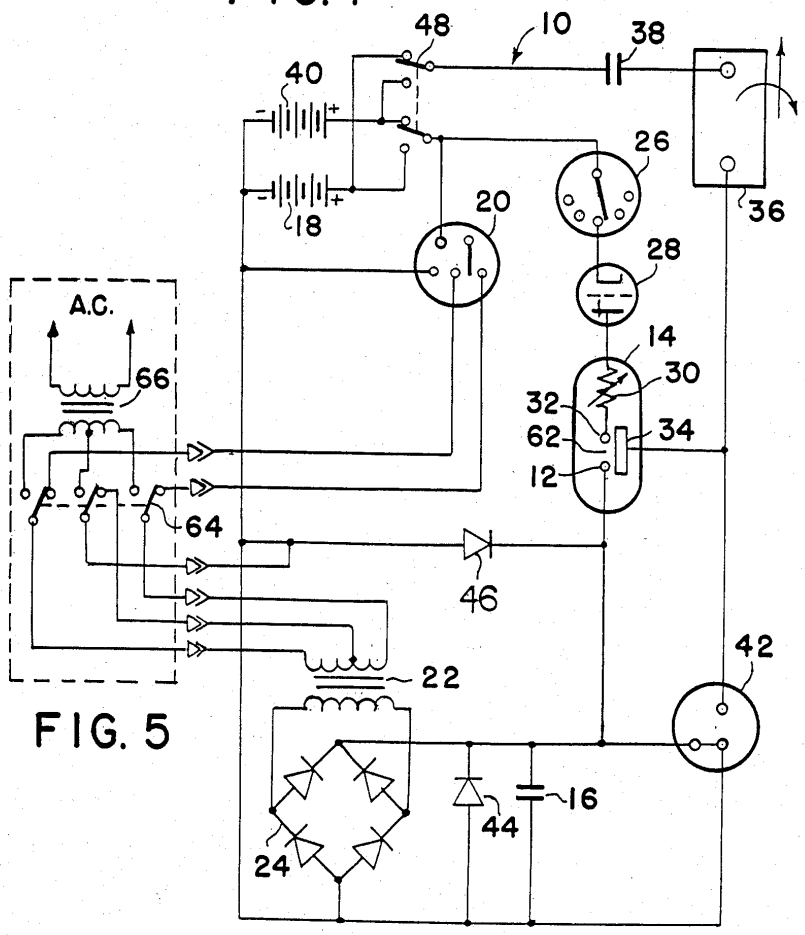


FIG. 5

FIG. 2

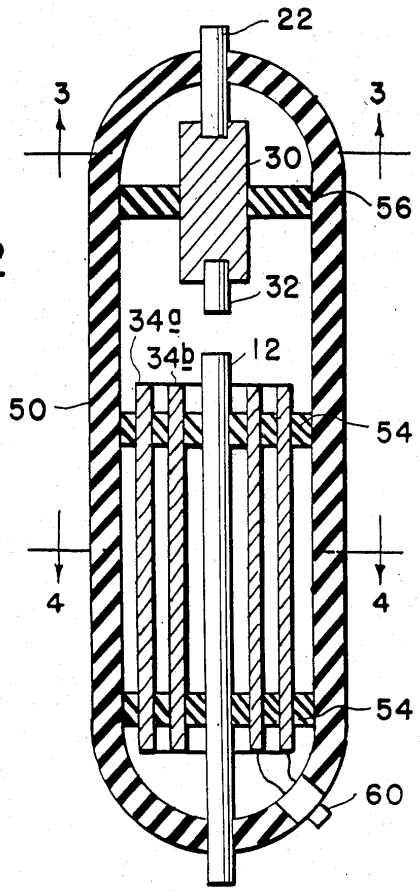


FIG. 3

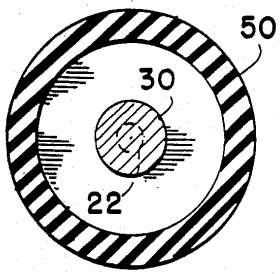
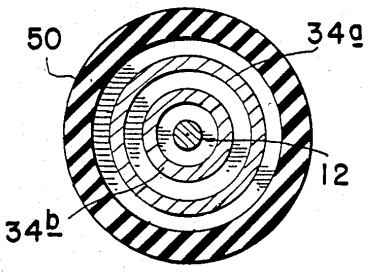


FIG. 4



APPENDIX II

Three U.S. Patents by Dr. Nikola Tesla

1. USP # 593,138 - "Electrical Transformer"

2. USP # 685,958 - "Method Of Utilizing Radiant Energy"

3. USP # 787,412 - "Art of Transmitting Electrical Energy Through the Natural Medium"

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

ELECTRICAL TRANSFORMER.

SPECIFICATION forming part of Letters Patent No. 593,138, dated November 2, 1897.

Application filed March 20, 1897. Serial No. 628,453. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electrical Transformers, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

The present application is based upon an apparatus which I have devised and employed for the purpose of developing electrical currents of high potential, which transformers or induction-coils constructed on the principles heretofore followed in the manufacture of such instruments are wholly incapable of producing or practically utilizing, at least without serious liability of the destruction of the apparatus itself and danger to persons approaching or handling it.

The improvement involves a novel form of transformer or induction-coil and a system for the transmission of electrical energy by means of the same in which the energy of the source is raised to a much higher potential for transmission over the line than has ever been practically employed heretofore, and the apparatus is constructed with reference to the production of such a potential and so as to be not only free from the danger of injury from the destruction of insulation, but safe to handle. To this end I construct an induction-coil or transformer in which the primary and secondary coils are wound or arranged in such manner that the convolutions of the conductor of the latter will be farther removed from the primary as the liability of injury from the effects of potential increases, the terminal or point of highest potential being the most remote, and so that between adjacent convolutions there shall be the least possible difference of potential.

The type of coil in which the last-named features are present is the flat spiral, and this form I generally employ, winding the primary on the outside of the secondary and taking off the current from the latter at the center or inner end of the spiral. I may depart from or vary this form, however, in the particulars hereinafter specified.

In constructing my improved transformers I employ a length of secondary which is approximately one-quarter of the wave length of the electrical disturbance in the circuit including the secondary coil, based on the velocity of propagation of electrical disturbances through such circuit, or, in general, of such length that the potential at the terminal of the secondary which is the more remote from the primary shall be at its maximum. In using these coils I connect one end of the secondary, or that in proximity to the primary, to earth, and in order to more effectually provide against injury to persons or to the apparatus I also connect it with the primary.

In the accompanying drawings, Figure 1 is a diagram illustrating the plan of winding and connection which I employ in constructing my improved coils and the manner of using them for the transmission of energy over long distances. Fig. 2 is a side elevation, and Fig. 3 a side elevation and part section, of modified forms of induction-coil made in accordance with my invention.

A designates a core, which may be magnetic when so desired.

B is the secondary coil, wound upon said core in generally spiral form.

C is the primary, which is wound around in proximity to the secondary. One terminal of the latter will be at the center of the spiral coil, and from this the current is taken to line or for other purposes. The other terminal of the secondary is connected to earth and preferably also to the primary.

When two coils are used in a transmission system in which the currents are raised to a high potential and then reconverted to a lower potential, the receiving-transformer will be constructed and connected in the same manner as the first—that is to say, the inner or center end of what corresponds to the secondary of the first will be connected to line and the other end to earth and to the local circuit or that which corresponds to the primary of the first. In such case also the line-wire should be supported in such manner as to avoid loss by the current jumping from line to objects in its vicinity and in contact with earth—as, for example, by means of long insulators, mounted, preferably, on metal poles, so that in case of leakage from the line it will pass harmlessly to earth. In Fig. 1, where such a system is illustrated, a dynamo G is con-

veniently represented as supplying the primary of the sending or "step-up" transformer, and lamps H and motors K are shown as connected with the corresponding circuit of the receiving or "step-down" transformer.

Instead of winding the coils in the form of a flat spiral the secondary may be wound on a support in the shape of a frustum of a cone and the primary wound around its base, as shown in Fig. 2.

In practice for apparatus designed for ordinary usage the coil is preferably constructed on the plan illustrated in Fig. 3. In this figure L L are spools of insulating material upon which the secondary is wound—in the present case, however, in two sections, so as to constitute really two secondaries. The primary C is a spirally-wound flat strip surrounding both secondaries B.

The inner terminals of the secondaries are led out through tubes of insulating material M, while the other or outside terminals are connected with the primary.

The length of the secondary coil B or of each secondary coil when two are used, as in Fig. 3, is, as before stated, approximately one-quarter of the wave length of the electrical disturbance in the secondary circuit, based on the velocity of propagation of the electrical disturbance through the coil itself and the circuit with which it is designed to be used—that is to say, if the rate at which a current traverses the circuit, including the coil, be one hundred and eighty-five thousand miles per second, then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long, and each wave length would be two hundred miles in length. For such a frequency I should use a secondary fifty miles in length, so that at one terminal the potential would be zero and at the other maximum.

Coils of the character herein described have several important advantages. As the potential increases with the number of turns the difference of potential between adjacent turns is comparatively small, and hence a very high potential, impracticable with ordinary coils, may be successfully maintained.

As the secondary is electrically connected with the primary the latter will be at substantially the same potential as the adjacent portions of the secondary, so that there will be no tendency for sparks to jump from one to the other and destroy the insulation. Moreover, as both primary and secondary are grounded and the line-terminal of the coil carried and protected to a point remote from the apparatus the danger of a discharge through the body of a person handling or approaching the apparatus is reduced to a minimum.

I am aware that an induction-coil in the form of a flat spiral is not in itself new, and this I do not claim; but

What I claim as my invention is—

1. A transformer for developing or converting currents of high potential, comprising a primary and secondary coil, one terminal of the secondary being electrically connected with the primary, and with earth when the transformer is in use, as set forth.

2. A transformer for developing or converting currents of high potential, comprising a primary and secondary wound in the form of a flat spiral, the end of the secondary adjacent to the primary being electrically connected therewith and with earth when the transformer is in use, as set forth.

3. A transformer for developing or converting currents of high potential comprising a primary and secondary wound in the form of a spiral, the secondary being inside of, and surrounded by, the convolutions of the primary and having its adjacent terminal electrically connected therewith and with earth when the transformer is in use, as set forth.

4. In a system for the conversion and transmission of electrical energy, the combination of two transformers, one for raising, the other for lowering, the potential of the currents, the said transformers having one terminal of the longer or fine-wire coils connected to line, and the other terminals adjacent to the shorter coils electrically connected therewith and to the earth, as set forth.

NIKOLA TESLA.

Witnesses:
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(No Model.) 2 Sheets—Sheet 1.

N. TESLA.

ELECTRICAL TRANSFORMER.

No. 593,138. Patented Nov. 2, 1897.

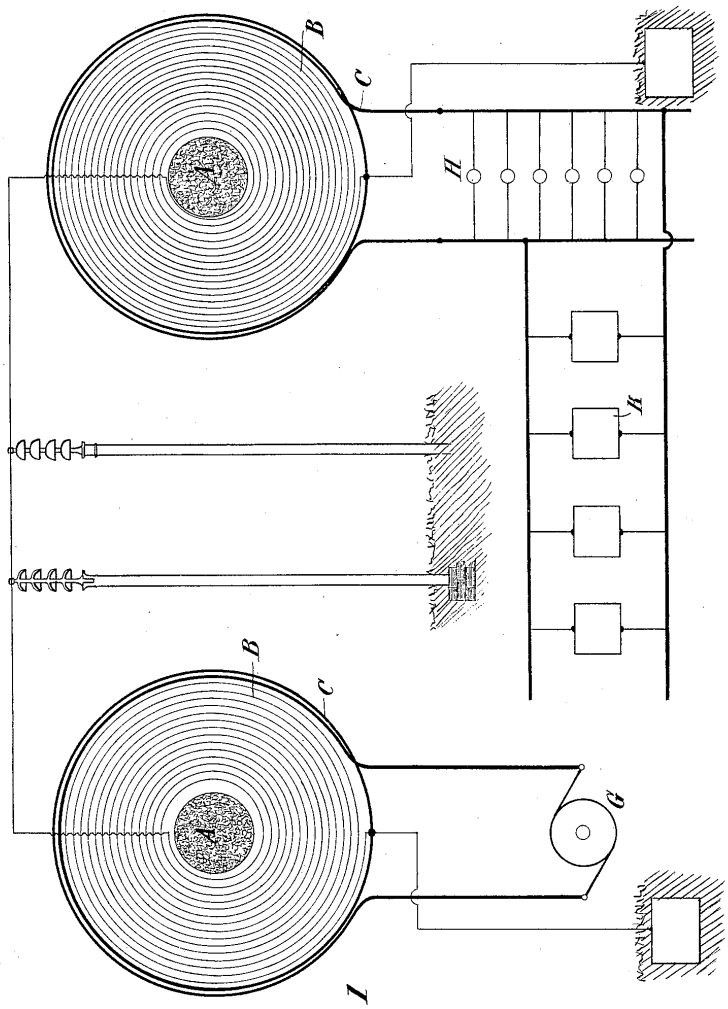

Fig. 1

WITNESSES

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Nikola Tesla

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(No Model.) 2 Sheets—Sheet 2.

N. TESLA.

ELECTRICAL TRANSFORMER.

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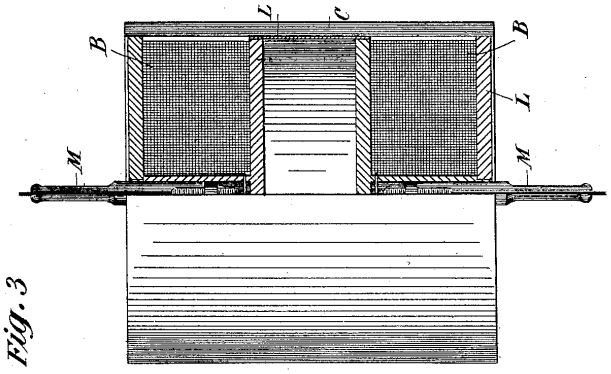

Fig. 3

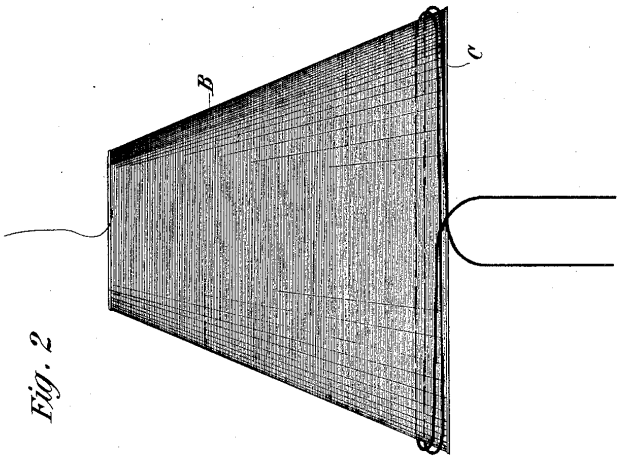

Fig. 2

WITNESSES

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UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF UTILIZING RADIANT ENERGY.

SPECIFICATION forming part of Letters Patent No. 685,958, dated November 5, 1901.

Application filed March 21, 1901. Serial No. 52,154. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Utilizing Radiant Energy, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

It is well known that certain radiations—such as those of ultra-violet light, cathodic, Roentgen rays, or the like—possess the property of charging and discharging conductors of electricity, the discharge being particularly noticeable when the conductor upon which the rays impinge is negatively electrified. These radiations are generally considered to be ether vibrations of extremely small wave lengths, and in explanation of the phenomena noted it has been assumed by some authorities that they ionize or render conducting the atmosphere through which they are propagated. My own experiments and observations, however, lead me to conclusions more in accord with the theory heretofore advanced by me that sources of such radiant energy throw off with great velocity minute particles of matter which are strongly electrified, and therefore capable of charging an electrical conductor, or even if not so may at any rate discharge an electrified conductor either by carrying off bodily its charge or otherwise.

My present application is based upon a discovery which I have made that when rays or radiations of the above kind are permitted to fall upon an insulated conducting body connected to one of the terminals of a condenser, while the other terminal of the same is made by independent means to receive or to carry away electricity, a current flows into the condenser so long as the insulated body is exposed to the rays, and under the conditions hereinafter specified an indefinite accumulation of electrical energy in the condenser takes place. This energy after a suitable time interval, during which the rays are allowed to act, may manifest itself in a powerful discharge, which may be utilized for the operation or control of mechanical or electrical devices or rendered useful in many other ways.

In applying my discovery I provide a condenser, preferably of considerable electrostatic capacity, and connect one of its terminals to an insulated metal plate or other conducting body exposed to the rays or streams of radiant matter. It is very important, particularly in view of the fact that electrical energy is generally supplied at a very slow rate to the condenser, to construct the same with the greatest care. I use by preference the best quality of mica as dielectric, taking every possible precaution in insulating the armatures, so that the instrument may withstand great electrical pressures without leaking and may leave no perceptible electrification when discharging instantaneously. In practice I have found that the best results are obtained with condensers treated in the manner described in a patent granted to me February 23, 1897, No. 577,671. Obviously the above precautions should be the more rigorously observed the slower the rate of charging and the smaller the time interval during which the energy is allowed to accumulate in the condenser. The insulated plate or conducting body should present as large a surface as practicable to the rays or streams of matter, I having ascertained that the amount of energy conveyed to it per unit of time is under otherwise identical conditions proportionate to the area exposed, or nearly so. Furthermore, the surface should be clean and preferably highly polished or amalgamated. The second terminal or armature of the condenser may be connected to one of the poles of a battery or other source of electricity or to any conducting body or object whatever of such properties or so conditioned that by its means electricity of the required sign will be supplied to the terminal. A simple way of supplying positive or negative electricity to the terminal is to connect the same either to an insulated conductor, supported at some height in the atmosphere, or to a grounded conductor, the former, as is well known, furnishing positive and the latter negative electricity. As the rays or supposed streams of matter generally convey a positive charge to the first condenser-terminal, which is connect-

ed to the plate or conductor above mentioned, I usually connect the second terminal of the condenser to the ground, this being the most convenient way of obtaining negative electricity, dispensing with the necessity of providing an artificial source. In order to utilize for any useful purpose the energy accumulated in the condenser, I furthermore connect to the terminals of the same a circuit including an instrument or apparatus which it is desired to operate and another instrument or device for alternately closing and opening the circuit. This latter may be any form of circuit-controller, with fixed or movable parts or electrodes, which may be actuated either by the stored energy or by independent means.

The rays or radiations which are to be utilized for the operation of the apparatus above described in general terms may be derived from a natural source, as the sun, or may be artificially produced by such means, for example, as an arc-lamp, a Roentgen tube, and the like, and they may be employed for a great variety of useful purposes.

My discovery will be more fully understood from the following detailed description and annexed drawings, to which reference is now made, and in which—

Figure 1 is a diagram showing typical forms of the devices or elements as arranged and connected in applying the method for the operation of a mechanical contrivance or instrument solely by the energy stored; and Fig. 2 is a diagrammatical representation of a modified arrangement suitable for special purposes, with a circuit-controller actuated by independent means.

Referring to Fig. 1, C is the condenser, P the insulated plate or conducting body, which is exposed to the rays, and P′ another plate or conductor, all being joined in series, as shown. The terminals T T′ of the condenser are also connected to a circuit including a receiver R, which is to be operated, and a circuit-controlling device *d*, which in this case is composed of two very thin conducting-plates *t t′*, placed in close proximity and very mobile, either by reason of extreme flexibility or owing to the charater of their support. To improve their action, they should be inclosed in a receptacle from which the air may be exhausted. The receiver R is shown as consisting of an electromagnet M, a movable armature *a*, a retractile spring *b*, and a ratchet-wheel *w*, provided with a spring-pawl *r*, which is pivoted to armature *a*, as illustrated. The apparatus being arranged as shown, it will be found that when the radiations of the sun or of any other source capable of producing the effects before described fall upon the plate P an accumulation of electrical energy in the condenser C will result. This phenomenon, I believe, is best explained as follows: The sun as well as other sources of radiant energy throw off minute particles of matter positively electrified, which, impinging upon the plate P, communicate an electrical charge to the same. The opposite terminal of the condenser being connected to the ground, which may be considered as a vast reservoir of negative electricity, a feeble current flows continuously into the condenser, and inasmuch as these supposed particles are of an inconceivably small radius or curvature, and consequently charged to a relatively very high potential, this charging of the condenser may continue, as I have found in practice, almost indefinitely, even to the point of rupturing the dielectric. Obviously whatever circuit-controller be employed it should operate to close the circuit in which it is included when the potential in the condenser has reached the desired magnitude. Thus in Fig. 2 when the electrical pressure at the terminals T T′ rises to a certain predetermined value the plates *t t′*, attracting each other, close the circuit connected to the terminals. This permits a flow of current which energizes the magnet M, causing it to draw down the armature *a* and impart a partial rotation to the ratchet-wheel *w*. As the current ceases the armature is retracted by the spring *b* without, however, moving the wheel *w*. With the stoppage of the current the plates *t t′* cease to be attracted and separate, thus restoring the circuit to its original condition.

Many useful applications of this method of utilizing the radiations emanating from the sun or other source and many ways of carrying out the same will at once suggest themselves from the above description. By way of illustration a modified arrangement is shown in Fig. 2, in which the source S of radiant energy is a special form of Roentgen tube devised by me having but one terminal *k*, generally of aluminium, in the form of half a sphere with a plain polished surface on the front side, from which the streams are thrown off. It may be excited by attaching it to one of the terminals of any generator of sufficiently-high electromotive force; but whatever apparatus be used it is important that the tube be exhausted to a high degree, as otherwise it might prove entirely ineffective. The working or discharge circuit connected to the terminals T T′ of the condenser includes in this case the primary *p* of a transformer and a circuit-controller comprising a fixed terminal or brush *t* and a movable terminal *t′* in the shape of a wheel with conducting and insulating segments which may be rotated at an arbitrary speed by any suitable means. In inductive relation to the primary wire or coil *p* is a secondary *s*, usually of a much greater number of turns, to the ends of which is connected a receiver R. The terminals of the condenser being connected as indicated, one to an insulated plate P and the other to a grounded plate P′, when the tube S is excited rays or streams of matter are emitted from the same, which convey a positive charge to the plate P and condenser-terminal T, while terminal T′ is continuously receiving negative electricity from the plate

P'. This, as before explained, results in an accumulation of electrical energy in the condenser, which goes on as long as the circuit including the primary p is interrupted. Whenever the circuit is closed, owing to the rotation of the terminal t', the stored energy is discharged through the primary p, this giving rise in the secondary s to induced currents which operate the receiver R.

It is clear from what has been stated above that if the terminal T' is connected to a plate supplying positive instead of negative electricity the rays should convey negative electricity to plate P. The source S may be any form of Roentgen or Lenard tube; but it is obvious from the theory of action that in order to be very effective the electrical impulses exciting it should be wholly or at least preponderatingly of one sign. If ordinary symmetrical alternating currents are employed, provision should be made for allowing the rays to fall upon the plate P only during those periods when they are productive of the desired result. Evidently if the radiations of the source be stopped or intercepted or their intensity varied in any manner, as by periodically interrupting or rythmically varying the current exciting the source, there will be corresponding changes in the action upon the receiver R, and thus signals may be transmitted and many other useful effects produced. Furthermore, it will be understood that any form of circuit-closer which will respond to or be set in operation when a predetermined amount of energy is stored in the condenser may be used in lieu of the device specifically described with reference to Fig. 1, and also that the special details of construction and arrangement of the several parts of the apparatus may be very greatly varied without departure from the invention.

Having described my invention, what I claim is—

1. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations, and the other armature by independent means, and discharging the condenser through a suitable receiver, as set forth.

2. The method of utilizing radiant energy, which consists in simultaneously charging a condenser by means of rays or radiations and an independent source of electrical energy, and discharging the condenser through a suitable receiver, as set forth.

3. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations, and the other by independent means, controlling the action or effect of said rays or radiations and discharging the condenser through a suitable receiver, as set forth.

4. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations and the other by independent means, varying the intensity of the said rays or radiations and periodically discharging the condenser through a suitable receiver, as set forth.

5. The method of utilizing radiant energy, which consists in directing upon an elevated conductor, connected to one of the armatures of a condenser, rays or radiations capable of positively electrifying the same, carrying off electricity from the other armature by connecting the same with the ground, and discharging the accumulated energy through a suitable receiver, as set forth.

6. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations, and the other by independent means, and effecting by the automatic discharge of the accumulated energy the operation or control of a suitable receiver, as set forth.

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Witnesses:
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RICHARD DONOVAN.

455-619 AU 233 EX
FIP8106 OR 685,958

No. 685,958. Patented Nov. 5, 1901.

N. TESLA.

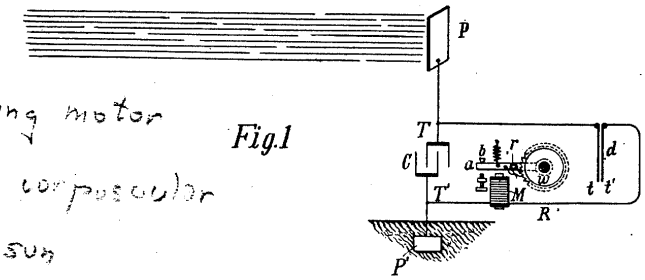
METHOD OF UTILIZING RADIANT ENERGY.

(Application filed Mar. 21, 1901.)

(No Model.)

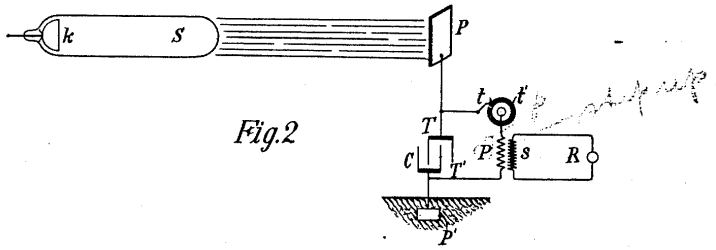
Electric stepping motor energized by corpuscular energy from sun

Fig.1



No rays.

Fig.2



Witnesses:
Raphael Netter
M. Lawson Dyer

Nikola Tesla, Inventor
by Kerr, Page & Cooper Attys

No. 787,412. Patented April 18, 1905.

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

ART OF TRANSMITTING ELECTRICAL ENERGY THROUGH THE NATURAL MEDIUMS.

SPECIFICATION forming part of Letters Patent No. 787,412, dated April 18, 1905.

Application filed May 16, 1900. Renewed June 17, 1902. Serial No. 112,034.

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have discovered a new and useful Improvement in the Art of Transmitting Electrical Energy Through the Natural Media, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

It is known since a long time that electric currents may be propagated through the earth, and this knowledge has been utilized in many ways in the transmission of signals and the operation of a variety of receiving devices remote from the source of energy, mainly with the object of dispensing with a return conducting-wire. It is also known that electrical disturbances may be transmitted through portions of the earth by grounding only one of the poles of the source, and this fact I have made use of in systems which I have devised for the purposes of transmitting through the natural media intelligible signals or power and which are now familiar; but all experiments and observations heretofore made have tended to confirm the opinion held by the majority of scientific men that the earth, owing to its immense extent, although possessing conducting properties, does not behave in the manner of a conductor of limited dimensions with respect to the disturbances produced, but, on the contrary, much like a vast reservoir or ocean, which while it may be locally disturbed by a commotion of some kind remains unresponsive and quiescent in a large part or as a whole. Still another fact now of common knowledge is that when electrical waves or oscillations are impressed upon such a conducting-path as a metallic wire reflection takes place under certain conditions from the ends of the wire, and in consequence of the interference of the impressed and reflected oscillations the phenomenon of "stationary waves" with maxima and minima in definite fixed positions is produced. In any case the existence of these waves indicates that some of the outgoing waves have reached the boundaries of the conducting-path and have been reflected from the same. Now I have discovered that notwithstanding its vast dimensions and contrary to all observations heretofore made the terrestrial globe may in a large part or as a whole behave toward disturbances impressed upon it in the same manner as a conductor of limited size, this fact being demonstrated by novel phenomena, which I shall hereinafter describe.

In the course of certain investigations which I carried on for the purpose of studying the effects of lightning discharges upon the electrical condition of the earth I observed that sensitive receiving instruments arranged so as to be capable of responding to electrical disturbances created by the discharges at times failed to respond when they should have done so, and upon inquiring into the causes of this unexpected behavior I discovered it to be due to the character of the electrical waves which were produced in the earth by the lightning discharges and which had nodal regions following at definite distances the shifting source of the disturbances. From data obtained in a large number of observations of the maxima and minima of these waves I found their length to vary approximately from twenty-five to seventy kilometers, and these results and certain theoretical deductions led me to the conclusion that waves of this kind may be propagated in all directions over the globe and that they may be of still more widely differing lengths, the extreme limits being imposed by the physical dimensions and properties of the earth. Recognizing in the existence of these waves an unmistakable evidence that the disturbances created had been conducted from their origin to the most remote portions of the globe and had been thence reflected, I conceived the idea of producing such waves in the earth by artificial means with the object of utilizing them for many useful purposes for which they are or might be found applicable. This problem was rendered extremely difficult owing to the immense dimensions of the planet, and consequently enormous movement of electricity or rate at which electrical energy had to be delivered in order to approximate, even in a remote degree, movements or rates which are manifestly attained in the displays of elec-

trical forces in nature and which seemed at first unrealizable by any human agencies; but by gradual and continuous improvements of a generator of electrical oscillations, which I have described in my Patents Nos. 645,576 and 649,621, I finally succeeded in reaching electrical movements or rates of delivery of electrical energy not only approximating, but, as shown in many comparative tests and measurements, actually surpassing those of lightning discharges, and by means of this apparatus I have found it possible to reproduce whenever desired phenomena in the earth the same as or similar to those due to such discharges. With the knowledge of the phenomena discovered by me and the means at command for accomplishing these results I am enabled not only to carry out many operations by the use of known instruments, but also to offer a solution for many important problems involving the operation or control of remote devices which for want of this knowledge and the absence of these means have heretofore been entirely impossible. For example, by the use of such a generator of stationary waves and receiving apparatus properly placed and adjusted in any other locality, however remote, it is practicable to transmit intelligible signals or to control or actuate at will any one or all of such apparatus for many other important and valuable purposes, as for indicating wherever desired the correct time of an observatory or for ascertaining the relative position of a body or distance of the same with reference to a given point or for determining the course of a moving object, such as a vessel at sea, the distance traversed by the same or its speed, or for producing many other useful effects at a distance dependent on the intensity, wave length, direction or velocity of movement, or other feature or property of disturbances of this character.

I shall typically illustrate the manner of applying my discovery by describing one of the specific uses of the same—namely, the transmission of intelligible signals or messages between distant points—and with this object reference is now made to the accompanying drawings, in which—

Figure 1 represents diagrammatically the generator which produces stationary waves in the earth, and Fig. 2 an apparatus situated in a remote locality for recording the effects of these waves.

In Fig. 1, A designates a primary coil forming part of a transformer and consisting generally of a few turns of a stout cable of inappreciable resistance, the ends of which are connected to the terminals of a source of powerful electrical oscillations, diagrammatically represented by B. This source is usually a condenser charged to a high potential and discharged in rapid succession through the primary, as in a type of transformer invented by me and not well known; but when it is desired to produce stationary waves of great lengths an alternating dynamo of suitable construction may be used to energize the primary A. C is a spirally-wound secondary coil within the primary having the end nearer to the latter connected to the ground E′ and the other end to an elevated terminal E. The physical constants of coil C, determining its period of vibration, are so chosen and adjusted that the secondary system E′ C E is in the closest possible resonance with the oscillations impressed upon it by the primary A. It is, moreover, of the greatest importance in order to still further enhance the rise of pressure and to increase the electrical movement in the secondary system that its resistance be as small as practicable and its self-induction as large as possible under the conditions imposed. The ground should be made with great care, with the object of reducing its resistance. Instead of being directly grounded, as indicated, the coil C may be joined in series or otherwise to the primary A, in which case the latter will be connected to the plate E′; but be it that none or a part or all of the primary or exciting turns are included in the coil C the total length of the conductor from the ground-plate E′ to the elevated terminal E should be equal to one-quarter of the wave length of the electrical disturbance in the system E′ C E or else equal to that length multiplied by an odd number. This relation being observed, the terminal E will be made to coincide with the points of maximum pressure in the secondary or excited circuit, and the greatest flow of electricity will take place in the same. In order to magnify the electrical movement in the secondary as much as possible, it is essential that its inductive connection with the primary A should not be very intimate, as in ordinary transformers, but loose, so as to permit free oscillation—that is to say, their mutual induction should be small. The spiral form of coil C secures this advantage, while the turns near the primary A are subjected to a strong inductive action and develop a high initial electromotive force. These adjustments and relations being carefully completed and other constructive features indicated rigorously observed, the electrical movement produced in the secondary system by the inductive action of the primary A will be enormously magnified, the increase being directly proportionate to the inductance and frequency and inversely to the resistance of the secondary system. I have found it practicable to produce in this manner an electrical movement thousands of times greater than the initial—that is, the one impressed upon the secondary by the primary A—and I have thus reached activities or rates of flow of electrical energy in the system E′ C E measured by many tens of thousands of horsepower. Such immense movements of elec-

tricity give rise to a variety of novel and striking phenomena, among which are those already described. The powerful electrical oscillations in the system E' C E being communicated to the ground cause corresponding vibrations to be propagated to distant parts of the globe, whence they are reflected and by interference with the outgoing vibrations produce stationary waves the crests and hollows of which lie in parallel circles relatively to which the ground-plate E' may be considered to be the pole. Stated otherwise, the terrestrial conductor is thrown into resonance with the oscillations impressed upon it just like a wire. More than this, a number of facts ascertained by me clearly show that the movement of electricity through it follows certain laws with nearly mathematical rigor. For the present it will be sufficient to state that the planet behaves like a perfectly smooth or polished conductor of inappreciable resistance with capacity and self induction uniformly distributed along the axis of symmetry of wave propagation and transmitting slow electrical oscillations without sensible distortion and attenuation.

Besides the above three requirements seem to be essential to the establishment of the resonating condition.

First. The earth's diameter passing through the pole should be an odd multiple of the quarter wave length—that is, of the ratio between the velocity of light—and four times the frequency of the currents.

Second. It is necessary to employ oscillations in which the rate of radiation of energy into space in the form of hertzian or electromagnetic waves is very small. To give an idea, I would say that the frequency should be smaller than twenty thousand per second, though shorter waves might be practicable. The lowest frequency would appear to be six per second, in which case there will be but one node, at or near the ground-plate, and, paradoxical as it may seem, the effect will increase with the distance and will be greatest in a region diametrically opposite the transmitter. With oscillations still slower the earth, strictly speaking, will not resonate, but simply act as a capacity, and the variation of potential will be more or less uniform over its entire surface.

Third. The most essential requirement is, however, that irrespective of frequency the wave or wave-train should continue for a certain interval of time, which I have estimated to be not less than one-twelfth or probably 0.08484 of a second and which is taken in passing to and returning from the region diametrically opposite the pole over the earth's surface with a mean velocity of about four hundred and seventy-one thousand two hundred and forty kilometers per second.

The presence of the stationary waves may be detected in many ways. For instance, a circuit may be connected directly or inductively to the ground and to an elevated terminal and tuned to respond more effectively to the oscillations. Another way is to connect a tuned circuit to the ground at two points lying more or less in a meridian passing through the pole E' or, generally stated, to any two points of a different potential.

In Fig. 2 I have shown a device for detecting the presence of the waves such as I have used in a novel method of magnifying feeble effects which I have described in my Patents Nos. 685,953 and 685,955. It consists of a cylinder D, of insulating material, which is moved at a uniform rate of speed by clockwork or other suitable motive power and is provided with two metal rings F F', upon which bear brushes a and a', connected, respectively, to the terminal plates P and P'. From the rings F F' extend narrow metallic segments s and s', which by the rotation of the cylinder D are brought alternately into contact with double brushes b and b', carried by and in contact with conducting-holders h and h', supported in metallic bearings G and G', as shown. The latter are connected to the terminals T and T' of a condenser H, and it should be understood that they are capable of angular displacement as ordinary brush-supports. The object of using two brushes, as b and b', in each of the holders h and h' is to vary at will the duration of the electric contact of the plates P and P' with the terminals T and T', to which is connected a receiving-circuit including a receiver R and a device d, performing the duty of closing the receiving-circuit at predetermined intervals of time and discharging the stored energy through the receiver. In the present case this device consists of a cylinder made partly of conducting and partly of insulating material c and c', respectively, which is rotated at the desired rate of speed by any suitable means. The conducting part c is in good electrical connection with the shaft S and is provided with tapering segments $f f'$, upon which slides a brush k, supported on a conducting-rod l, capable of longitudinal adjustment in a metallic support m. Another brush, n, is arranged to bear upon the shaft S, and it will be seen that whenever one of the segments f' comes in contact with the brush k the circuit including the receiver R is completed and the condenser discharged through the same. By an adjustment of the speed or rotation of the cylinder d and a displacement of the brush k along the cylinder the circuit may be made to open and close in as rapid succession and remain open or closed during such intervals of time as may be desired. The plates P and P', through which the electrical energy is conveyed to the brushes a and a', may be at a considerable distance from each other in the ground or one in the ground and the other in the air, preferably at some height. If but one plate is connected to earth and the other maintained at an

elevation, the location of the apparatus must be determined with reference to the position of the stationary waves established by the generator, the effect evidently being greatest in a maximum and zero in a nodal region. On the other hand, if both plates be connected to earth the points of connection must be selected with reference to the difference of potential which it is desired to secure, the strongest effect being of course obtained when the plates are at a distance equal to half the wave length.

In illustration of the operation of the system let it be assumed that alternating electrical impulses from the generator are caused to produce stationary waves in the earth, as above described, and that the receiving apparatus is properly located with reference to the position of the nodal and ventral regions of the waves. The speed of rotation of the cylinder D is varied until it is made to turn in synchronism with the alternate impulses of the generator, and the position of the brushes b and b' is adjusted by angular displacement or otherwise, so that they are in contact with the segments S and S' during the periods when the impulses are at or near the maximum of their intensity. These requirements being fulfilled, electrical charges of the same sign will be conveyed to each of the terminals of the condenser, and with each fresh impulse it will be charged to a higher potential. The speed of rotation of the cylinder d being adjustable at will, the energy of any number of separate impulses may thus be accumulated in potential form and discharged through the receiver R upon the brush k coming in contact with one of the segments f''. It will be understood that the capacity of the condenser should be such as to allow the storing of a much greater amount of energy than is required for the ordinary operation of the receiver. Since by this method a relatively great amount of energy and in a suitable form may be made available for the operation of a receiver, the latter need not be very sensitive; but when the impulses are very weak or when it is desired to operate a receiver very rapidly any of the well-known sensitive devices capable of responding to very feeble influences may be used in the manner indicated or in other ways. Under the conditions described it is evident that during the continuance of the stationary waves the receiver will be acted upon by current impulses more or less intense, according to its location with reference to the maxima and minima of said waves; but upon interrupting or reducing the flow of the current the stationary waves will disappear or diminish in intensity. Hence a great variety of effects may be produced in a receiver, according to the mode in which the waves are controlled. It is practicable, however, to shift the nodal and ventral regions of the waves at will from the sending-station, as by varying the length of the waves under observance of the above requirements. In this manner the regions of maximum and minimum effect may be made to coincide with any receiving station or stations. By impressing upon the earth two or more oscillations of different wave length a resultant stationary wave may be made to travel slowly over the globe, and thus a great variety of useful effects may be produced. Evidently the course of a vessel may be easily determined without the use of a compass, as by a circuit connected to the earth at two points, for the effect exerted upon the circuit will be greatest when the plates P P' are lying on a meridian passing through ground-plate E' and will be *nil* when the plates are located at a parallel circle. If the nodal and ventral regions are maintained in fixed positions, the speed of a vessel carrying a receiving apparatus may be exactly computed from observations of the maxima and minima regions successively traversed. This will be understood when it is stated that the projections of all the nodes and loops on the earth's diameter passing through the pole or axis of symmetry of the wave movement are all equal. Hence in any region at the surface the wave length can be ascertained from simple rules of geometry. Conversely, knowing the wave length, the distance from the source can be readily calculated. In like ways the distance of one point from another, the latitude and longitude, the hour, &c., may be determined from the observation of such stationary waves. If several such generators of stationary waves, preferably of different length, were installed in judiciously-selected localities, the entire globe could be subdivided in definite zones of electric activity, and such and other important data could be at once obtained by simple calculation or readings from suitably-graduated instruments. Many other useful applications of my discovery will suggest themselves, and in this respect I do not wish to limit myself. Thus the specific plan herein described of producing the stationary waves might be departed from. For example, the circuit which impresses the powerful oscillations upon the earth might be connected to the latter at two points. In this application I have advanced various improvements in means and methods of producing and utilizing electrical effects which either in connection with my present discovery or independently of the same may be usefully applied.

I desire it to be understood that such novel features as are not herein specifically claimed will form the subjects of subsequent applications.

What I now claim is—

1. The improvement in the art of transmitting electrical energy to a distance which consists in establishing stationary electrical waves in the earth, as set forth.

2. The improvement in the art of transmit-

ting electrical energy to a distance which consists in impressing upon the earth electrical oscillations of such character as to produce stationary electrical waves therein, as set forth.

3. The improvement in the art of transmitting and utilizing electrical energy which consists in establishing stationary electrical waves in the natural conducting media, and operating thereby one or more receiving devices remote from the source of energy, as set forth.

4. The improvement in the art of transmitting and utilizing electrical energy which consists in establishing in the natural conducting media, stationary electrical waves of predetermined length and operating thereby one or more receiving devices remote from the source of energy and properly located with respect to the position of such waves, as herein set forth.

5. The improvement in the art of transmitting and utilizing electrical energy, which consists in establishing in the natural conducting media, stationary electrical waves, and varying the length of such waves, as herein set forth.

6. The improvement in the art of transmitting and utilizing electrical energy, which consists in establishing in the natural conducting media stationary electrical waves and shifting the nodal and ventral regions of these waves, as described.

NIKOLA TESLA.

Witnesses:
M. LAWSON DYER,
BENJAMIN MILLER.

No. 787,412. PATENTED APR. 18, 1905.

N. TESLA.

ART OF TRANSMITTING ELECTRICAL ENERGY THROUGH THE NATURAL MEDIUMS.

APPLICATION FILED MAY 16, 1900. RENEWED JUNE 17, 1902.

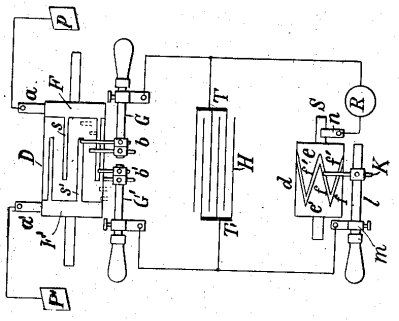


Fig. 2

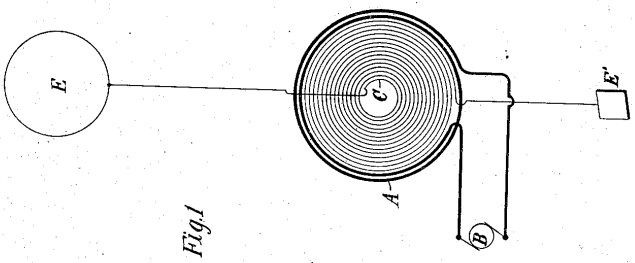


Fig. 1

Witnesses:
Raphael Netter
M. Lawson Dyer.

Nikola Tesla Inventor
by Kerr, Page & Cooper Attys

APPENDIX III

Two Articles by Dr. Peter Lindemann

1. "Thermodynamics and Free Energy", *Journal of Borderland Sciences Research,* Third Quarter, 1994.

2. "Tesla's Self-Acting Engine", *Journal of Borderland Sciences Research,* Third Quarter, 1995

THERMODYNAMICS & FREE ENERGY

by Peter A. Lindemann

The mainstream scientific community dismisses the idea of "Free Energy" or "Over-Unity" machines because they say that the behavior of such machines violates the "SecondLaw of Thermodynamics." The purpose of this article is to squarely face this issue from an alternative science point of view. Many engineers and inventors, working in the alternative energy field, still mistakenly believe that the "Laws of Thermodynamics" are universally true. For them, the "free energy" machine can only be a clever scientific slight of hand where the machine becomes "outlaw", breaking some fundamental universe law. For progress to be made in this field, the limitations and errors inherent in the "Laws of Thermodynamics" must be exposed. Only then will people realize that scientific experimentation is the only reliable tool for revealing the behavior of physical reality.

In order to bring this about, it will be helpful to quickly review some of the pivotal historical events which helped shape the modem scientific era with regards to thermodynamics. Before the year 1800, perpetual motion machines were considered possible and heat was not regarded as a form of energy. Both of these long standing assumptions, dating back thousands of years, were effectively toppled by the ideas of Hermann von Helmholtz in 1847 when he postulated that since no one had ever been able to build a working perpetual motion machine, that just probably, it was not possible. In order to deny the possibility of perpetual motion and hold the argument together, he had to assume that energy in the system was being conserved. It had long been observed that mechanical devices could not transfer energy perfectly. There was always some friction in the working parts. Friction was not only known to impede the transfer of energy in the machine, but it was known to produce heat. In order to simultaneously explain the work loss and the heat gain, so that **conservation** could be satisfied, Helmholtz postulated that heat was a form of energy consisting of a small, random motion in the molecules of matter. He went on to speculate that the loss of work in the machine as large scale motion was still present as heat in the small scale motion of the molecules in the material the machine was made o£ He suggested from this that both the heat and work must be considered energy, and that it was the total that was **conserved,** rather than the heat or work separately.

By 1850, Rudolf Clausius was able to synthesize the work of Helmholtz, James Joule, Sadi Camot and others to express a generalized statement that has become known as the "First Law of Thermodynamics." It states that "energy can be changed from one form to another, but it is neither created nor destroyed." By the time this thought became universally believed, it had totally transformed the intellectual landscape of mechanics, physics and energy dynamics. This was a clean break from the set of thoughts and assumptions that had come forward from antiquity. A new era in science had begun.

In understanding these historical developments, it is important to realize that besides the new theoretical explanation about the nature of heat, all of the other data that led to the new theoretical generalizations was derived experimentally. This can be illustrated by an observation made by Sadi Camot in his extensive work regarding the behavior of heat in machines. He states that "in all cases in which work is produced by the agency of heat, a quantity of heat is consumed that is proportional to the work done; and conversely, by the expenditure of an equal quantity of work, an equal quantity of heat is produced.' This statement by Carnot was based on hundreds of experimental measurements. Aftersuch convincing experimentation, it was not unreasonable for Clausius to conclude that heat could be converted into mechanical work It was, however, a theoretical leap of logic to conclude that energy, in general, could be changed from one form to another.

Before we go on, it is important, for our purposes, to be reminded that this new idea expressed as the "First Law of Thermodynamics" consists of a number of overlapping ideas and assumptions that can be expressed as follows:

1) Perpetual motion machines are impossible
2) The nature of heat is reduced to the random motions of molecular matter
3) Energy can be changed from one form

to another without any explanation as to how this conversion is actually accomplished in any specific case

4) Energy is not created in or destroyed by its passage through a mechanism
5) All forms of energy behave the same way

All of these ideas are fundamentally inherent in "The First Law of Thermodynamics." From an alternative science point of view, the experimental work of Carrot and joule will stand for all time. It is the intellectual overlay of Hehnholtz and Clausius, on this experimental work, where the problems are introduced. The theory of conversion and the ideas about the nature of heat will be taken up again later in this article, after more ground work has been laid.

The “Second Law of Thermodynamics” evolved out of further studies of the behavior of heat in closed systems. Remarkably, there is no one statement that is universally recognized as the definitive expression of this so called Law." Among the more popular statements which reflect the general understanding of the "Second Law of Thermodynamics" are the following. "In a closed system, entropy does not decrease', "The state of order in a closed system does not spontaneously increase without the application of work", "Among all the allowed states of a system with given values of energy, number of particles and constraints, one and only one is a stable equilibrium state", and It is impossible to construct a device that operates in a cycle and produces no other effect than the production of work and exchange of heat with a single reservoir." For those who can fathom the language, these statements clearly do not all express the same idea. Some have brad ramifications while others are more narrowly defined. All of these statements grew out of the idea, expressed fairly well as the last statement in the series, that a perpetual motion machine could not be made that operated on the a work/heat exchange when quantity of heat at the start After that amount of heat was converted to work and ture ambient temperature outside, no further

This is not only reasonable, but it is backed up by thousands of experiments.

narrowly defined as a statement that reflects upon the behavior of heat in author has no problem with agreeing completely.

Problems arise, however, with some of he more generalized interpretations of

dosed system does not spontaneously increase without the application of to

Researchers in the “free energy” field should not concern themselves with the outmoded ideas presented as the so-called "Laws of Thermodynamics". They embody an erroneous concept of a mechanical universe that mysteriously burst forth as a fully wound spring that has been unwinding ever since. It is a lifeless, empty vision that ignores the Source of the energy it started with and closes the minds of its adherents to the solutions at hand.

univer-

define our terms. We must understand what is meant by the "state of order" in a

boundaries of the "closure" of that system. In the first ca

system is generally regarded as the temperature.

Understanding this, we can rephrase this statement to say, that in a thermally

not increase unless work or energy is added to the syst

clearly defining our terms, and limiting the discussion to heat and work, we have a ment backed up by mountains of experimental data. If,

a generalized "quantity of energ

further define the "dosed system" as the Universe, we are led to believe that under

possible to create a condition where the

spontaneously. This is not true!

While it should be understood that

electrical equipment and heat generally do

of the planet does not. The Etheric Energy Field behaves in direct opposition to the he "Second Law of Thermodynamics" and

experimental data. One of the best documented examples of this is the

the "orgone accumulator', invented by Dr. Wilhelm Reich in 1940. He enclosure made of alternating layers of organic and inorganic

density of the Etheric Energy Field to be concentrated in the local area, without the ap work. This new and higher energy concent tion is then reflected as a spontaneous rise ture. This situation does not break the "Second

because we admit that new energy is en

It does break the "Second Law" in the gen

energy is entering without the application of

designed as an attempt to shield and isolate this energy from its presence in the

however, that he was not able to isolate y effects inside the accumulator be

penetrated the walls of the enclosure. He eventually realized that with regard to

to" close the system" in the local sense. This is important

directly refutes the assumption that the universe consists only of dosed systems at

Here then is a major problem with how the

Thermodynamics." When the discussion is

systems, the "Second Law of Thermody-

description of what happens under those

circumstances. It is when it is incorrectly assumed that all forms of energy behave this way and that enclosure of the system is possible at all levels, that grossly false conclusions can be drawn from what started out as experimentally derived observations. The scientific community-at-large obviates these problems simply by denying the existence of the Etheric Energy Field because it doesn't fit within their intellectual model Unfortunately for them, the mounting experimental evidence is making this increasingly hard to do.

Certainly, the best evidence to date of the existence of the Etheric Energy Field and its capability of being drawn to high concentrations without the application of work is demonstrated by the Etheric Weather Engineering techniques developed by Trevor James Constable and his Atmos Engineering group. As a member of this group, I have personally seen how simple Etheric Energy projectors, that do no work in the classical sense, can cause the etheric potentials in the atmosphere to rise to such high concentrations that millions of gallons of water **will** precipitate from the air for hours at a time.

When these Etheric Energy projectors are motorized, they draw a few hundred watts of electric energy. If the rain produced is dropped behind a dam and then released through a hydroelectric turbine, the electrical energy gain in the system can be enormous, on the order of 100,000 to 1. This method of creating "free energy" is a practical reality today. While I know of no community using this method for supplying its energy needs, it is eminently practicable. This example is theoretical in the sense that it has never been done, but it is a good model of other "free energy" systems under development around the world today.

Because the input to motorize the Etheric Energy projectors is electric and the output from the hydroelectric generators is electric, many people might mistake this for a so-called "over-unity' system There is nothing "over-unity" about this situation. Each and every component of the machinery used in this system has operational and frictional losses. The energy tapped by the system is the atmospheric ether and all of the energy gain in the system occurs outside of the equipment The fact that a small electric input yields a huge electric output does not mean the system is operating "over-unity.'

The problem with the `over-unity' concept goes back to the "First Law of Thermodynamics" and its inherent idea about the ability to convert one form of energy into another. This assumption includes the idea that these various conversions are accomplished at known and accepted rates of exchange. The idea of efficiency of conversion requires that the various rates of exchange are fixed and ad as an upper limit for the calculation of a ratio that approaches one (10096) where the numerator of this fraction is the "output' and the denominator is the "input." Since it is generally agreed that every machine experiences so-called losses, the idea that this ratio could be greater than one is, of course, ridiculous. This, coupled with the assumption in the "Second Law' that all energy systems are dosed, (meaning that no new energy can enter the system in-between the "input" and the "output") makes the idea of an "over-unity' system even more impossible than a mere perpetual motion machine. The line of logic embodied in the "Laws of Thermodynamics" is flawless. The problem doesn't exist in the logic, but it does illustrate that logic alone is not enough to reveal the truth. The problem exists in certain interpretations of these "Laws." Let's go back and look at the "First Law' again in light of our "over-unity" discussion. "Energy can be changed from one form to another, but it is neither created nor destroyed." This seems simple enough to understand. Underneath the surface, however, there is an assumption that this also means that energy will not spontaneously appear or disappear from the system. This is also a necessary condition if conservation of energy is to be satisfied LOCALLY as well as UNIVERSALLY.

This discussion becomes relevant, for instance, in describing the operation of the rotating magnet generator, the so called N-machine or Space Power Generator (SPG). Most of the important work in this field has been done by Bruce DePalma and Paramahamsa Tewari. The following is a brief summary. The rotation of the magnet sets up two force fields that act at right angles to each other. These two force fields are the racially distributed inertial frame of space (centrifugal force) and the intersecting axially distributed magnetic field of the rotating magnet The area of magnetized, polarized, inertial space appears to open up a region through which new energy can enter the system. When careful measurements are taken of current flows in the generator and in the external circuit, evidence suggests that electric charges are appearing at the periphery of the generator and disappearing at the center of the generator that do not actually ***pass through*** the generator. This experimental finding may explain why this configuration of electric generator experiences less mechanical drag than standard generator designs for each unit of electrical output produced. While energy is probably not being created or destroyed in the universal context, it is apparently appearing and disappearing from the machine during operation in the local space. This extra energy can be used to produce useful work in external circuits. Tewari has shown that twice as much hydrogen can be generated from an electrolysis cell run from the output of a SPG than if the cell is run directly. It is impossible to rationalize the behavior of this style of electric generator with the ideas of simple conversion and local conservation as they are postulated in the "First Law of Thermodynamics."

In a standard generator, if all losses are ignored for the moment, conventional *theory* says if 550 Ft Lbs of work are applied to the input shaft in one second, 746 Watts will be delivered at the output If I blindly believe that the generator simply has the mysterious ability to convert the mechanical energy into electrical energy, l don't ask the following questions: what is the mechanism of this conversion?, where does the torque go?, and where does the electrical energy come from? The apparent observation that the generated current produces a motoring effect that opposes the input torque should not be interpreted as a vindication of the conservation rule, but as an admission that this is an inefficient way to generate electricity. The Space Power Generator experiences far less drag per unit of electrical output than a standard generator.

This opens up a much larger discussion about the validity of the conversion idea all together. Are there actual and universal equivalents between the various forms of heat, mechanical work, and electricity? At this point, all we know for sure are the various measurements that have been taken from the devices that demonstrate these energy translations. For instance, in 1845, James joule found that if he placed a small paddle wheel in a bucket of water, he had to

apply 772.5 foot-pounds of mechanical work to spin the paddle wheel to raise the temperature of one pound of water, one degree Fahrenheit. This has led to very careful calculations that now set this "universal conversion' between mechanical work and heat at 778.26 FT-Lbs = 1 BTU. For paddle wheels in water, this is no doubt true. But what happens if paddle wheels are not used? Is there another method that does not use paddle wheels in water to convert ruechanical work to heat that does the job better, with less expenditure of work for the same heat gained? The answer is yes. In fact, there are numerous patents on record to accomplish this. One uses rotating parallel disks, not unlike the design of Tesla's turbine, to heat water with less than half the mechanical expenditure.

Once again, we have entered a new scientific era where the exact equivalence between mechanical work as foot-pounds, electrical work as watt-hours, and heat work as BTU's is not known! A wide variety of physical experiments have demonstrated a broad range of differing energy translation effects. The intellectual edifice of Clausius' conversion idea is crumbling; and no one should allow their thinking to be constrained by it any longer. The results of physical experiments have all but disproved it. The "First Law of Thermodynamics" should be seen only as an outmoded, intellectual MODEL that is not supported by all of the experimental data. Likewise, the idea of "over-unity" should be abandoned by those working on 'free energy" systems as it is an intellectual contradiction based both on the belief in conversion and the ability to circumvent it 'Over-unity" is an oxymoron that should be removed from the vocabulary of the alternative science community-This brings me back to the other problem presented earlier, namely, the nature of heat itself. Is heat, as Hermann Yon Helmholtz suggests, simply the random motion of molecular matter, or is it something completely different, whose presence causes molecular matter to exhibit random motion?. This is a very long and involved exploration that has already been handled masterfully by Rudolf Steiner in March of 1920 and published as his Warmth Course. I will summarize some of these ideas briefly.

The ancient's believed that there were four 'elements" that all physical reality was composed o£ These were Earth, Water, Air and Fire. In modern language, we can restate this as follows. There are four "states" that all matter appears as. These are solid, liquid, gas and heat. From an etheric science point of view, heat is the fourth state of matter and the transition state between matter and ether. Here is why. The only difference between the appearance of ice, water, or steam, for example, is its temperature or internal heat condition. Heat is absolutely fundamental in all considerations regarding matter because a change in heat

“Over-unity” is an oxymoron that should be removed from the vocabulary of the alternative science, community.

is the only element required to bang about a change of state from solid to liquid or from liquid to gas. In solid matter, the "atoms" are very close together and they bind each other in a way that allows them to hold their shape without being in a container. Heat can be added to the solid and its temperature will rise, correspondingly, until the melting point is reached At this point, adding more heat does not raise its temperature, but rather causes the material to change state as the solid melts into a liquid. Once all of the material is liquefied, adding more heat once again causes the temperature to rise. In liquid matter, the `atoms" are less close together and they bind each other in a way that allows the liquid to take the shape of whatever open topped container it is put in. As more heat is added to the liquid, the "atoms" move farther apart until the boiling point is reached. At this point, once again, adding more heat does not raise its temperature, butrather causes the material to change state as the liquid boils into a gas. Once all of the material is gaseous, adding more heat once again causes the temperature to rise. In gaseous matter, the "atoms" are so far apart that they will hold no shape at all and can only be contained by a complete enclosure. As more heat is added to the gas, the "atoms" become so dispersed that eventually, all thatis left is the heat_ The relationships between heat, temperature, matter and state are quite complex and cannot easily be reduced to simple explanations. Steiner's explorations of these relationships go into great detail, forming a seamless line of logic, backed up by a great deal of experimental data. Anyone interested in the nature of heat should study Rudolf Steiner's Warmth Course.

While this may make no sense to people trained in mechanistic thought processes, it is much closer to the truth about heat than the ideas of Helmholtz, with which Steiner was completely familiar. Helmholtz's idea that the nature of heat can be fully described by the random motions of molecular matter is far too simplistic. It ignores many of the well known behaviors of heat and matter as well as the existence of the Etheric Energy Field. It should be considered an "interesting' historical attempt to describe heat that is not supported by all of the experimental data.

For those who are not familiar with etheric science, it might be useful to review some of the characteristics of the Etheric EnergyField at this time. The Etheric Energy Field is made up of an extremely fine, mass-free fluid. Its activity can be divided into four main levels. These different aspects of the Ether have been called: the Warmth Ether, the Light Ether, the Tone (or Chemical) Ether, and the Life Ether. The Etheric Energy Field, as a whole, penetrates all matter, flows around and through the planet in well defined ways, exhibits elastic characteristics, and spontaneously moves from low concentrations to high concentrations before discharging. Understanding all of these factors has made engineering the weather a practical reality today. Many other amazing technologies also become possiblewhen the ether is fully understood. Likewise, many aspects of today's science that are still confusing eventually become clear.

One area of the greatest confusion lies in

the field of electrical science. The entire study ofwhat has been called "static electricity' is just a confusing encounter with the Light Ether as it behaves under certain circumstances. When fully understood, socalled "static electricity" will be seen to be neither static nor electricity. Normal electricity always flows from high potential to low potential and usually requires metallic conductors to flow along. On the other hand, "static electricity" does not discharge in the same way, and readily moves and collects on both conductors and insulators. Because "static electricity" behaves more like ether than electricity, I am going coin a term for this form of energy when it is present in wires and circuits. I call it “ETHERICITY”, to distinguish it from electricity all together.

In some ways, electricity behaves like electricity and in some ways it behaves differently. This has been the source of confusion. Up until now, most people have thought that there was only one kind of energy moving in electrical style circuits. This can now change. Electric appliances are designed to run on the discharge of electric potential from high to low, as in the draining of a battery to power a load. Properly designed circuits employing ethericlty run the appliance on the charging phase, as the energy spontaneously moves from low potential to high. Once the behaviors of etheric ity are clearly understood, it will be just as easy to run motors and lights from this source as we now do on electricity. In the 1940's, Dr. Wilhelm Reich demonstrated both lighting and motoring effects running on the Etheric Energy Field that he tapped using his "orgone accumulators" and special circuitry. Bit many other ways have been discovered to harness elecricity. The patent office has many designs of so-called "electrostatic' motors on file that work quite well They all run on ethencity, including some powered by circuits set up between the ground and a wire suspended high in the air. Many types of capacitors will spontaneously charge up on days with low relative humidity. This, too, is the classic appearance of ethecricity. I have seen how an "electrostatic" generator failed to do anything, one humid morning, until the moment that sunlight fell on the metallic surfaces. It then jumped to life. This was one of the most convincing demonstrations I have ever seen that "static electricity" (ethericity) is related to light (the Light Ether).

Here then are some of the known characteristics of elecricity that engineers and inventors should understand

1) Ethericity can be accumulated from the ground or the air at almost any location
2) It can be "reflected' down wires (this is not conduction)
3) Flows of electricity can be interrupted by diodes and Mosfet type devices
4) Its potential can be raised or lowered in air core transformers
5) It can be stored in capacitors
6) It will operate neon style lighting; when the potential is high enough
7) It can create fields of opposing forces in coils and motor windings

"Free energy' is here in the Etheric Energy Field. Etheric Energy can be accumulated without the expenditure of work, and then released in controlled ways to perform work, in properly engineered systems. Understanding this fact presents engineers and inventors the most direct and dear path to follow. Systems that precipitate heat directly from the ether have already been demonstrated in Dr. Reich's accumulator. Placing one of these accumulators over a moving body of water increases the precipitation of heat dramatically. This is a rich vane of truth waiting to reveal its secrets to the systematic researcher. Likewise, power circuits that run on ethericity for lighting and motive power are waiting to be perfected.

Researchers in the "free energy" field should not concern themselves with the ideas presented as the so-called "Laws of Thermodynamics". The "First Law", with its ideas of conversion and conservation, is essentially incorrect There is no way to convert mechanical energy into etheric energy, actually make one into the other. This one example is enough to disprove the universal interpretation of the conversion idea all together. Beyond this, the energy forms that can be transmuted by the action o£ certain kinds of machines, apparently do so within a wide range of activity, depending on the geometry of the machine. This throws into question the idea of conservation, especially local conservation. These experimental findings render the "First Law" without any basis in fact The real universe does not behave in accordance with these ideas.

In the narrow case, the "Second Law' is really only a statement which describes the behavior of heat under certain circumstances. **This** much is basically true, as it is founded on experimental observation. In the general case, however, the "Second Law' is an intellectual extrapolation that does not accurately describe the behavior of physical reality under all circumstances. It embodies an erroneous concept of a mechanical ini- verse which mysteriously burst forth (Big Bang) as a fully wound spring that has been unwinding ever since ("in a dosed system, entropy does not decrease"). It is a lifeless, empty vision that ignores the Source of the energy it started with and doses the minds of its adherents to the solutions at hand.

Learning how to tap the non-thermodynamic forces in nature is the hope of the future. A modem society needs light, heat, and motive power, all of which can be derived directly from the Etheric Energy Field without consuming limited physical resources owned by monopoly interests.

In this society, theoretical science has been elevated to a very high level of prestige. Under this system of belief, the real needs of humanity have not been well served. Itis time that these incorrect theories be carefully examined and discarded, so that experimental science can once again take the leading role in defining the nature of physical reality. Only then will Etheric Science be free to offer its bounty of solutions to a desperate and waiting world.

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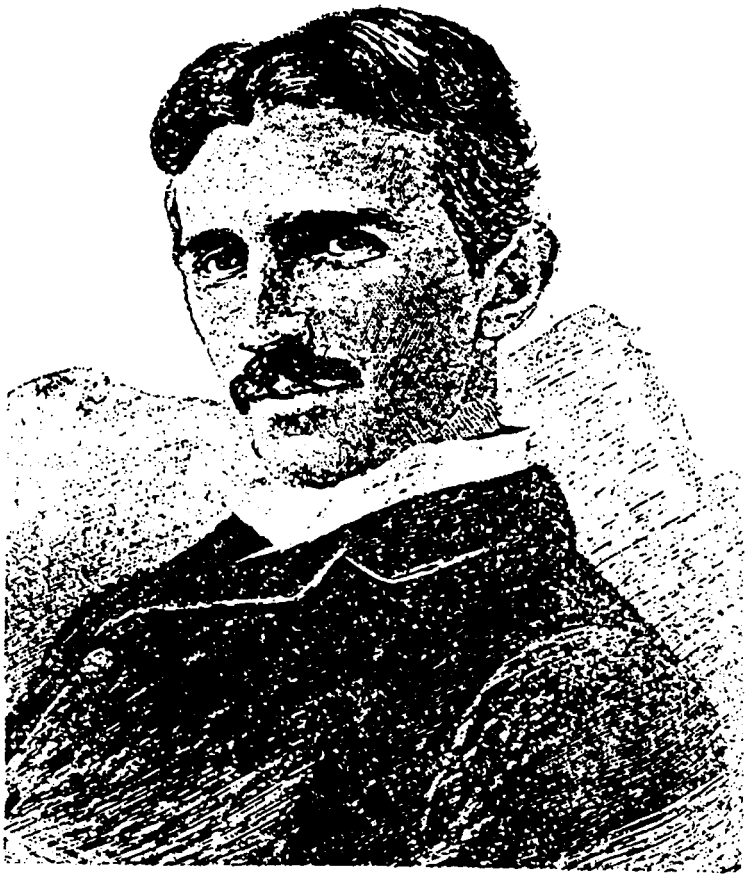
Tesla's “Self-Acting” Engine

by Peter A. Lindemann



In June of the year 1900, Nikola Tesla published an article in Century Magazine titled *The Problems of Increasing Human Energy.* Never be fore or since has there been such a masterful and exhaustive discussion of how to extract useful energy from the environment In its original magazine format, this article is 31 pages in length. After discussing every known method for energy generation then in use, Tesla begins a discussion of "a departure from known methods - possibility of a 'self-acting' engine - the ideal way of obtaining motive power".

Beginning on page 200, and continuing to page 204 of the original Century Magazine article, Tesla outlines his ideas. The following quotations are extracted from this section of the article.

"...a survey of the various ways of utilizing the energy of the medium convinced me, ..that to arrive at a practical solution, a radical departure from the methods then known had to be made. The windmill, the solar engine, the engine driven by terrestrial heat, had their limitations in the amount of power obtainable. Some new way had to be discovered which would enable us to get more energy."

"..the problem was to discover some new method which would make it possible both to utilize more of the heat-energy of the medium and also to draw it away from the same at a more rapid rate."

"I was vainly endeavoring to form an idea of how this might be accomplished, when I read some statements from Carnot and Lord Kelvin which meant virtually that it is impossible for an inanimate mechanism or *self-acting machine to cool a portion of the medium below the temperature of the surrounding, and operate by the heat extracted.* These statements interested me intensely. Evidently, a living being could do this very thing, and since the experiences of my early life ... convinced me that a living being is only an automaton, or, otherwise stated, a 'self-acting engine,' I came to the conclusion that it was possible to construct a machine which would do the same."

"Suppose that an extremely low temperature could be maintained by some process in a given space; the surrounding medium would then be compelled to give off heat, which could be converted into mechanical or other form of energy, and utilized. By realizing such a plan, we should be enabled to get at any point of the globe a continuous supply of energy, day and night."

"A closer investigation of the principles involved, and calculation, now showed that the result I aimed at could not be reached in a practical manner by ordinary machinery, as I had in the beginning expected. This led me, as a next step, to the study of a type of engine generally designated as `turbine,' which at first seemed to offer better chances for a realization of the idea."

"..my conclusions showed that if an engine of a peculiar kind could be brought to a high degree of perfection, the plan I had conceived was realizable, and I resolved to proceed with the development of such an engine, the primary object of which was to secure the greatest economy of transformation of heat into mechanical energy."

"(In early 1895) Dr. Carl Linde announced the liquefaction of air by a self-cooling process, demonstrating that it was practicable to proceed with the cooling until liquefaction of air took place. This was the only experimental proof which I was still wanting that energy was obtainable from the medium in the manner contemplated by me."

"Much 01 "3 task on which I have labored so long remains to be done. A number of mechanical details are still to be perfected and some difficulties of a different nature to be mastered, and I cannot

hope to produce a self-acting machine deriving energy from the ambient medium for a long time yet, even if all my expectations should materialize."

Testa's idea was radical. Design a machine powered by the heat resident in the ambient air that produced an output of mechanical energy and refrigeration simultaneously. He called it "the ideal way of obtaining motive power". Such a machine would be able to produce useful energy at any time of the day or night, at any location on the globe, drawing upon the vast heat reservoir of the atmosphere. He worked for years toward this goal and absolutely convinced himself, by the power of his own nearly infallible logic, of its potential reality.

To my knowledge, Testa never finished the work on this invention. But his pioneering efforts clearly conceived the idea, as well as outlined most of the engineering problems to be solved.

It's remarkable to me, that with all of the attention given to Nikola Testa in the last few years, I have not heard any mention of this aspect of his work. Volumes have been written on so-called "free energy" devices, wherein the would-be inventors are searching in vain for a ubiquitously present, inexhaustible source of energy from which their machines may draw. Imaginative theories have postulated "tachyons", "zero-points", and "magnetism" as the source of choice from which to extract energy. And, while future work may prove that these sources can be made practical, it is still surprising that the most readily available, untapped source of energy from which to draw, atmospheric heat, has been all but neglected.

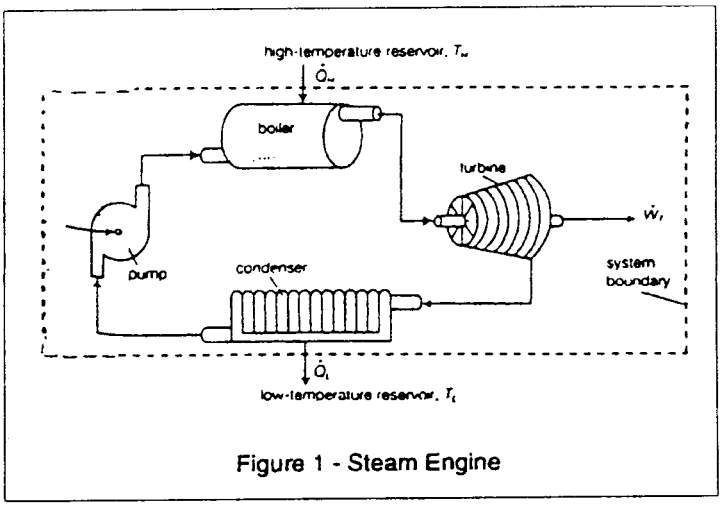


Figure 1 - Steam Engine

The patent office is crammed with hundreds of "permanent magnet motors", none of which work, to my knowledge. Testa dismisses these ideas with a short stroke, "We may even find ways of applying forces such as magnetism or gravity for driving machinery without using any other means. Such realizations, while highly improbable, are not impossible." While leaving the door open, Tesla considers this area of research worthy of only a brief mention. He then goes on for four pages, discussing his efforts to tap the ambient temperature as a source of power.

Tesla was a master thinker and inventor. His mind penetrated the ultimate solution to humanity's energy needs. Like a scientific Sherlock Holmes using the power of his own deduction, when all of the 'improbables' and "impossibles" were removed, what remained must be the solution. Atmospheric heat was the largest untapped reservoir of energy on the planet Tesla refused to overlooked the obvious. He was that rare fish capable of contemplating the water he was swimming in. Few were able to follow his ideas. Even fewer were able to follow-up on his work

When I first read this article from Century Magazine, I was fascinated by the section on the "self-acting" engines. But Testa's idea of gaining energy by dumping heat into an inexhaustible "cold spot" seemed unrealizable. My mind could not penetrate the unknowns involved. Luckily, other minds were not so dull.

To begin to get an understanding of Tesla's idea, let's fast look at the fundamentals of fluid dynamics. Follow along if you can. If a gaseous fluid (like air) is confined in a closed space, three properties of this gas become interdependent upon each other. These properties are: 1) Volume, how much space it occupies, 2) Temperature, how much heat it contains, and 3) Pressure, how much force it exerts on the walls of the container. For instance, if the container remains the same size and we increase the temperature of the air inside, the pressure it exerts on the walls also rises. Likewise, if the volume stays the same and we reduce the pressure, the temperature must also drop. Conversely, if we increase the volume, either the temperature or the pressure will go down (or both). From this we may see that temperature and pressure are directly related to each other, but are inversely related to the volume. This is how Dr. Carl Linde liquefied air by his "self-cooling" process. By manipulating the pressure and volume of a quantity of gaseous air, he was able to liquefy some of it by taking advantage of these principles.

One hundred years ago, this was an amazing accomplishment. Now, these processes are used commercially every day. To illustrate, we need go no further than a useful novelty available in a mail order catalog. Many compressed gases are available today. One of them is carbon dioxide. For less than $30, you can buy a special nozzle that attaches to a canister of compressed carbon dioxide. When the gas is released through this nozzle, "dry ice" is formed. Room temperature compressed carbon dioxide, when allowed to expand rapidly under controlled conditions, refrigerates itself to form "dry ice'. By this method, about 20% of the compressed gas can be liquefied, or in this case, solidified. This illustrates what Tesla refers to as the "self-cooling" process that allowed Dr. Carl Linde to liquefy air in 1895. Tesla immediately understood the implications. He states that his invention could be designed to run on liquid air, but that "its temperature is unnecessarily low." All that was needed was a working fluid that changed from a gas to a liquid at a temperature below the ambient

Dr. Linde's process required a mechanical energy input to compress the air. But Tesla knew that mechanical processes were reversible. The machine he envisioned used the methods discovered by Dr. Linde, but ran them backwards. To understand how this can be done, we need go no further than our own medicine cabinet If room temperature isopropyl alcohol is rubbed on your

arm, it "feels . cold". It feels cold because it is evaporating. It is evaporating because of a change in "vapor pressure" between the closed bottle and the open air. This change of pressure is "forcing" the evaporation to take place. But, for the alcohol to evaporate (change from a liquid to a gas), it needs heat Since no heat source is available, it must get the necessary heat from the immediate environment So, it extracts that heat from your arm. That's why your arm feels cold (refrigeration). Believe it or not, Tesla saw an energy machine in all of this. The one part of the equation that is not so apparent here, is that the volume of space occupied by the evaporating alcohol is increasing dramatically. This increasing volume of gas could be confined to form a pressure that could drive an engine. Tesla saw it all, and knew what it meant He spent years trying to solve all of the engineering problems associated with it, so that a future society could have all of its energy needs supplied by these processes.

So, what does Tesla's "self-acting" engine really look like? In order to visualize this, it may be helpful first to review the workings of two different kinds of heat systems that operate on "two phase fluids"; the first is a steam engine and the second is a heat pump. In Figure 1, water is boiled in the boiler to become pressurized steam. This high temperature, high pressure steam is then used to drive a turbine engine to convert the vapor pressure into mechanical work. The low temperature, low pressure steam coming out of the turbine is then allowed to cool further in the condenser, becoming liquid water again. The liquid water is then pumped back into the boiler, and the cycle begins again. In this example, we can easily see that the system takes in heat at the boiler and gives off heat at the condenser.

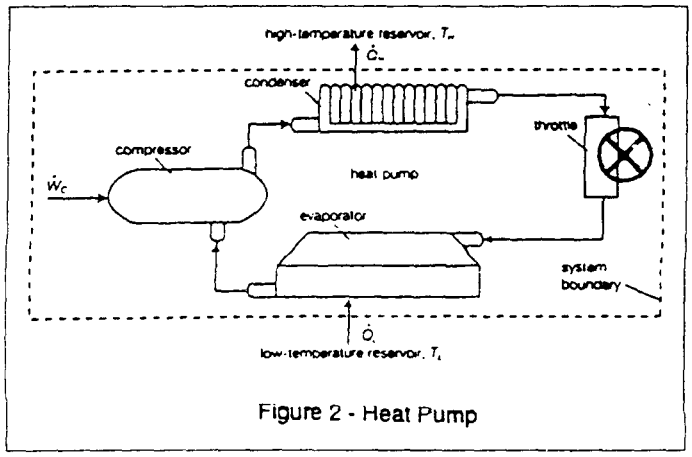


Figure 2 - Heat Pump

Figure 2 is a diagram of a heat pump. Low temperature vapor enters the compressor and is compressed to a high pressure and temperature. This vapor is then condensed to a liquid in the condenser. Then, the pressurized liquid is throttled through a special nozzle to low pressure and temperature. Releasing the pressure allows some of the liquid to vaporize. This "two phase fluid", part liquid and part vapor, now enters the evaporator, in which the remaining liquid is boiled. The resultant low temperature vapor then enters the compressor, completing the cycle. In this example, we can see that the system takes in heat at the evaporator and gives off heat at the condenser.

There is a high degree of similarity between these two systems. Both have a location where heat is absorbed (boiler and evaporator). Both have a location where the pressure is released (turbine and throttle). Both have a location where heat is released (condensers). And both have a *location* where the working fluid is pressurized to complete the cycle (pump and compressor). In the steam engine, heat energy is added to the system at the boiler and mechanical energy is removed from the system at the turbine. That amount of heat that was not successfully transformed to mechanical energy at the turbine, is then thrown away at the, condenser and represents a loss of efficiency. In the heat pump, mechanical energy is added to the system at the compressor and heat energy is removed from the system at the condenser. That amount of liquid that vaporizes at the throttle represents a loss of efficiency because no heat is absorbed from .the environment to create the vaporization.

The main difference between these two systems is that the steam engine runs on a working fluid (water) that changes phase from a liquid to a gas at 212' Fahrenheit, whereas the heat pump runs on a working fluid (freon) that changes phase from a liquid to a gas at -50' Fahrenheit Tesla's "self-acting" engine was a unique hybrid between these two systems.

Tesla knew that his system, if it was to work, had to be much more efficient than standard systems. In our steam engine example, for instance, if we could elimi nate the condenser, the system would be more efficient In our heat pump example, if we integrated the throttle into the evaporator so that all of the expansion happened there, the system would be more efficient. These are the .kinds of engineering problems Tesla was attempting to solve. By taking elements from both of these systems, we can begin to understand what Tesla had discovered. Figure 3 shows such a system. It runs on a low temperature phase change material, like freon. The first element acts like a combination of the pump and the compressor. Its job is to take the "two phase fluid", part liquid and part vapor, and compress it until it is 100% liquid. The next element of the system takes the place of the boiler. It is really a heat exchanger that allows the working fluid to absorb heat from the environment without boiling. On the outside, this element gets cold and produces refrigeration effects. On the inside, the working fluid is gaining in its stored heat potential. The next element of the system is the throttle or control valve. This component allows the pressurized, liquid material to experience a rapid pressure drop that promotes instant vaporization of some of the working fluid. Since no heat source is available here, the heat of vaporization must come from the stored heat in the working fluid itself. This rapidly expanding vapor/liquid combination is then harnessed by the next element of the system, the turbine. As Tesla said, this is "an engine of a peculiar kind." It must be able to efficiently operate on the part vapor, part liquid material coming through it When the volumetric expansion is spent, the "two phase fluid" is then re-compressed to a liquid, and the cycle starts over. Tesla envisioned that his turbine would produce more mechanical energy than the compressor required, so that the s*ystem would* produce a net gain of mechanical energy.

Unlike the two previously discussed systems, Tesla's "self acting" engine has no condenser where unused heat is thrown away. Heat energy is absorbed from the ambient, mechanics energy is removed from the turbine and all of the remaining hea potential in the working fluid is recycled for the next go-round.

The whole thing is an amazing idea, but will it work? Can the necessary efficiencies actually be attained? In the 1930's, an Austrian engineer named Rudolf Doczekal successfully built a steam engine that ran on a combination of water and benzene. To his amazement, it could run with or without the condenser in the system. Its efficiency was well above the calculated Carnot Cycle maximum. He was granted a Patent on this system in 1939 (NR. 155744). It took 39 years, and someone else to prove it, but Tesla was right; a high efficiency heat engine could be run without a condenser.

But can all of the other efficiencies be attained? Is there a device that can efficiently compress the "two phase fluid" back to a liquid?

The answer is yes. Today, the Copeland Scroll Compressor can perform this function. Is there a turbine that can run efficiently on the rapidly expanding "two phase fluid?" Again, the answer is yes. Impulse turbines with the pressure nozzles built directly into the housing can perform this function, so that all of the fluid expansion occurs inside the engine. In fact, all of the other engineering problems have been solved.

Today there are working models of machines that convert the ambient temperature of the air into mechanical energy, while creating refrigeration as a by-product One hundred years after Tesla identified the "ideal way of gaining motive power", the gigantic reservoir of atmospheric heat has been successfully tapped. Real "free energy" has arrived on planet Earth. Obviously, the working details of these machines are complicated. The average reader will not have a thorough understanding of them without considerable study. Still, the basic principles upon which they operate have been outlined here with only minor oversimplification.

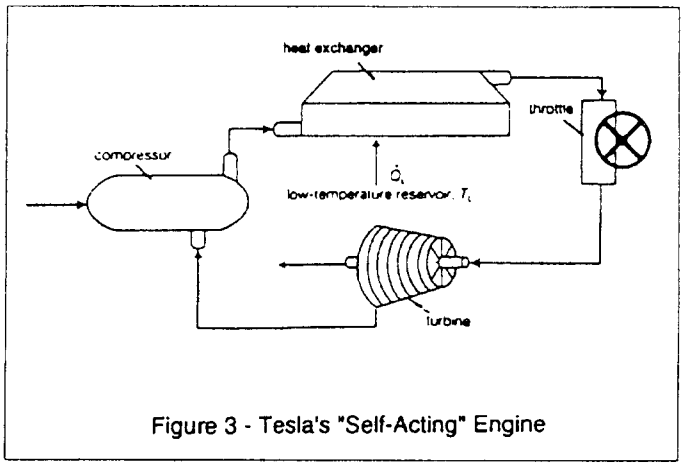


Figure 3 - Tesla's "Self-Acting" Engine

As of June, 1995, there are two slightly different processes being pursued that give the same basic result The first is a machine designed by a German physicist, Dr. Bernhard Schaeffer, along with a Russian inventor, Albert Serogodski, building on the pioneering work of Doczekal. Their latest machine has been granted German Patent # DE 42 44 016 A 1, and is capable of being embodied as a refrigerator that produces electricity rather than consumes it The other development is based on the work of Canadian engineer, George Wiseman, building more directly on Tesla's ideas. Wiseman has written three books that fully outline the principles of this amazing invention. His **HEAT Technology Series, Book 1, Book 2, and Book 3** are must reading for anyone interested in this subject In these books, turbine designs are explored along with complete mathematical models of the system. For copies of these books, write to: Eagle Research, Box 145, Eastport, ID, 83826 USA. Each book is $15, post paid in North America. Add $5 more for overseas postage. Buy both books, as they cover different aspects of the system.

One hundred years ago, Nikola Tesla discovered the ultimate way to harness the energy of the sun by converting the ambient temperature of the air into mechanical energy. He outlined the entire method and even solved many of the difficulties himself. But forces during his lifetime prevented him from completing this work. His "self-acting" engine is a true fuel-less power plant, capable of producing useful energy at any location on the planet, at any time of the day or night It has taken one hundred years for others to finally complete this work, but that day has now arrived. While I do not wish to minimize the irreplaceable and outstanding contributions by Wiseman, Schaeffer, Doczekal and others, still, it is to Tesla that the future owes its thanks once again.

When Tesla first conceived of this invention, he started by deciding that the basic assumptions embodied in the "Second Law of Thermodynamics" were not universally true and therefore could not act as an absolute limiting case. These assumptions are built into our lives today by the idea that if I want the temperature of my environment to be either warmer or cooler than the ambient, I have to expend energy to do it Tesla was not afraid to question or even disagree with these assumptions. Even the stature and historic "authority" of Sadi Carnot and Lord Kelvin, whose work was the basis of the "Laws of Thermodynamics", did not intimidate him. He was willing to rethink all of the fundamentals in the light of his own experiments and insight, and draw his own conclusions. By doing so, he was able to conceive of an invention that has taken 100 years to create.

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"Technological, historical, and philosophical dynamite! Clarifies the fundamental juncture at which electric power technology diverged from Tesla's liberating genius."—*Trevor James Constable (Researcher and Author)*

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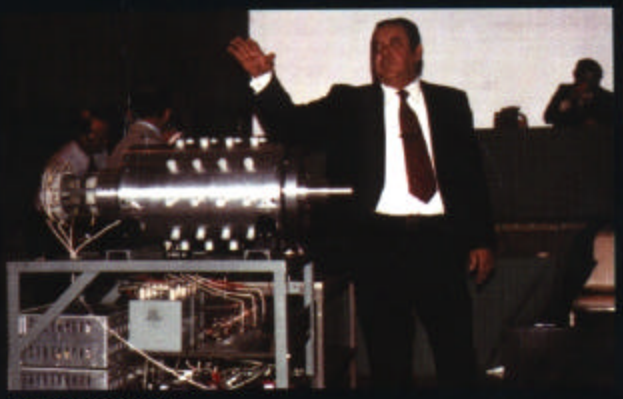
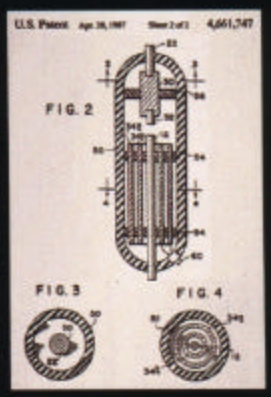
". . .Dr. Lindemann explains Tesla's bizarre electricity experiments, which no amount of exposure to Tesla's work, from all other sources, has ever done for me. ...The video tape [book] gives enough general and specific information that a detailed design can confidently be built by any competent tinkerer with a working knowledge of electronics and electric power circuitry."—*Ken Rauen (Infinite Energy Magazine, January 2001)*



Ed Gray in 1977

Conversion Tube Close Up



Conversion Tube Patent

Finally, long-time Free Energy researcher Dr. Peter Lindemann steps up and tells all. This four part book explains exactly how Edwin Gray, Sr. produced what he called "cold electricity." Mr. Gray discovered that the discharge of a high voltage capacitor could be shocked into releasing a huge, radiant, electrostatic burst. This energy spike was produced by his circuitry and captured in a special device Mr. Gray called his "conversion element switching tube." The non-shocking, cold form of energy that came out of this "conversion tube" powered all of his demonstrations, appliances, and motors, as well as recharged his batteries. Mr. Gray referred to this process as "splitting the positive."

Even more remarkable, Dr. Lindemann found that Nikola Tesla actually discovered this same effect, back in 1889. With the information in this book, you will learn what it took Tesla, Gray and others decades to figure out. Using articles, patents, diagrams, and photographs, Dr. Lindemann unravels the mystery until the whole method is fully revealed. Now you can do it too! This is the information free energy enthusiasts have been waiting for.

Nikola Tesla

Wardenclyffe Tower