F. B. MacLAREN.

ELECTRIC GUN.

APPLICATION FILED MAR. 16, 1916.

1,384,769.

Patented July 19, 1921.

3 SHEETS—SHEET 1.

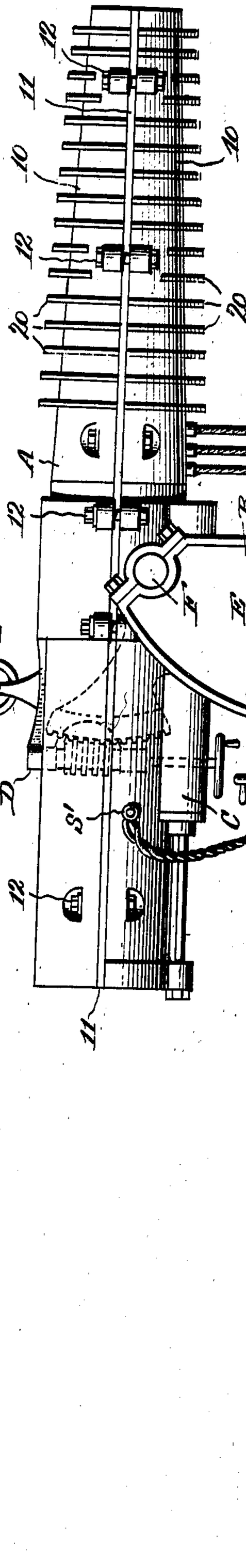

Fig. 1.

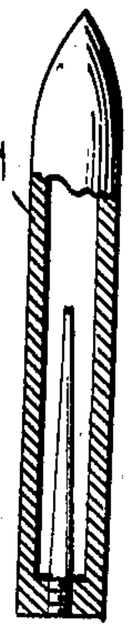

Fig. 2.

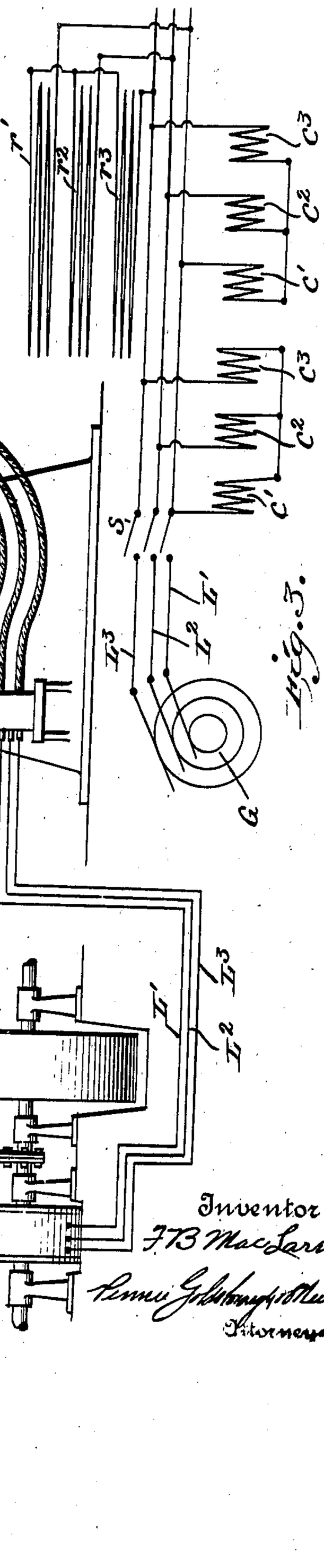

Fig. 3.

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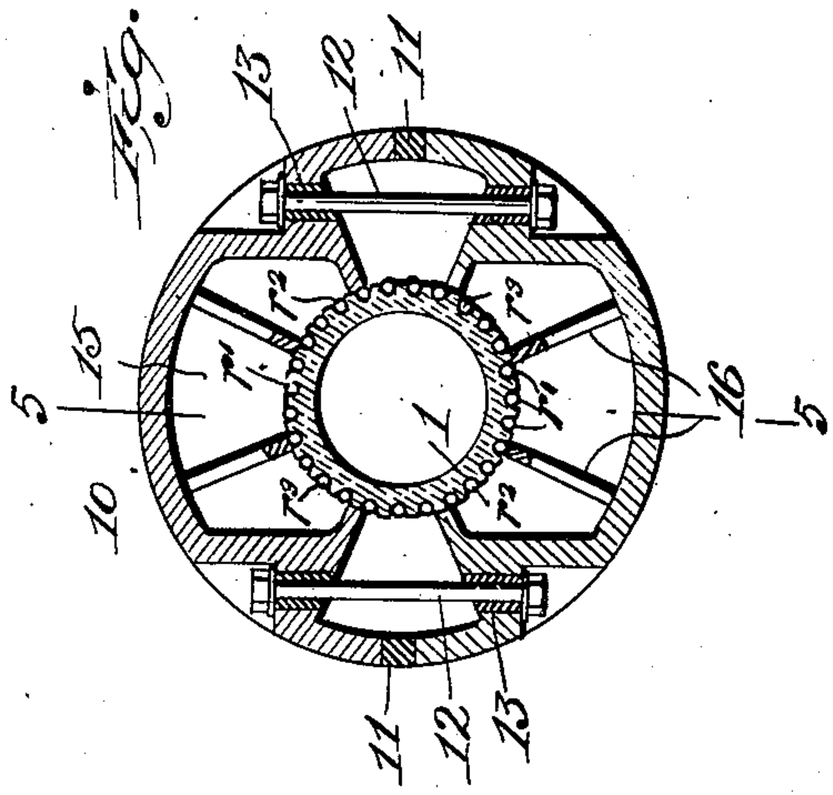

Fig. 4.

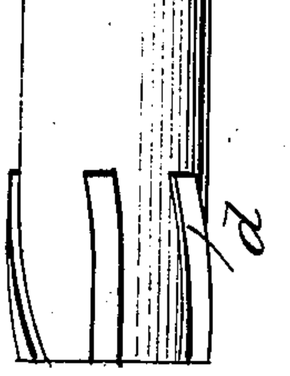

Fig. 7.

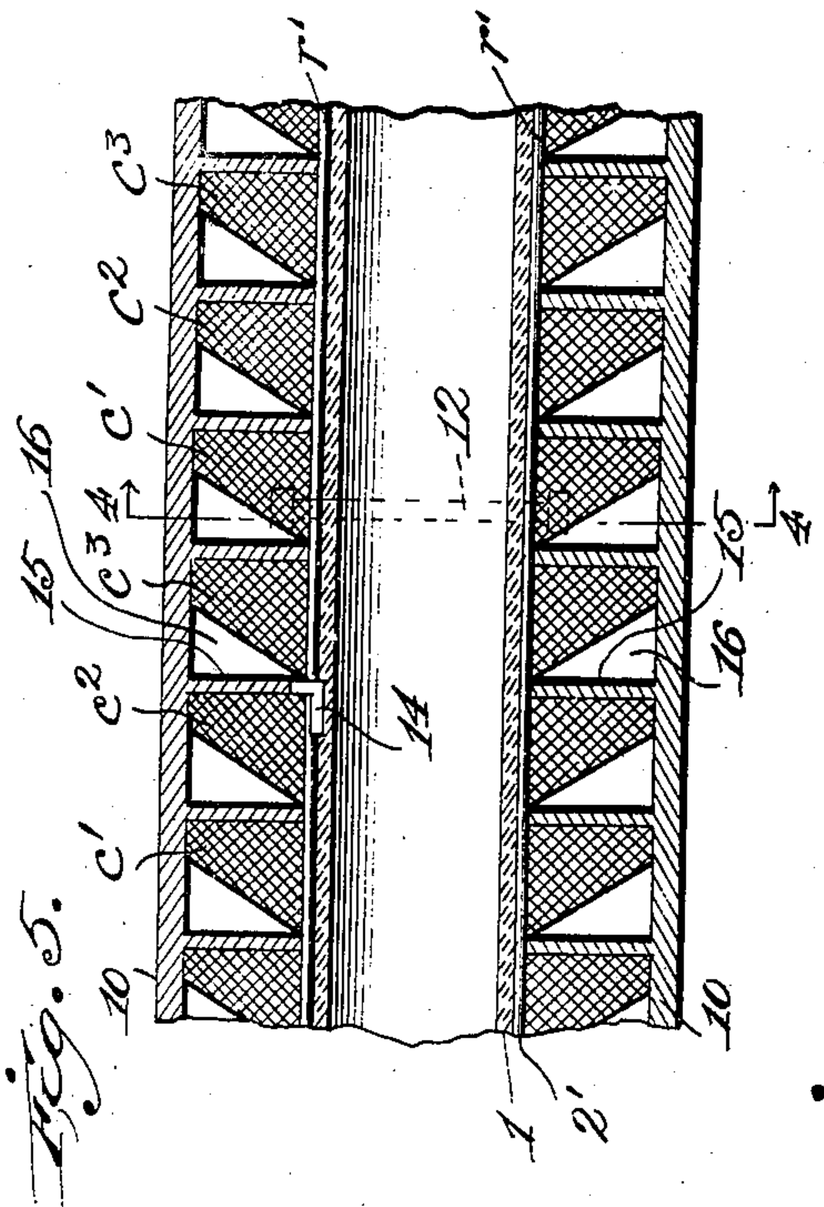

Fig. 5.

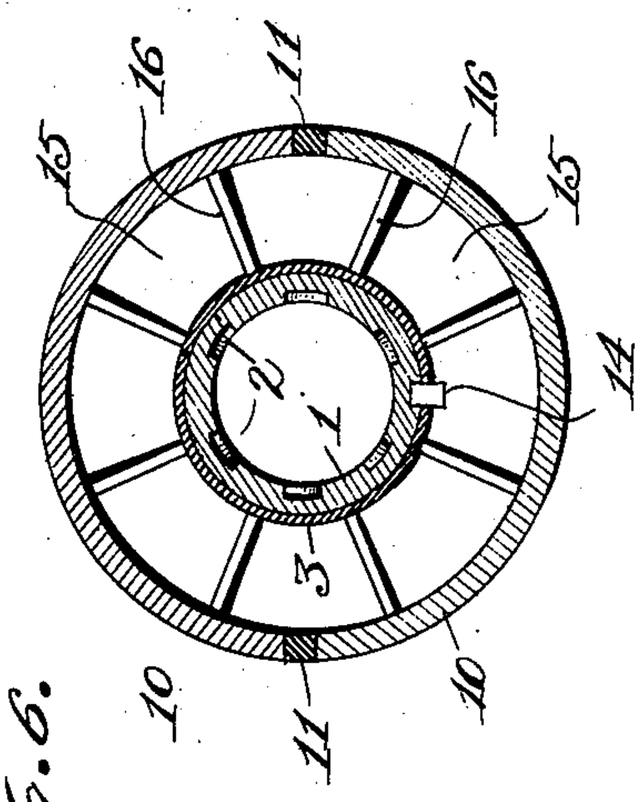

Fig. 6.

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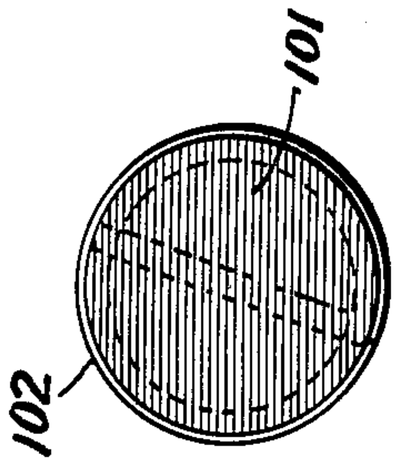

Fig. 9.

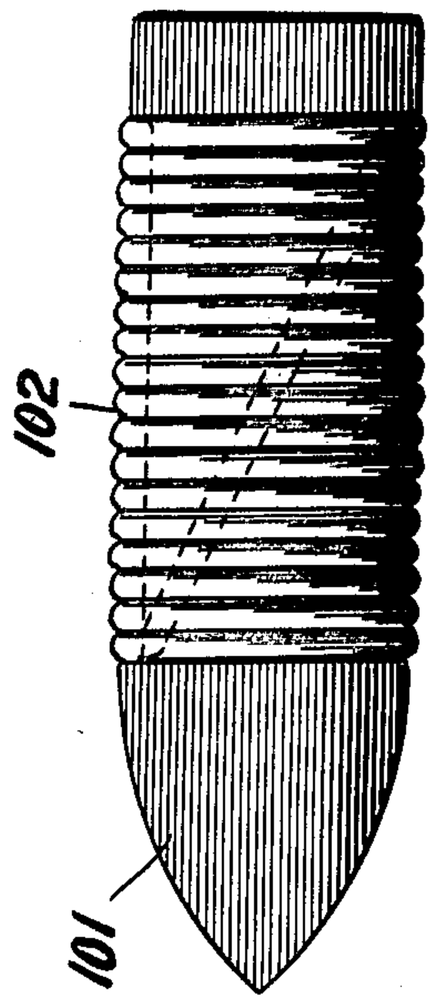

Fig. 8.

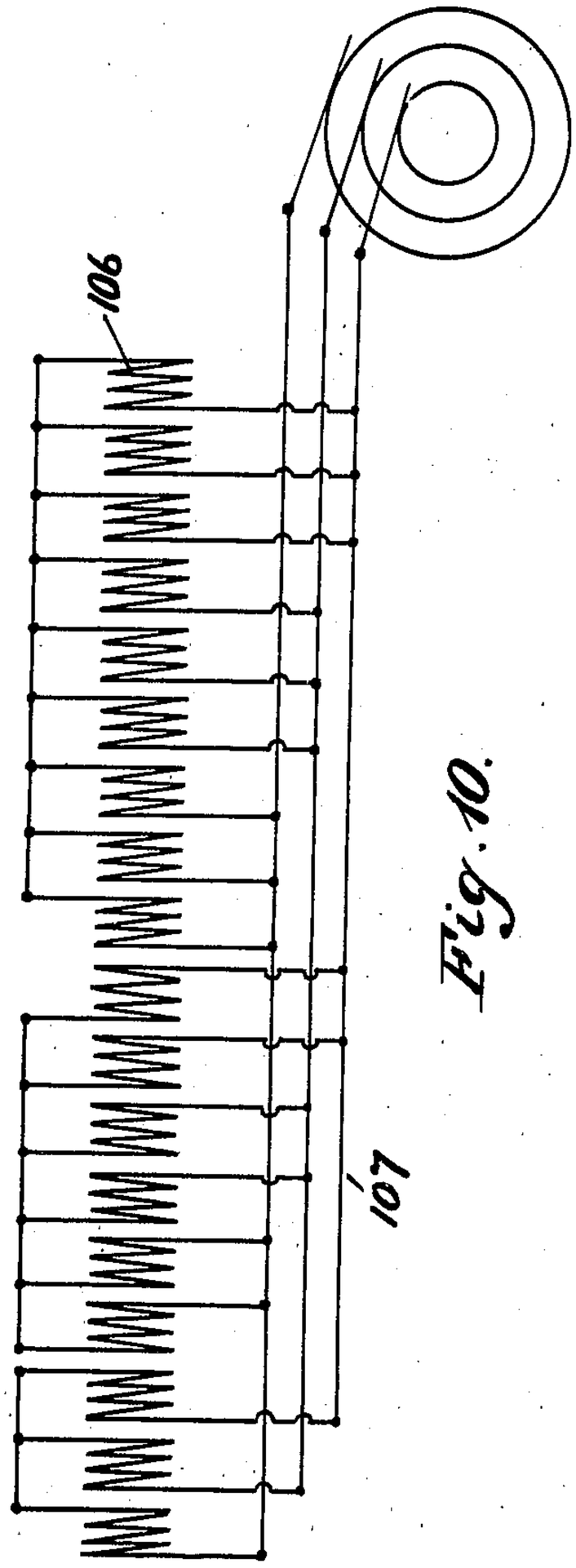

Fig. 10.

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UNITED STATES PATENT OFFICE.

FREDERICK B. MacLAREN, OF JERSEY CITY, NEW JERSEY, ASSIGNOR TO ELECTRIC GUN CORPORATION, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF DELAWARE.

ELECTRIC GUN.

1,384,769. Specification of Letters Patent. Patented July 19, 1921.

Application filed March 16, 1916. Serial No. 84,674.

To all whom it may concern:

Be it known that I, FREDERICK B. MACLAREN, a citizen of the United States, residing at Jersey City, county of Hudson, and State of New Jersey, have invented certain new and useful Improvements in Electric Guns; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains, to make and use the same.

The invention relates to electric guns, and has for one object to provide a novel method of discharging or propelling projectiles, which consists in generating traveling magnetic fields, annular in form, propagated in the direction of the desired line of flight of the projectile, by means of polyphase electric current developed and delivered by a generator so constructed as to be capable of storing up energy, as in a heavy rotating mass and delivering the same, when desired, in the form of current of high frequency and large power. The invention has for another object to provide a novel form of apparatus for carrying out the method aforesaid, comprising a generator of polyphase alternating current of high frequency and high power, provided with a heavy fly wheel or the like, to store the energy developed by a prime mover, and deliver the same to the generator, when required, and a gun comprising a barrel surrounded by a series of annular coils so disposed and arranged that, when they are connected to the leads from the generator, they will produce a series of traveling annular magnetic fields progressing successively from the breech to the muzzle of the gun, so that when a suitable projectile is placed in the breech, said projectile will be subject to the effect of current induced in it by said traveling magnetic fields and will be moved through the bore of the gun barrel toward the muzzle, with an increasing velocity, which ultimately approximates that of the traveling magnetic fields, and said projectile is discharged from the gun muzzle at the attained velocity.

These and other objects and novel features of the invention will appear from the annexed description, in connection with the accompanying drawings, in which:

Figure 1 is a side elevation of a gun and the means for operating the same.

Fig. 2 is a side elevation, partly in section, of a shell or projectile adapted for use with the gun.

Fig. 3 is a diagram of the power circuits.

Fig. 4 is a vertical transverse section through the gun taken on the line 4—4 of Fig. 5, with coils omitted.

Fig. 5 is a fragmentary longitudinal section through the gun taken on line 5—5 of Fig. 4.

Fig. 6 is a view similar to that shown in Fig. 4, illustrating a modification of the gun structure.

Fig. 7 is a side elevation of a shell or projectile adapted for use with a gun of the type shown in Fig. 6. Figs. 8 and 9 are respectively a side and an end view of a modified form of projectile, and Fig. 10 is a diagrammatic view illustrating one way of changing pole pitch.

Referring to the drawings, and more particularly to Fig. 1, A indicates the barrel of the gun as a whole, which in the type shown is mounted by the usual form of trunnions F upon a swiveled base B supported on a suitable sub-base or foundation B′ and is provided with any suitable type of recoil mechanism C, traversing mechanism E, elevating mechanism D, and sighting devices I. Obviously, any of the other usual or well known types of mounting and operating mechanism may be employed to suit the particular character of the gun and its mode and place of use.

As illustrated in Figs. 1, 4 and 5, the gun barrel preferably consists of an inner tubular member 1 provided with a clear unobstructed bore and open at both ends, which constitutes the guideway for the projectile. This inner member 1 is preferably formed of a tube of metal possessing high specific resistance to electric currents, such, for example, as silicon steel, or, where practicable, of a non-conducting material, such as indurated fiber or a composite material possessing sufficient strength to withstand the stresses imposed upon it. By making the inner member 1, of high resistance, a substantially equal distribution of flux around the gun is effected and any possible tendency.

to shoot the member 1 is opposed and the energy loss due to eddy currents is reduced.

Surrounding the inner tubular member 1 and spaced therefrom is an outer tube or jacket 10, which is preferably split or divided longitudinally into two sections, the adjacent edges or flanges of which are separated by insulation 11 and are rigidly secured together at appropriate intervals by means of bolts and nuts 12, which in turn are electrically insulated from the jacket sections 10 by means of sleeves and washers 13 of indurated fiber or other good insulating medium. The splitting of the jacket 10 is to prevent short circuit currents from flowing in it.

The annular space between the inner and outer tubular members 1 and 10 is subdivided transversely by means of annular partitions 15, which in turn are provided at intervals with radial generally triangular ribs or fins 16, the partitions and ribs, 15 and 16, being preferably rigidly connected or formed integrally with the outer sections 10 of the jacket.

Arranged within the cellular structure formed by the inner tube 1 and the outer jacket 10 is a series of annular coils c', c^2, c^3, arranged is successive groups and extending from the breech to the muzzle of the gun, each of said coils being so formed as to conform to the annular space defined between the vertical wall of an adjacent partition 15 and the rearwardly inclined edges of the ribs 16 so that the partitions 15 and the strengthening ribs 16 serve to take up the thrust produced in the gun by the passage of a projectile through the same and distribute such thrust uniformly throughout the gun barrel.

It will be understood that the inner tube 1 is rigidly locked to the other parts of the barrel structure at the muzzle and breech, or, if desired, at intermediate points so as to prevent any independent movement between the inner tube and the parts of the gun barrel.

The several sets of annular coils c', c^2, c^3 constitute the means for generating in the barrel or bore of the gun, traveling magnetic fields, which are propagated longitudinally of the gun barrel from the breech toward the muzzle and which, when a projectile of appropriate material is placed in the bore of the gun at the breech, induce currents in the projectile, thereby setting up a force tending to move the projectile through the gun toward the muzzle.

As illustrated, the coils c', c^2, c^3 are supplied with current of the alternating three-phase type, but obviously current of any other polyphase type might be employed by proper selection and arrangement of the coils.

Each group of coils, c', c^2, and c^3 is connected with the leads L', L^2 and L^3 of a three-phase generator G which is especially designed to develop alternating currents of high frequency and great power, the connections being made in accordance with the wiring diagram illustrated in Fig. 3.

The generator G, designed for high frequency and to deliver very large currents for relatively short periods of time, is provided with a heavy fly wheel G′, and is adapted to be coupled up with a steam engine or other prime mover. The fly wheel G′ serves as an agency for storing the energy developed by the prime mover and for delivering the stored energy to the generator. The necessity for some energy-storing means will be apparent when it is remembered that the power supplied by the generator is utilized only while the projectile is traveling through the gun barrel and with a gun barrel of the ordinary length and the high velocity imparted to the projectile, each period of time, when power is demanded of the generator, is but a small fraction of a second. As the amount of power or energy required during this brief interval of time is very large, however, the reserve energy stored up in the fly wheel becomes available.

In order to control the supply of current from the generator to the coils of the gun barrel, there is interposed in the circuit between the generator and the coils a suitable switch S, which in turn is controlled by a push button or other circuit controlling means S′, preferably mounted on the gun barrel and electrically connected with the switch S. Said switch S may be of any of the well known types used in circuits of this general character.

The projectile P consists of either a solid or hollow body of metal which may be of any appropriate shape common to shot or shell. Preferably the projectile is made of metal having good electrical conductivity and sufficient strength to stand the strains imposed upon it, such as steel, brass, copper, aluminum or similar metals. If desired, the projectile may consist of laminated iron as shown at 101, Figs. 8 and 9, associated with insulated copper conductors 102, the iron portions acting as part of the magnetic circuit and the insulated copper as the electric circuit for the induced currents. In the preferred form of the projectile, however, the magnetic circuit is not especially provided for, but the good electrical conductivity of the projectile is a desideratum. The projectiles, as indicated, may be made hollow to provide space for an explosive and a detonator, when the projectile takes the form of a high explosive, or armor-piercing shell, or to provide space for powder, fuse and balls when the projectile is used as a shrapnel. In order to

increase the efficiency of the projectile as an element of the electrical system which effects its discharge from the gun, the walls of the shell should be as thick and heavy as possible, and the material of which the shell is formed should possess high electrical conductivity.

In order to produce the necessary rotation of the projectile to insure its proper flight through the air, suitable means for rotating the shell in its passage through the gun barrel must be provided. As illustrated in the diagram in Fig. 3, the gun barrel is provided with longitudinal coils r', r^2, r^3, which are preferably located between the inner tubular member 1 and the coils c', c^2 and c^3, each of said coils r', r^2, and r^3 being connected with the proper lead of the polyphase circuit from the generator so that when the polyphase current flows in the said coils, they set up a rotary field within the gun barrel which imparts a rotary motion to the projectile P. It is evident that the gun, as described, when operating to discharge a projectile therethrough, constitutes a polyphase motor of the induction type, of very high power and relatively small size. It is a well known fact that motors of this type generate heat during their operation, and in the present instance, special means is provided for rapidly dissipating the heat generated. This is preferably effected by providing the outer jacket 10 of the gun with ribs or fins 20 to increase the convection and radiation surfaces. In addition to this cooling means, when necessary, the gun may be provided with means for circulating a cooling medium, such as oil, around the coils surrounding the inner tube 1, or by blowing air around the coils, or by providing the outer jacket with double walls to constitute a water jacket through which water or other cooling medium may be forced. In the relatively small gun illustrated in the drawings, a sufficient cooling effect is produced by the ribs or fins 20, associated with a body of oil confined in the spaces between the inner and outer tubular members, not occupied by the exciting coils, the oil serving as a medium for conducting the heat from the coils to the outer jacket 10, where it is dissipated by the ribs 20.

Instead of providing the gun with the longitudinal coils r', r^2, r^3, to produce a rotary field, to impart the desired rotary motion to the projectile, the same result may be attained by providing the bore of the inner tube 1 with suitable rifling 2, see Fig. 6, which are adapted to be engaged by complementary ribs d, formed on the projectile d', see Fig. 7. In this type of gun, it is necessary to prevent any relative rotary motion between the inner and outer members 1 and 10 of the gun barrel and to effect this object, the inner member 1 is securely locked to the outer member 10 by means of a key 14 which engages mating slots in the outer surface of the member 1 and the adjacent peripheral edges of the partitions 15. Preferably, in both types of the gun, as described, the inner tubular member 1 is insulated from the other parts of the barrel by means of an interposed sheath or tube 3 of insulation, and obviously the key 14 should be of insulating material or be properly insulated. In the particular form of gun in which the field coils r', r^2, r^3 are employed, the latter may be disposed within or adjacent to the insulating tube 3, which is located in the space 2′ between the inner tubular member 1 and the adjacent edges of the partitions 15. In Fig. 4, the inner tube is of practically insulating material whereas in Fig. 6, the insulation is shown as applied to the inner tube.

It is obvious that the muzzle velocity of the projectile should be as high as possible, and as the velocity of the projectile cannot exceed that of the traveling field, it is, therefore, necessary that the velocity of the traveling field should be maintained as high as practicable. The velocity of the traveling field is proportional to the pole pitch and the frequency of the inducing current so that by varying or regulating either one or both of these factors, the velocity of the traveling field may be correspondingly varied. Referring to Fig. 10, one way of varying the pole pitch is shown. In that figure a series of coils 106 is shown. The first three being connected to the polyphase system 107 to form one pole, the following six coils being connected to the same system to form a pole of twice the length of the first pole, and by repetition the pole pitch may be increased indefinitely.

If the frequency of the currents in the gun coils is constant, the frequency of the current induced in the projectile is highest at the breech and gradually decreases toward the muzzle as the velocity of the projectile increases. It is a well known fact that in polyphase induction motors of any type, the forces acting on the part carrying the induced currents are a maximum for a certain frequency of induced currents, and if the frequency is descreased, the forces fall off quickly, and if increased, the forces decrease slowly from said maximum. In consonance with this principle, therefore, it is decidedly advantageous to maintain the frequency of the induced currents in the projectile constant, and of such value as will maintain the forces at a maximum. This result can be approximated for practical purposes by making the velocity of the traveling magnetic field comparatively low at the breech

and gradually increasing toward the muzzle of the gun. If the frequency of the current in the gun coils is constant, the result can be attained by varying the pole pitch, making it small at the breech and gradually increasing toward the muzzle. In addition to this particular mode of varying the velocity of the traveling field, the same result may be effected by increasing the frequency of the impressed current during the time the projectile is traveling from the breech to the muzzle of the gun, or by connecting the successive sets of coils on the gun to generators of different frequencies, which vary from a relatively low frequency near the breech and gradually increase to a maximum frequency at the muzzle. Obviously either of these two latter methods may be used in conjunction with the first method referred to, to wit, the variation of the pole pitch.

What I claim is:—

1. The method of discharging or propelling projectiles, which consists in generating traveling magnetic fields propagated in the direction of the desired flight of the projectile by means of polyphase electric current, and subjecting the projectile to the inductive accelerating influence of said traveling fields.

2. The method of discharging or propelling projectiles, which consists in generating annular traveling magnetic fields propagated in the direction of the desired flight of the projectile by means of polyphase electric current and interposing the projectile within said annular fields to subject the same to the inductive influence of the latter.

3. The method of shooting projectiles which consists in establishing a field traveling in the direction of flight by means of polyphase currents, and applying the accelerating motor effect of that field to the projectile to shoot it through the air.

4. The method of shooting projectiles by electricity which consists in producing a traveling magnetic flux flowing crosswise of the direction of flight and establishing a current flow in the projectile in directions at right angles to both the flux and flight paths and thereby causing the resultant motor effect to accelerate and shoot the projectile through the air.

5. An electric gun for discharging projectiles, comprising a tubular barrel, projectile revolving means, a series of annular coils surrounding the barrel and arranged to produce a traveling magnetic field progressing from the breech to the muzzle of the barrel, and means for simultaneously supplying polyphase electric currents to all of said coils to produce such field.

6. An electric gun for discharging projectiles, comprising a barrel having an inner tubular member constituting the bore of the gun, an outer housing, a series of annular coils interposed between the inner and outer members arranged to produce a traveling magnetic field progressing from the breech to the muzzle of the barrel, and means for supplying polyphase electric currents to said coils.

7. An electric gun for discharging projectiles, comprising a barrel, including a series of annular coils surrounding the barrel arranged to produce a traveling magnetic field progressing from the breech to the muzzle of the barrel, a series of coils arranged longitudinally of the barrel to produce a rotary magnetic field within the barrel, and means for supplying polyphase electric current to the respective sets of coils.

8. An electric gun for discharging projectiles, comprising a barrel including an inner tubular member of high electrical resistance to effect a substantially equal distribution of flux around the tubular member, a series of annular coils surrounding the tubular member and arranged to produce a traveling magnetic field progressing from the breech to the muzzle of the barrel, and means for supplying polyphase electric current to said coils.

9. An electric gun for discharging projectiles, comprising a barrel including an inner tubular member of high electrical resistance, an outer tubular member provided with heat dissipating means, and a series of coils interposed between the tubular members and arranged to produce a traveling magnetic field progressing from the breech to the muzzle of the barrel, and means for supplying polyphase electric current to said coils.

10. In an electric gun for discharging projectiles, a barrel comprising an inner tubular member, a spaced outer tubular member, annular partitions between said members and rigidly connected to one of them, and annular coils interposed between said members and between said partitions, said coils being arranged to produce, when supplied with polyphase electric current, a traveling magnetic field progressing from the breech to the muzzle of the barrel.

11. In an electric gun for discharging projectiles, a barrel comprising an inner tubular member, a spaced outer tubular member, annular partitions having ribs extending longitudinally of the barrel, and annular coils interposed between said members and between said partitions, said coils being arranged to produce, when supplied with polyphase electric current, a traveling magnetic field progressing from the breech to the muzzle of the barrel.

12. In an electric gun for discharging projectiles, a barrel comprising an outer tubular member split longitudinally, with insulation between the adjacent edges, an inner tubular member possessing high electrical

resistance, and a plurality of sets of annular coils interposed between the inner and outer members and arranged to produce, when supplied with polyphase electric current, a traveling magnetic field progressing from the breech to the muzzle of the barrel.

13. An ordnance system propelling projectiles at high velocity, comprising a generator of polyphase alternating currents of high frequency and power, a fly wheel connected to said generator to store up energy applied to said generator, and a gun comprising a barrel surrounded by a series of annular coils adapted to be simultaneously connected to said generator to produce a traveling magnetic field progressing from the breech to the muzzle of the gun.

In testimony whereof I affix my signature.

FREDERICK B. MacLAREN.