No. 733,515. PATENTED JULY 14, 1903.

C. P. STEINMETZ.

SYNCHRONIZING ALTERNATORS.

APPLICATION FILED NOV. 20, 1896.

NO MODEL.

FIG. 1.

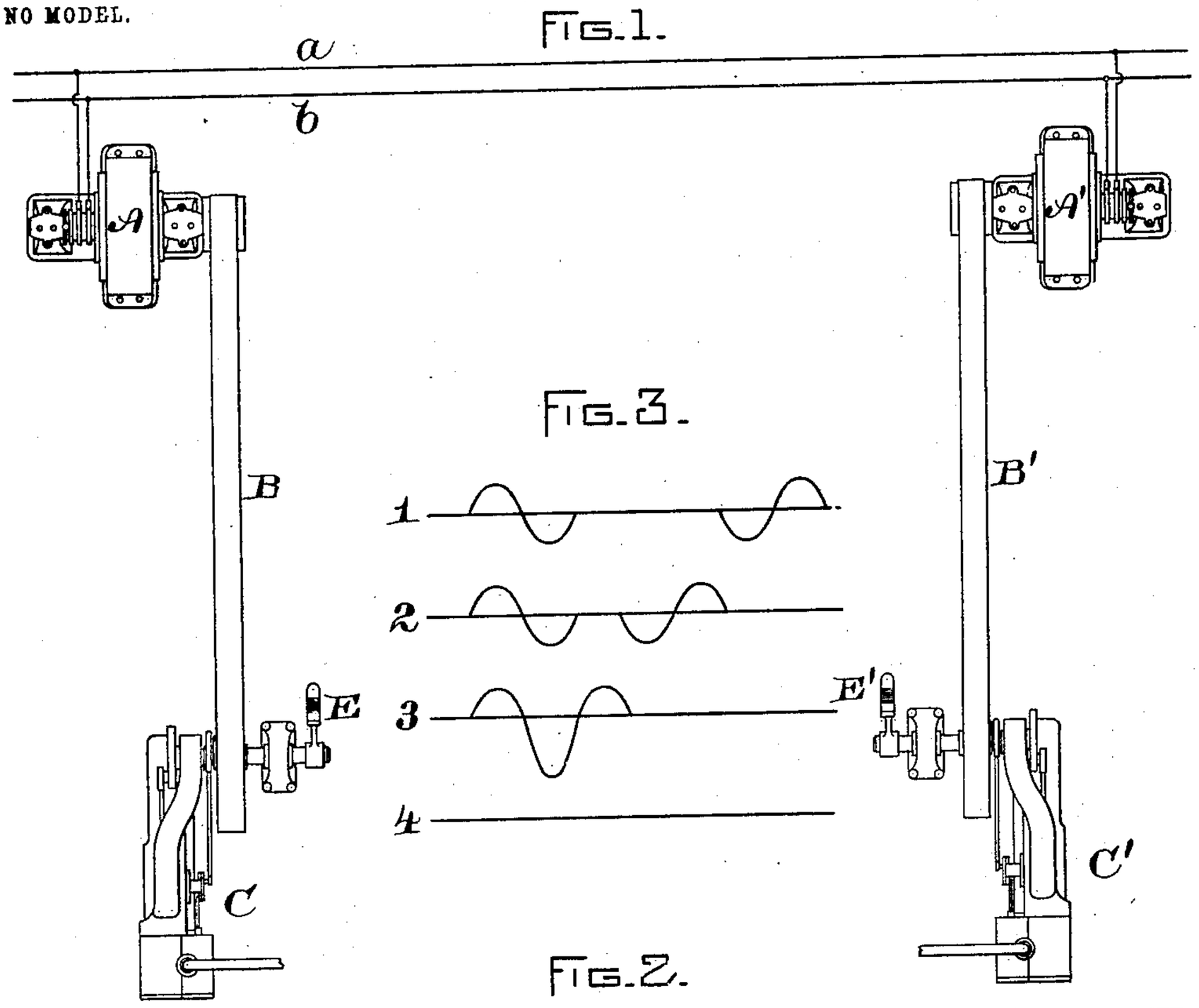
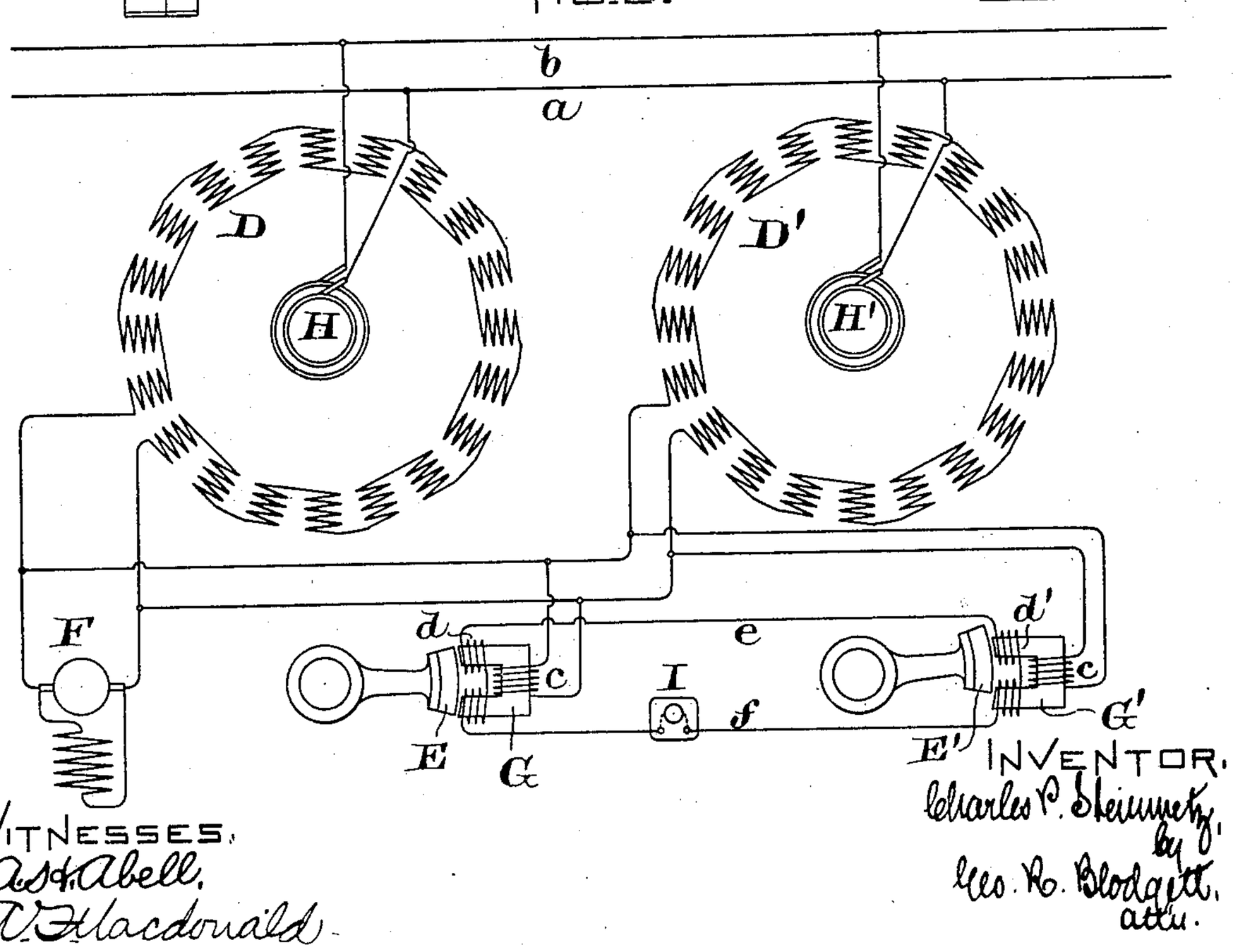


FIG. 3.

FIG. 2.



WITNESSES.
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No. 733,515. Patented July 14, 1903.

UNITED STATES PATENT OFFICE.

CHARLES P. STEINMETZ, OF SCHENECTADY, NEW YORK, ASSIGNOR TO THE GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

SYNCHRONIZING ALTERNATOR.

SPECIFICATION forming part of Letters Patent No. 733,515, dated July 14, 1903.

Application filed November 20, 1896. Serial No. 612,863. (No model.)

To all whom it may concern:

Be it known that I, CHARLES P. STEINMETZ, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Synchronizing Alternators, (Case No. 410,) of which the following is a specification.

My invention relates to synchronizing alternating-current machines operated in parallel, and has for its object to provide a simple, cheap, and convenient device chiefly useful for indicating when the engines operating the machines are running in synchronism, although it may also be employed for indicating the synchronism of the dynamos themselves.

In synchronizing alternators ordinarily but little trouble exists in getting the machines in step, inasmuch as when they are operated in parallel they have a tendency to preserve synchronism or to drop into synchronism when nearly in phase, so that in general no synchronizing devices are required for the machines themselves. In the construction, however, of the larger units, which are directly coupled each to its own engine, some difficulty has been experienced with alternators of many poles, due to the lack of uniformity in the speed during each revolution, which cannot be entirely overcome by fly-wheels. With alternators of many poles a very small fluctuation in speed may be sufficient to break the synchronism. For example, in certain eighty-pole machines with which I am familiar a fluctuation of speed of less than one per cent. is sufficient to break synchronism if the position of acceleration of one prime mover coincides with the position of retardation of the other or others. It thus becomes necessary in direct-coupled machines to synchronize the engines. A device suitable for this purpose is illustrated in the accompanying drawings, in which—

Figure 1 is a plan view of two engines which for convenience of illustration are shown as belted to independent dynamos operating in parallel. Fig. 2 is an illustrative diagram of the circuits. Fig. 3 is a series of diagrams showing the operation of the device.

The apparatus consists, essentially, of two small magnetic devices akin to transformers. Each of these has coöperating with it an arm or body of laminated material carried upon an arm or otherwise connected with the engine-shaft. The magnetic part of the device consists, essentially, of a horseshoe-magnet having upon its yoke a small energizing-coil which may derive its energy from the exciter-circuit or from any other convenient source. Upon the legs of each of these horseshoe-magnets are coils in series with each other and having no external source of energy. Those upon one device are wound or connected differentially to those upon the other, and in this circuit, which I may call the "exploring" circuit, is coupled a lamp or other indicating device, an incandescent lamp being a very convenient form.

In Fig. 1, *a b* are the bus-bars. A A′ are the dynamos. B B′ are the belts. C C′ are the engines. E E′ are the indicating or exploring devices.

In Fig. 2 the circuits are shown. *a b* are, as before, the bus-bars. D D′ are the field-magnet circuits of the two alternators. H H′ are their collecting devices coupled in multiple to the bus-bars. F is the exciter supplying in multiple the fields of the two machines. E E′ are bodies of laminated material carried upon arms connected to the engine-shafts. One of these is shown to be slightly out of phase with the other. The horseshoe-electromagnets G G′ have coils *c* upon their yokes, these being energized from the exciter-circuit. Coils *d d′* are wound upon the legs of the magnets and connected by the circuit *e f*, in which is included an indicating device I, the coils *d* being differentially wound or connected with reference to the coils *d′*.

The operation of the device is as follows: As the arm E moves past the electromagnet it causes a variation in the flux, cutting the coils *d*. A similar effect is produced by the arm E′. These variations of flux set up electromotive forces in the coils by which current is sent out over the circuit *e f*. Where these impulses occur coincidently, being equal and opposite, no current flows in the circuit,

and the lamp I remains dark. Where, however, as illustrated, one of these is slightly out of phase with the other, the current flows first in one direction, then in the other, owing to the differential winding of the coils, and the lamp is lighted. The action may be explained by reference to Fig. 3, where the engines are assumed to be running slightly out of phase and to be regulated according to the indications of the lamp, so as to be brought into phase. As in diagram 1 of Fig. 3, each of the indicators E E' gives rise to an impulse of electromotive force, as shown on the left and right, respectively, of this diagram, the impulses being somewhat separated. As the engines approach synchronism, however, the impulses also approach. They are shown close together in diagram 2. In diagram 3 the waves below the line coincide and the lamp is at this time brightest. In diagram 4, however, the straight line shows that there are no impulses of electromotive force, and the lamp remains dark. Owing to this coincidence of electromotive forces immediately before synchronism, the apparatus is exceedingly sensitive, so that the instant of attaining synchronism is very clearly marked.

I have shown only one indicator for each engine, but it is manifest that it might be duplicated without departing from my invention. Its application to other prime movers—such as water-wheels, steam-turbines, &c.—is also readily apparent without further description or drawings.

So far as I am aware I am the first to provide means of any kind for indicating synchronism of the prime movers of dynamos, and I therefore wish to make broad claims.

It is manifest that while my invention finds its greatest utility with alternating-machines in which the dynamos themselves must be brought into exact synchronism it would also be useful with continuous-current units of the larger types, in which it is desirable that the machines be rotating at about the same speed when they are thrown in multiple. No difference, however, would be needed in the construction to make it operative in this relation.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. A device for indicating synchronism of engines or other prime movers, consisting of differentially-wound electromagnetic devices included in a local circuit with an indicating device, and arranged each adjacent to a moving part of the respective engines acting by its motion past to vary the flux through the coils.

2. A device for indicating synchronism of engines driving dynamo-electric machines in parallel, consisting of a pair of electromagnets having coils thereon differentially wound and included in a local circuit with an indicator, and an external source of energy for the magnets; the whole adapted to operate with a moving part of the respective prime movers to indicate coincidence of revolution.

3. A device for indicating synchronism of a number of engines driving dynamo-electric machines in parallel, consisting of electromagnets having coils thereon differentially wound, the coils included in a local circuit with an indicator, and other coils connected in the exciting-circuit of the dynamo-electric machines, also wound upon the electromagnets and furnishing an initial energy for them, each magnet coöperating with a body of laminated material rotating with the shaft of the engine and so arranged as to vary the flux passing through the differentially-wound coils upon the magnets with each revolution, substantially as described and set forth herein.

4. In combination, a number of dynamo-electric machines, each having its own engine or other prime mover, and electrical means for indicating synchronism of the engines or other prime movers.

5. In combination, a plurality of dynamo-electric machines each having a movable member, an electric circuit, and means out of inductive relation with said members for varying the current in said circuit when said members assume a predetermined relation to each other.

6. In combination, a plurality of dynamo-electric machines each having a movable member, an electric circuit, and means out of inductive relation with said members for varying the current in said circuit as said movable members change their relative positions.

7. In an indicating apparatus, an electric circuit, a plurality of moving parts in operative relation therewith, and means for changing the impedance of said circuit when the moving parts assume a predetermined relation to each other.

In witness whereof I have hereunto set my hand this 28th day of October, 1896.

CHARLES P. STEINMETZ.

Witnesses:
B. B. HULL,
E. W. CODY.