No. 686,152. Patented Nov. 5, 1901.

A. W. SMITH.

MOTOR.

(Application filed Sept. 9, 1901.)

(No Model.)

Fig 1.

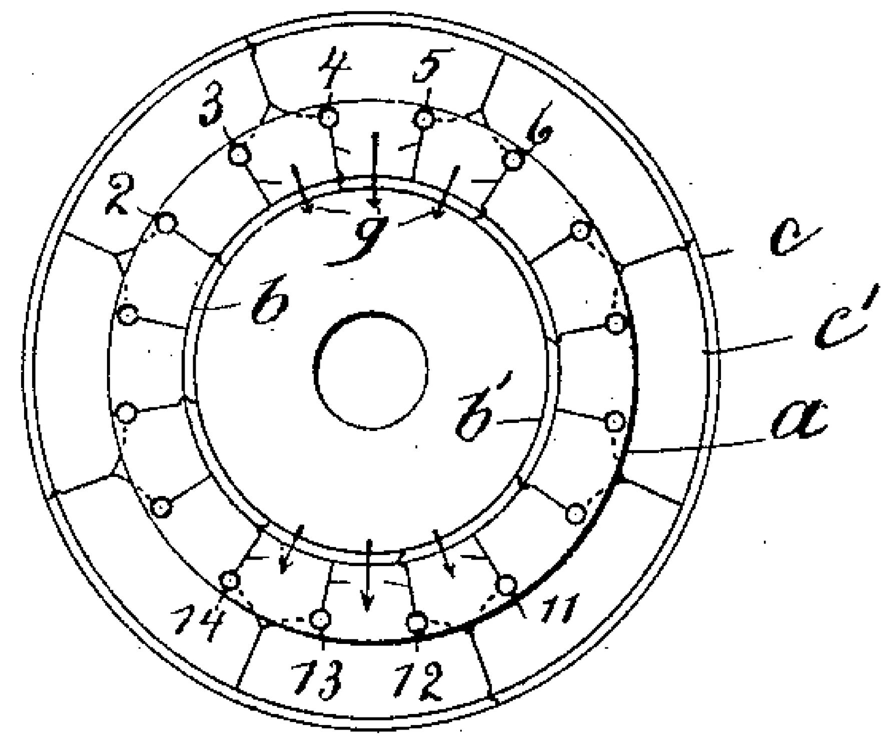


Fig 2.

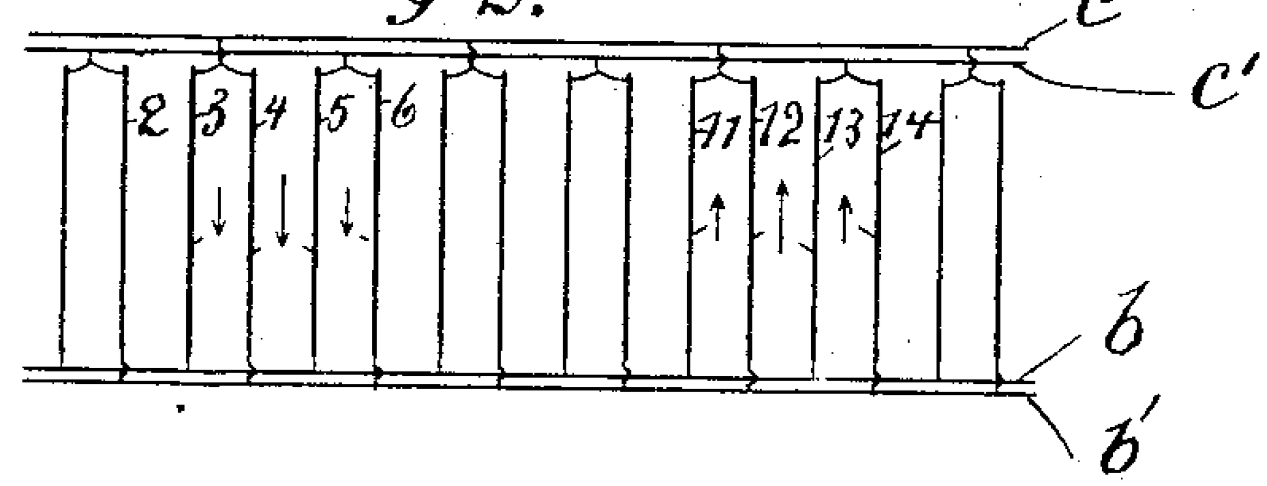


Fig 3.

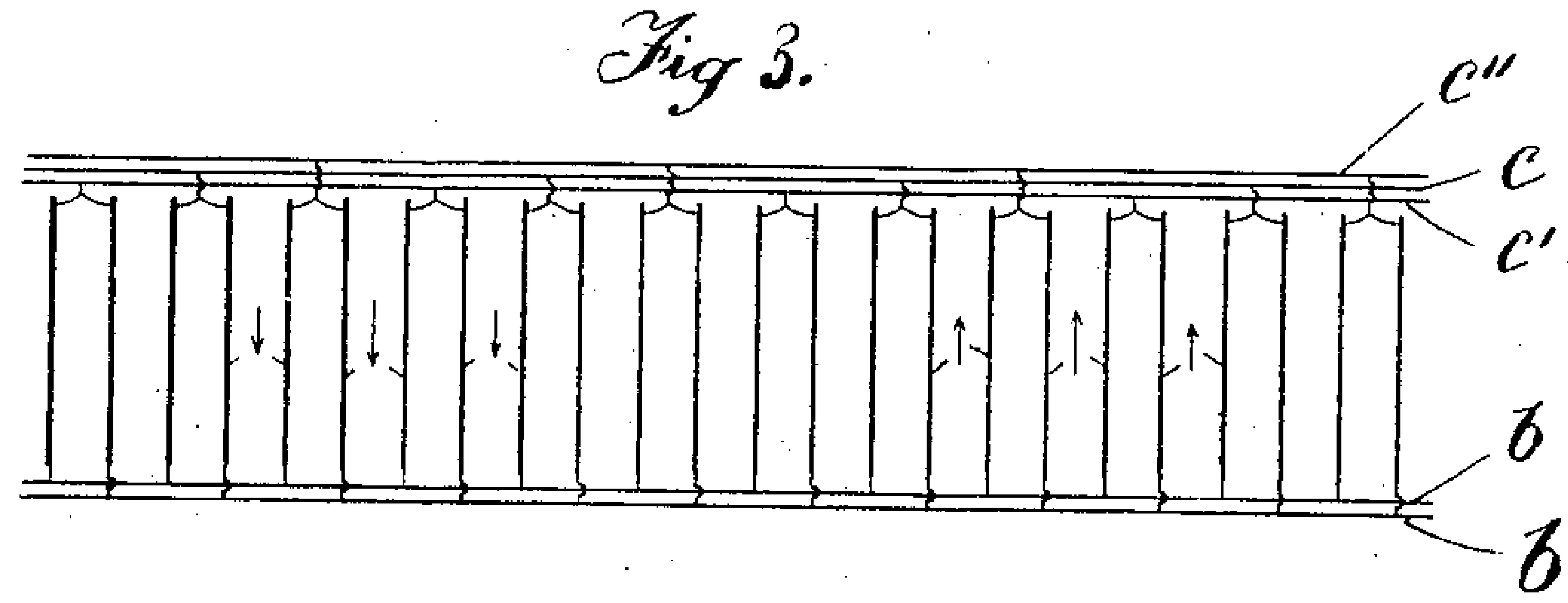


Fig 4.

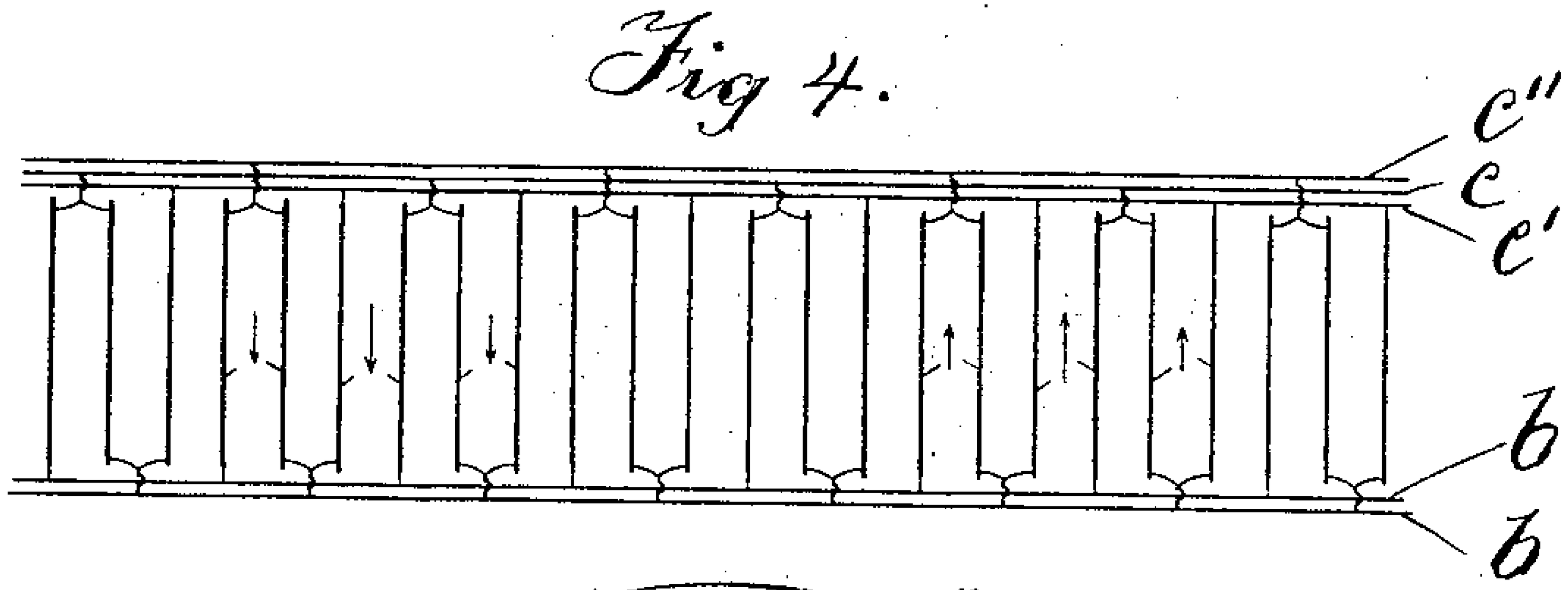
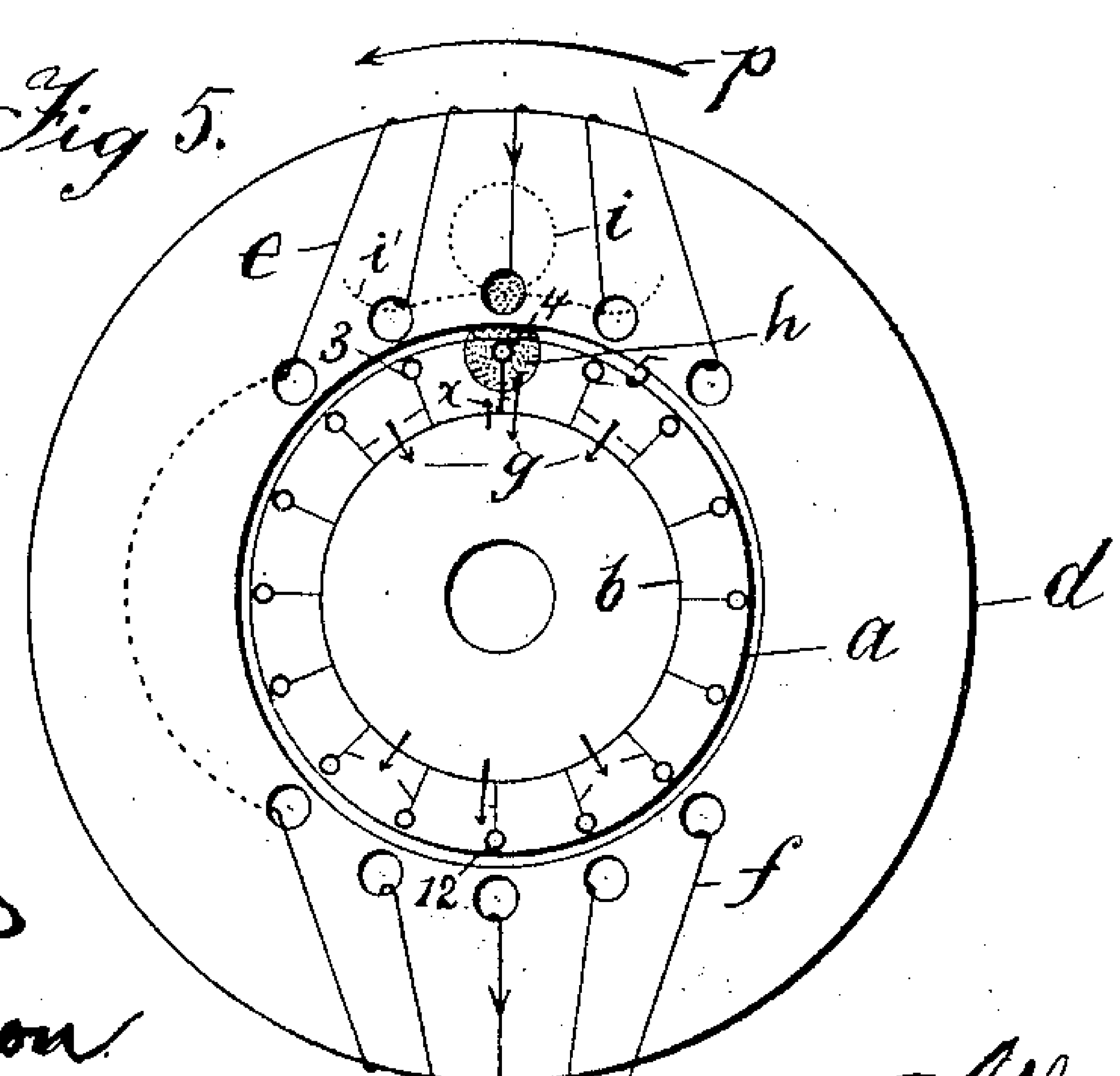


Fig 5.



Witnesses

Warren C. Stone

Maude M. Harrison

Inventor.

Albert W. Smith

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

ALBERT W. SMITH, OF WASHINGTON, DISTRICT OF COLUMBIA.

MOTOR.

SPECIFICATION forming part of Letters Patent No. 686,152, dated November 5, 1901.

Application filed September 9, 1901. Serial No. 74,856. (No model.)

To all whom it may concern:

Be it known that I, ALBERT W. SMITH, a citizen of the United States, residing at Washington, in the District of Columbia, have invented a new and useful Improvement in Induction-Motors, of which the following is a specification.

My invention relates to the squirrel-cage type of windings; and its object is to prevent lagging of the armature-current behind the inducing magnetism.

With induction-motors having distributed field-windings the inductive relation between a squirrel-cage winding and the field-coils is such that their respective currents should mutually compensate or balance each other, as in transformers, and the armature-current ought therefore to be in phase with the magnetism. As is well known, however, the armature-current lags abnormally, being subject both to great self-induction and inferior conductivity. I have discovered that these defects are due to a canceling effect between the parallel acting but unequal electromotive forces in the several armature-bars; and my invention consists in preventing this cancellation by electrically separating the adjacent armature-bars from each other. To obtain this result, I employ a plurality of end rings at each end of the armature and connect some of the bar ends in pairs thereto, while other bar ends are connected singly therewith.

In the drawings herewith, Figure 1 is a diagrammatic end view of an armature embodying my invention. Fig. 2 is a winding diagram of Fig. 1. Figs. 3 and 4 show modifications of my invention, and Fig. 5 is an explanatory diagram.

In all the views the same characters refer to like or corresponding parts.

a is the armature-core, wound with bars 2 3 4, &c.

b and *b'* are end rings connecting the front ends of the armature-bars, and *c* and *c'* are rings joining the back ends of the bars.

d is the field-core, wound with coils *e* and *f*.

The cause and effects of lagging armature-currents are explained by reference to Fig. 5, which is a diagram of a standard type of motor having a single bus-ring *b* at each end of the armature, thus constituting the ordinary squirrel-cage winding. While current is passing through coils *e* and *f*, as per arrow-heads thereon, parallel acting electromotive forces of unequal strength, as indicated by arrows *g*, are induced in the armature-bars, the bars 4 and 12 having the greatest electromotive forces, as represented by long arrows, and adjoining bars having lesser electromotive forces, as symbolized by shorter arrows. By the law of parallel circuits having unequal electromotive forces all of the inferior electromotive forces are canceled by the superior electromotive forces of bars 4 and 12, in which the entire current therefore concentrates, thus enabling its powerful magnetomotive force to set up the local self-inductive fields *h* and cause abnormal leakage of the main fields, as shown at *i*. The immediate effect on the armature of the local field *h* is to induce a counter electromotive force of self-induction (see arrow *x*) in bar 4. The field *h* and counter electromotive force *x* will increase until the counter electromotive force *x* depresses the effective electromotive force of bar 4 to parity with the electromotive forces of bars 3 and 5, when equal but badly-dephased currents will flow through the bars 3, 4, and 5 in parallel. Time is an important element in the equalizing process just described. It can therefore occur only when the armature is at rest or when moving slowly, as at starting. With the armature in rapid motion, as per arrow *p*, any given bar, as bar 4, can have the maximum electromotive force and entire armature-current for a very brief time only, each successive bar as it becomes superior in electromotive force setting up its own self-inductive field *h* and choking the current until the maximum point on the magnetic wave is reached, when the working current, lagging by a quarter-period, begins to flow in the bar or several bars when very close together, which last had the greatest electromotive force. It is thus seen that practically the entire armature-current is crowded through a single bar of limited conductivity, thus permitting its magnetomotive force to act locally, causing abnormal current lag and the large resistance losses which characterize the squirrel-cage winding. So much of the main field as is generated in the field-slot opposite the field *h* is entirely blown back and caused to leak, as per flux-line *i*, through the air-gap and field-slot, as shown, and the only way to reduce this leakage is to decrease the amount of field generated per slot by increasing the number of slots per pole. Some of the main field is also caused to leak, as per flux-line i'.

Having briefly explained the defects of the squirrel-cage winding, my improvement therein will now be explained by reference to Figs. 1 and 2.

At the front end of the armature alternate single bars are connected to the same ring b and the remaining bars are connected to the ring b'. At the back end alternate pairs of adjacent bars are connected to ring c and the remaining pairs are connected to ring c'. It is thus seen that at the front end adjacent bars are electrically separated from each other and that at the back adjacent pairs of bars are separated. I have shown that with the ordinary squirrel-cage winding, Fig. 5, but one set of bars (bars 4 and 12) can be fully active. With the connections shown in Figs. 1 and 2 there are four sets of bars fully active at all times. In explanation of this the current-paths of the several bars will now be traced.

The current of bar 4 flows through ring b' to and back through bar 12 and through ring c back to bar 4. The current of bar 5 flows via ring b to and through bar 13 and via ring c' back to bar 5. The current-path of bar 3 is through ring b to and through bar 11 and by ring c back to bar 3, and the current of bar 6 flows through ring b' to and through bar 14 and by way of ring c' back to bar 6.

The number of active bars per pole depends upon the span of any two bars, as bars 2 and 6, connecting both at their front and back ends to the same rings. It will be seen that if an electromotive force existed in bar 2 it would, except when exactly equal to that of bar 6, either cancel or be canceled by that of bar 6, and the current is therefore limited to four bars—viz., one of the spanning-bars, as bar 6, and the spanned bars 3, 4, and 5. It is thus seen that with two rings at each end of the armature four fully active bars per pole are obtained. This number will generally be sufficient. When more active bars are desired, it is only necessary to use more rings at the back end of the armature. In Fig. 3 is shown a bar-winding having three back rings c, c', and c'', thus making the circuit-span between any two rings seven bars and giving six fully active bars, as shown by arrows. In Figs. 1, 2, and 3 all the back ends of the bars are paired—that is, two adjacent ends are connected to the same ring and succeeding pairs of ends to different rings, while at the front alternate ends are connected singly to different rings. In Fig. 4 is shown a modification having both single and paired ends at each end of the armature, the single ends are, however, kept electrically separated from the paired ends by connecting all the single ends at the front to the same ring b', while all those at the back connect to the same ring c' all of the paired ends at the front connect to the same ring b, while at the back succeeding pairs connect to different rings. This construction is electrically equivalent to that of Fig. 3, the circuit-span between any two rings being the same and giving the same number—viz., six—of active bars, as shown by arrows.

Having now fully explained my construction, it will be seen that each set of coöperating bars, as bars 5 and 13, Figs. 1 and 2, has practically an independent path, and no interference can therefore exist between parallel acting but unequal electromotive forces, and the armature-currents will therefore be more nearly in phase with the inducing magnetism. Also since the current is not confined to a single bar the conductive losses peculiar to the squirrel-cage winding are obviated.

It will be seen that my invention is characterized by the employment of a plurality of rings at each end of the armature, also by connecting some of the bar ends singly to the rings, while other ends are connected in pairs thereto. I have also shown that all bars at one end may be singly connected, while all bars at the other end are paired, or, as in Fig. 4, that the same result is obtained by paired bars and single bars alternating at each end of the armature. My invention is therefore not to be narrowly construed; but

What I claim as my invention is—

1. The combination with the bars, or other winding elements, of an induction-motor armature, or secondary, of a plurality of end rings at each end of the armature, for interconnecting the ends of said bars, to form independent current-paths for adjacent bars, as set forth.

2. The combination with the bars of an induction-motor armature, of a plurality of end rings at each end of the armature, some of the bar ends being connected in pairs to said rings, and the remaining bar ends being connected singly therewith, as set forth.

3. The combination with the bars of an induction-motor armature, of two rings at the front end thereof, alternate bars connected to the same ring, and the remaining bars connected to the other ring, two or more rings at the back end of the armature, and pairs of adjacent bars connected to said rings, succeeding pairs of bars being connected to different rings, as set forth.

4. The combination with the bars of an induction-motor armature, of two rings at the front end thereof, alternate bars connected to the same ring, and the remaining bars connected to the other ring, two rings at the back end of said armature, alternate pairs of adjacent bars connected to the same ring, and the remaining pairs of adjacent bars connected to the other ring, as set forth.

ALBERT W. SMITH.

Witnesses:

WARREN C. STONE,

MAUDE M. HARRISON.