No. 895,100. PATENTED AUG. 4, 1908.

E. MORCK.

ALTERNATING CURRENT METER.

APPLICATION FILED DEC. 5, 1903.

3 SHEETS—SHEET 1.

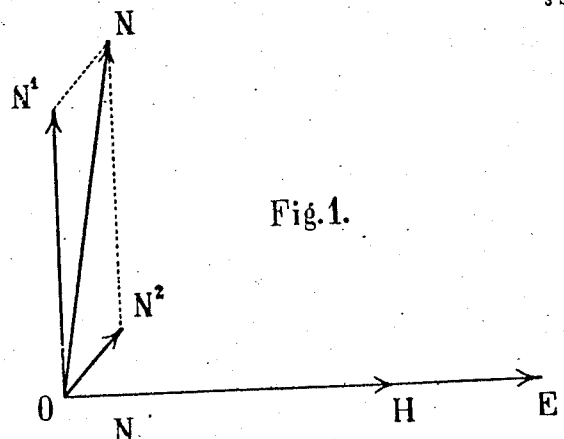


Fig. 1.

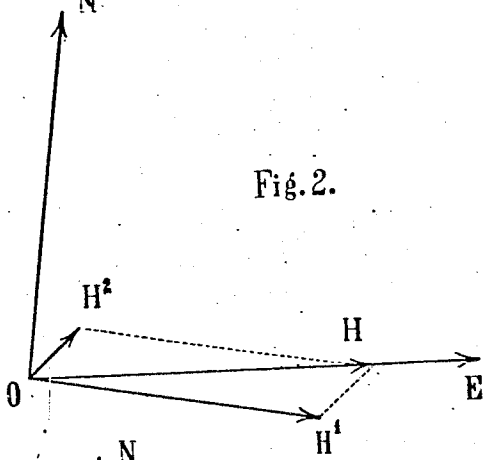


Fig. 2.

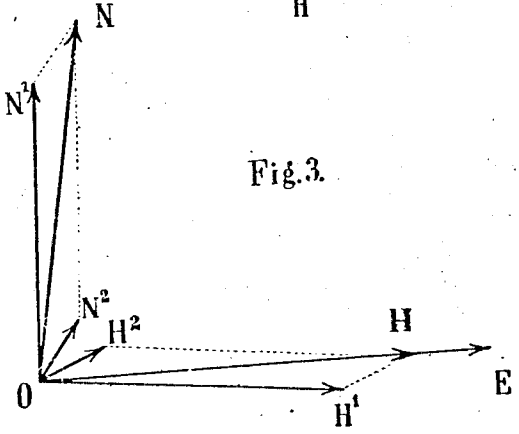


Fig. 3.

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3 SHEETS—SHEET 2.

Fig. 4.

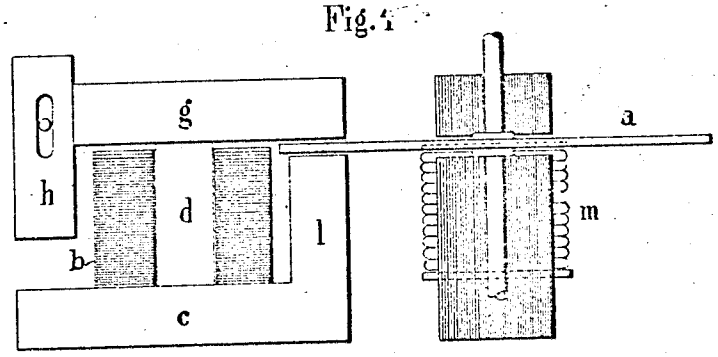


Fig. 5.

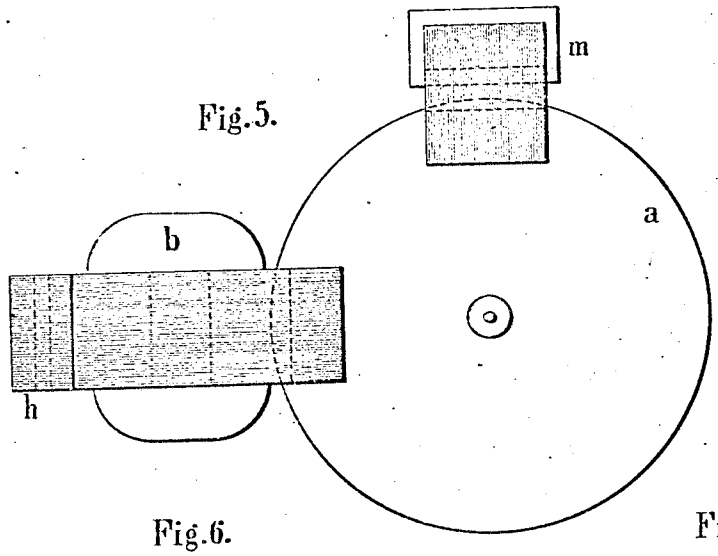


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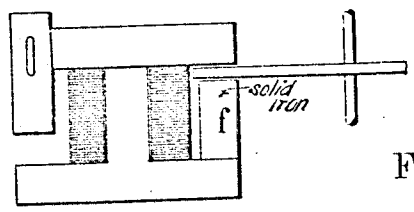


Fig. 8.

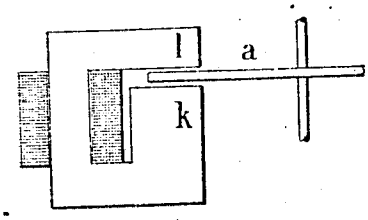
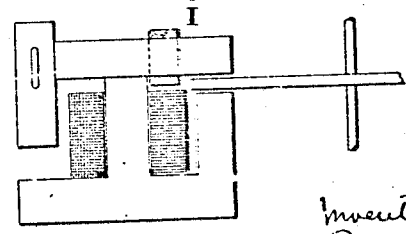


Fig. 7.



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3 SHEETS—SHEET 3.

Fig. 9.

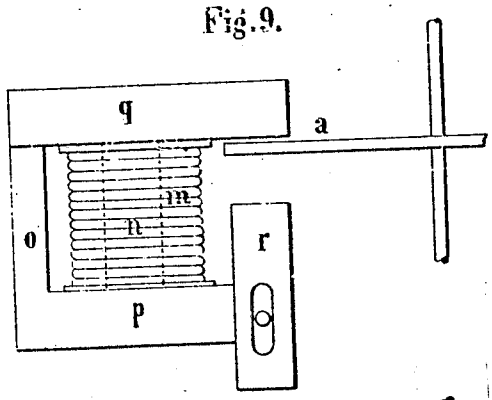
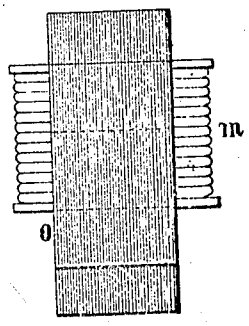


Fig. 10.



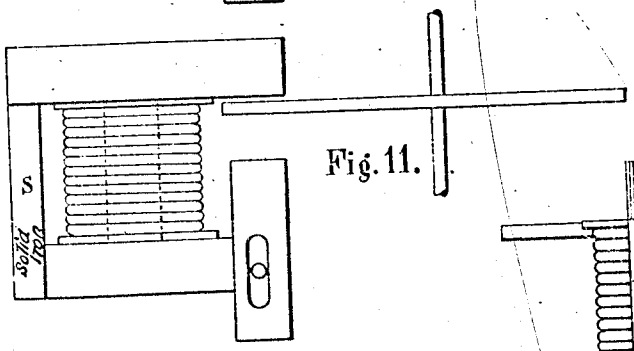
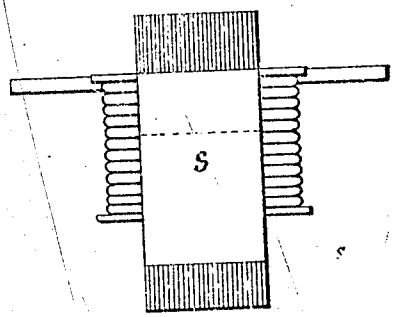


Fig. 11.

Fig. 14.



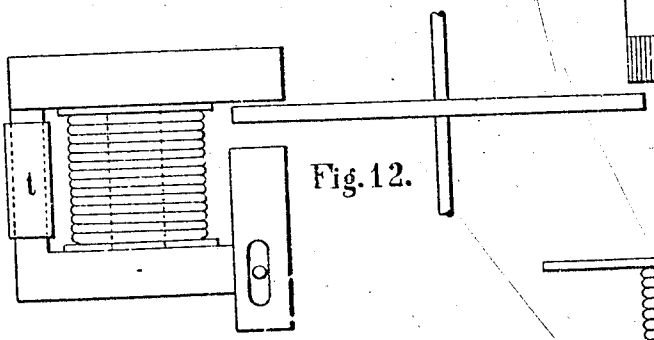
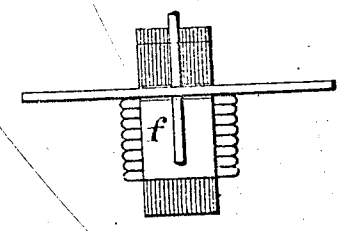


Fig. 12.

Fig. 13.



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UNITED STATES PATENT OFFICE.

EMANUEL MORCK, OF CHARLOTTENBURG, GERMANY.

ALTERNATING-CURRENT METER.

No. 895,100 Specification of Letters Patent. Patented Aug. 4, 1908.

Application filed December 5, 1903. Serial No. 183,928.

To all whom it may concern:

Be it known that I, EMANUEL MORCK, of 42 43 Grolmanstrasse, Charlottenburg, Germany, engineer, have invented certain new and useful Improvements in Alternating-Current Meters; and I do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement.

My invention relates to a process for producing a shifting of phase of 90 degrees in alternating current meters on Ferraris' principle.

An alternating current meter on Ferraris' principle consists of a short-circuit armature which is acted upon by a shunt-circuit field that is proportional to the potential, and by a main circuit field generated by the effective main current, while the work which is performed is absorbed by means of magnetic damping. The number of revolutions of the armature that is integrated by a counting mechanism is then proportional to the consumption in watts for all the shiftings of phase, if for cos $\varphi = 1$ the shifting of phase between the shunt circuit field and the main circuit field is equal to 90 degrees. Now according to the present invention a shifting of phase of this kind through 90 degrees is produced by resolving the magnetic flux into branches of different natures. For example I can produce this shifting of phase between the two branches of the flux of the coil which is energized by the current, that is proportional to the potential, or I can produce the shifting between the two branches of the flux of the coil, which is energized by the main current, or I can combine the shifting of the flux of both, that is to say the total flux of the potential coil and of the current coil, is resolved into components which are shifted relatively to one another and therefore also relatively to the flux which constitutes their resultant. Then it is that component of the flux of a coil which is acting on the armature, that is shifted in phase through 90 degrees relatively to the flux (or the component thereof) of the other coil which is also acting on the armature.

These relations are clearly illustrated in the diagram shown in Figs. 1 to 3 of the accompanying drawings.

Figure 1 illustrates the branching or resolution of the flux of the potential coil. Fig. 2 illustrates the branching or resolution of the main current coil and Fig. 3 illustrates the branching or resolution of both fluxes. Figs. 4 to 8 illustrate some constructions, showing by way of example, in what manner the branching or resolution of the potential flux may be effected. Figs. 9 to 12 illustrate construction for the branching or resolution of the flux of the current coil. Figs. 13 and 14 are side views of Figs. 6 and 11 respectively.

In Fig. 1 O E represents the vector of the potential. For cos $\varphi = 1$, the main current is in phase with the potential, and the field generated by the main current may be also in phase with the potential. The field N which is generated by a current proportional to the potential, is resolved into two components N^1 and N^2 by dividing N into branches of different natures. N^1 lags behind. N^2 leads relatively to N; only N^1 acts upon the armature and is shifted in phase brought 90 degrees relatively to the main current field H.

In Fig. 2, O E again represents the vector of the potential. N represents the field of the potential coil, which acts upon the armature. In this case the field H which is generated by the current coil is resolved into two components H^1 and H^2, of which H^2 lags behind H, while H^1 leads. H^1 acts on the armature and forms with N an angle of 90 degrees.

In Fig. 3, the flux of the potential coil is resolved in the manner shown in Fig. 1, while the flux of the current coil is resolved as shown in Fig. 2. The lagging component N^1 of the flux of the potential coil acts together with the leading component H^1 of the flux of the current coil upon the armature, and N^1 is shifted in phase through 90 degrees relatively to H^1.

In the following I shall show for example how to carry out the process by some apparatuses which may be constructed in different ways and may be employed with advantage.

A displacement of the two branch-fluxes may take place:

1. Through the different retarding effect of the hysteresis,

2. Through the effect of the secondary effects,

3. Through both of said effects.

The difference in phase displacement in the branches can be caused by the lagging influence of the hysteresis, for instance by giving the two branches different sized air-

gaps. This can be explained in the following manner: In an entirely iron-closed circuit the equivalent sine-wave of the magnetic flux lags behind the magnetomotive force by reason of the effect of the hysteresis. If an air-gap be inserted in the magnetic path, a portion of the magnetomotive force will be consumed for carrying the flux through the air gap. If the air gap increases the magnetomotive force which is necessary for causing the flux to pass through the iron, becomes small compared to that which causes the flux to pass through the air. In the same way the influence of the hysteresis becomes small with respect to the total flux and the total flux lags less behind the magnetomotive force. It is therefore evident that with a small air-gap there is a great displacement of phase of the flux behind the magnetomotive force, and with a big air-gap there is a small displacement of phase of the flux behind the magnetomotive force. If the flux is divided over two branches, one of which contains more air than the other (in the first one the hysteresis is no doubt of only slight influence), a phase displacement of the two branch fluxes must necessarily take place or in other words the total flux divides into a less displaced flux and a more displaced flux. The secondary fields may be obtained by means of special inserted short-circuit coils or through the secondary fields of the armature.

The apparatus shown in Figs. 4 and 5 in elevation and in plan respectively, consists of a motor armature *a*, a potential coil *b* and an iron frame of F-shape composed of the parts *c*, *d*, *l*; the iron parts *g* and *k* complete the magnetic branches. *m* is the current coil. The total flux which is generated by *b* flows through *d*, splits up into branches and flows in part through an iron branch (which is almost closed and has only a narrow slit or air-gap for the reception of the motor armature *a*) back through *c*, *l* and *g*. The other portion of the total flux flows through a wide air space (which may be varied for the purpose of accurate adjustment of the phase) and through *c*, *k* and *g*. The different magnetic conformation of the two branches has the result of causing the portion of flux in *l* to lag in phase behind the total flux in *d*. The iron parts are laminated.

With the object of otherwise producing a difference between the branches, a portion of the effective branch may be made solid, as for instance the part *f* shown in Figs. 6 and 13. For the same reason a short-circuit winding may be included in this branch as shown at *i* in Fig. 7. The action of the unlaminated iron in Fig. 6 or the short-circuit winding *i* in Fig. 7 will be clear by the following consideration. If I have a constant magnetic alternating flux and I put unlaminated iron in its way or I apply a short-circuited winding, there will be produced a secondary field by eddy currents and the resulting field will lag in phase as well known. Now, if the flux of one coil is divided into two branches that are wholly the same only one has a short-circuit winding or is partly unlaminated, there must occur between the two fluxes in the branches a shifting of phase.

In Fig. 8, one branch of the flux passes from *k* through the air to 1, and the other branch passes from *k* through the armature *a* to 1. The difference in the conformation of the two branches is effected in this case by means of the armature.

Figs. 9 and 10 show a construction in elevation and in plan respectively for the purpose of shifting the current field. *a* is the armature, *n*, *o*, *p* are parts of an iron frame of F-shape. The iron parts *q* and *r* complete the branches. The iron parts are laminated. The flux of the current coil *m* flows through *n*, divides into branches; the one which acts on the armature flows through *p*, *r*, and an adjustable air space for the purpose and regulating the phase, and back through *q*. The other branch is short-circuited through iron and flows back through *p*, *o*, *q*. The different nature of the two branches produces an advance in the phase of the flux acting on the armature relatively to the total flux so that a shifting of 90 degrees is produced between the active partial flux of the current coil and the flux of the potential coil.

In order to produce the desired difference between the magnetic branches one part of the branch that does not act in a motive sense, may be made solid, as indicated for example by the part *s* in Figs. 11 and 14, or a short-circuit coil may be arranged as is indicated at *t* in Fig 12. Of course still other conformations and arrangements may be made for the purpose of establishing two magnetic branches of different natures. Likewise, an exact adjustment of the phase may be effected by modifying any one portion of the magnetic branches with respect to position or amount.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed I declare that what I claim is:—

1. An alternating current meter comprising a main current coil mounted upon a frame having two magnetic branches one of which said branches is provided with an adjustable air space; a potential coil also mounted upon a frame having two magnetic branches one of which said potential coil branches is provided with a constant air space and the other with an adjustable air space; and a suitable armature cutting the magnetic field of the main current coil in its adjustable air space, and the magnetic field of the potential coil in its constant air space.

2. In an alternating current meter employing a main current and a potential coil, the combination of frames for mounting said main current and potential coils each of which comprises two magnetic branches of which one branch of each frame is provided with an adjustable air-gap and the other branch of one of the frames is provided with a constant air-gap; a disk armature adapted to be rotated through the constant air-gap of one frame and the adjustable air gap of the other frame; and means connected with each of the aforesaid adjustable air-gaps whereby the width of said air-gap may be varied at will to modify the magnetic reluctance of the several branches relative to each other and to the total flux of each coil

3. In an alternating current meter employing main current and potential coils, the combination with a disk armature, of frames for mounting said coils adjacent thereto, each of said frames comprising two magnetic branches of which one branch of each coil is provided with an air gap within which said disk armature is adapted to be rotated by the magnetic flux in that branch; and means connected with each frame whereby the magnetic reluctance of each active branch of the magnetic flux may be modified relatively to that of the other branches in such manner as to enable a shifting of phase of exactly 90 degrees between the active branches of the two fluxes.

4. The process for producing a shifting phase of 90 degrees in an alternating current meter which consists in resolving the flux of the current coil and of the potential coil into two magnetic branches one of which is motively effective and the other of which is motively ineffective in such a manner that that portion of the flux of the potential coil which acts in a motive sense lags behind the total flux of the same while that portion of the flux of the current coil which acts in a motive sense leads relatively to the total flux of the current coil, in such a manner that a shifting in phase of 90 degrees is produced between the active portions of the fluxes of the current and potential coils, substantially as set forth.

5. The process for producing a shifting of phase of 90° in an alternating current meter, which consists in resolving the flux of the current of the current coil and of the potential coil into two magnetic branches and in varying the magnetic reluctance in the active branch of the former coil and in the ineffective branch of the latter coil in such manner as to produce a shifting of phase of 90° between the active portions of the fluxes of the two coils, as described.

In testimony that I claim the foregoing as my invention, I have signed my name in presence of subscribing witnesses.

EMANUEL MORCK.

Witnesses:
WOLDEMAR HAUPT,
HENRY HASPER,
KARL FRANCKE.