May 5, 1925. 1,536,761

F. F. BRAND

STATIONARY INDUCTION APPARATUS

Filed March 14. 1919

Fig. 1.

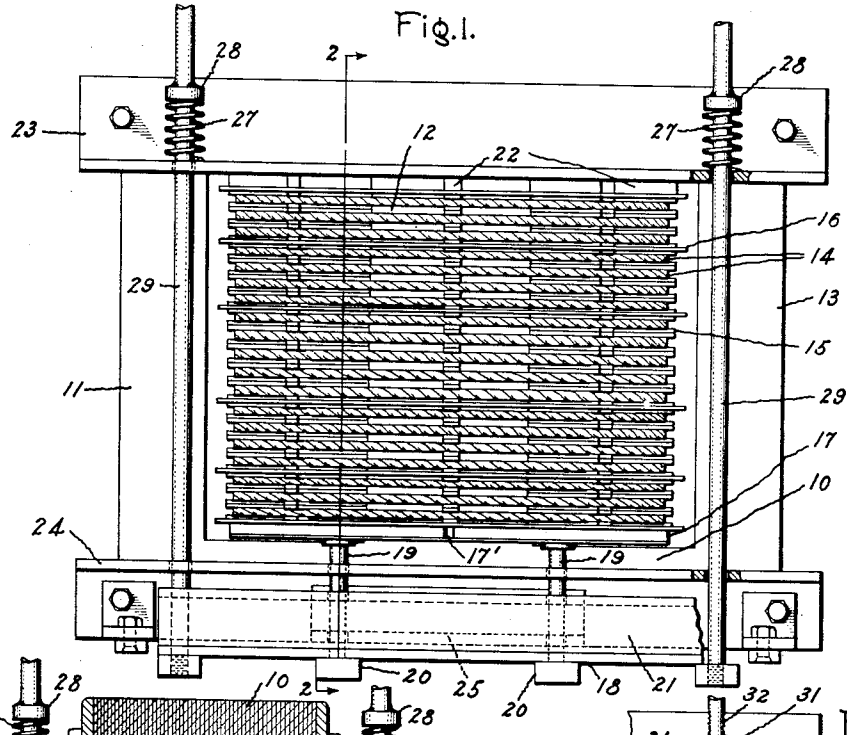


Fig. 2.

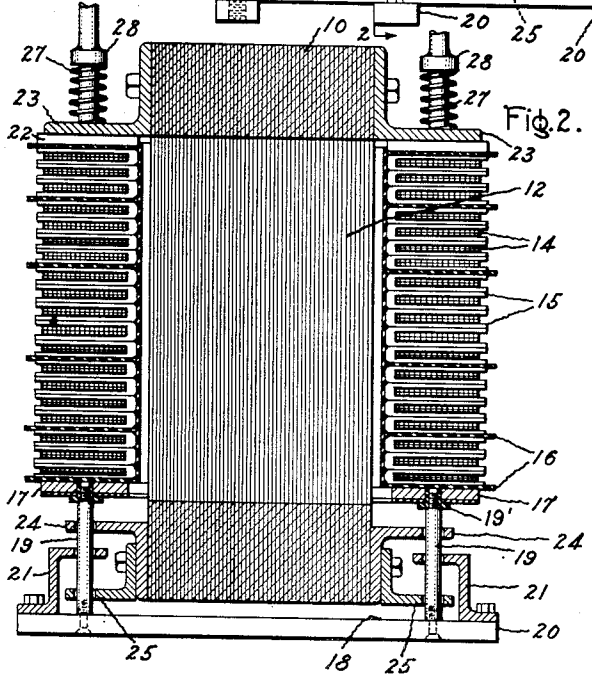


Fig. 3.

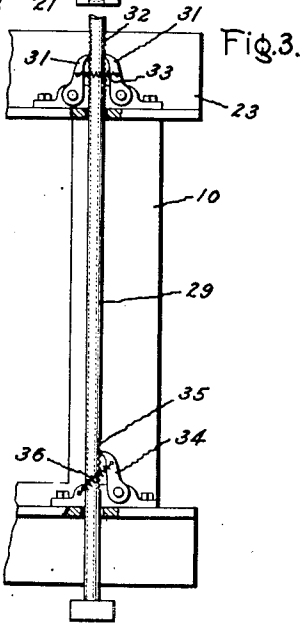
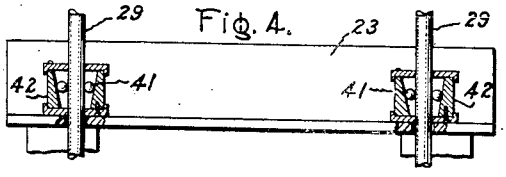


Fig. 4.



Inventor:
Frederick F. Brand,
by Albert G. Davis
His Attorney.

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UNITED STATES PATENT OFFICE.

FREDERICK F. BRAND, OF PITTSFIELD, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

STATIONARY INDUCTION APPARATUS.

Application filed March 14, 1919. Serial No. 282,568.

To all whom it may concern:

Be it known that I, FREDERICK F. BRAND, a subject of the King of Great Britain, residing at Pittsfield, in the county of Berkshire, State of Massachusetts, have invented certain new and useful Improvements in Stationary Induction Apparatus, of which the following is a specification.

My invention relates to stationary induction apparatus, such as transformers, reactors and the like and has for its object an improved construction whereby such apparatus may be constructed in a strong, efficient and economical manner.

More specifically my invention relates to apparatus of this type which is designed for heavy duty and apt to be subject to severe transient disturbances such as short circuits, and the like; and is intended to provide an improved construction which will yield ample strength to resist the mechanical strains occasioned by the transient without resort to a costly construction or the employment of unduly bulky or heavy parts.

A further object of my invention is to provide an improved construction which at all times will keep the windings firmly held in their place by automatically compensating for any shrinkage or contraction in the space occupied by the windings.

In carrying my invention into effect I take advantage of the fact that there is always a time element involved in the action of a resilient structure in absorbing in full the shock of a transient disturbance such as the disruptive force occasioned by a short circuit. If this time element is sufficient to permit the transient to have appreciably decayed before the shock is absorbed in full, only the average of the sustained shock is transmitted to the abutments of the resilient structure; consequently the supporting structure need only possess strength sufficient to resist the average shock and not the maximum shock in order to withstand safely the transient disrupting forces.

In the resilient structure which I employ, resort is had to a novel arrangement of parts, disposed and proportioned so that the time element involved may be as long as practicable and at the same time adapted to compensate for shrinkage in the windings whereby the best advantage of the materials of construction employed is to be had.

For a more complete understanding of the nature and objects of my invention reference should be had to the following detailed description taken in connection with the accompanying drawing in which Fig. 1 is a view in side elevation of a transformer constructed in accordance with my invention, Fig. 2 is a section taken on line 2—2 of Fig. 1 and Figs. 3 and 4 show modifications embodying my invention.

In a consideration of the forces involved when masses of material, such as enter into the construction of transformers, are moved by the mutual attraction and repulsion in the windings occasioned by a transient such as a short circuit when acting against a resilient resistance, it appears from the analysis thereof that the motion is made up of:

1. An oscillating motion at double the frequency of the applied voltage, that is, at the frequency of the applied force.

2. An oscillating motion at the frequency of the applied voltage and of decreasing amplitude proportional to the time constants of the system.

3. A decaying motion proportional to the time constants of the system.

4. An oscillating motion at the natural frequency of the system.

Letting T denote the natural period of vibration of the mass which is moved by the forces occasioned by a transient, then it may be shown mathematically that

$$T = 2\pi\sqrt{\frac{M}{L}}.$$

This means that before the maximum transient disrupting force to be sustained by the retaining means for the windings of the apparatus can be transmitted to such means, a definite period of time $\frac{T}{2}$, predetermined as it were by the strength of the resilient element to be compressed and the mass to be accelerated, must elapse.

To reduce the initial shock of the disruptive force it is desirable to make this period as long as practicable; hence L should be small, i. e. the resilient abutment or spring should be strong, and M should be large, i. e. the mass to be moved should be made great.

I will now describe a preferred form of my invention as applied to transformers ar-

ranged to have a long time period for the movement of the mass under the influence of a transient such as a short circuit; obviously though my invention is not limited to transformers but is applicable in general to all stationary induction apparatus.

Referring now to the drawing, and to Figs. 1 and 2 in particular, 10 denotes a rectangular core of laminated magnetic material having three vertical legs 11, 12 and 13. About the central leg 12, the windings 14 are assembled; here shown as comprising an interleaved disc coil construction in which the coils are spaced apart by U-shaped spacing members 15 which latter are superposed one above the other when in assembled relation as clearly shown in Fig. 2.

These windings 14, together with suitable insulating barriers and partitions 16, while assembled about the leg 12, are not carried thereby; but by the supporting collar 17 which is split at some convenient point as 17′ to prevent eddy currents and is rigidly secured to but insulated from the base 18 by means of the short posts or columns 19 shown as screwed into the insulating bushings 19′ protruding from the under side of collar 17.

The base 18 may be constructed in any convenient form but is here shown as comprising cross pieces 20 bolted or otherwise secured to angle bars 21.

The assembled coils of winding 14 are pressed down from above by the horizontal sides of the top core clamps 23, the latter forming part of the core structure and being shown as angle bars bolted or otherwise secured to the upper yoke portion of the core 10; suitable spacing blocks 22 being interposed between the windings 14 and the sides of the core clamps in order to provide adequate egress for the cooling medium which passes up between the windings and the leg 12 of the core. The lower core clamps 24, on the other hand, while secured to the lower yoke, do not serve as support but merely as guides for the core; since they but loosely engage with the columns 19. This guiding function is conveniently supplemented by the short angle irons shown at 25 as loosely engaging the columns 19; but such supplemental guides are not essential.

It is thus apparent that the whole weight of the core and its clamps is borne by the upper core clamps and bears upon the windings 14, and that the core itself, including the lower core clamps, moves up and down with the expansion and contraction of the windings 14.

By utilizing the weight of the core and its clamps in this manner, the mass to be accelerated by the mutual forces of repulsion in the windings is made to include the whole core and its clamps, and is thus made large without increasing the material used in construction.

In order to provide a resilient abutment to react against the mutual forces of repulsion engendered in the windings when traversed by current, springs 27 are placed so as to bear down upon the windings 14, preferably with the horizontal sides of the clamps 23 intervening as shown. These springs in turn react against collars or other suitable abutments 28 formed on rods 29 which are secured in the base 18.

Instead of springs 27, however, resistance devices may be substituted for that class of service where the function of the weight of the core bearing on the windings 14 will be mainly to keep them tightly compressed and to take up shrinkage; short circuits or transient overload currents being of comparatively infrequent occurrance. Such resistance devices as I prefer to use in place of springs are shown in Figs. 3 and 4.

In Fig. 3 there is shown a pair of dogs 31 resiliently held in engagement with grooves 32 on rod 29 by means of a spring 33. The dogs are shown as pivotally mounted on the top core clamp 23, but obviously any convenient way of imparting the motion of the core thereto is sufficient. A dog is also shown as mounted on the lower case clamp; the one shown at 34 being resiliently held in engagement with grooves 35 on rod 29 by means of springs 36.

In Fig. 4 instead of dogs, balls having a wedging action are employed. The balls 41 are slipped into conical receptacles 42 which in turn are slipped over rods 29 and are secured on the core clamps 23.

These balls 41 thus wedge between the rods 29 and the interior conical surfaces of the receptacles 42. They permit the core to move downward and readily follow any contraction in the windings 14 but resist any upward thrust such as occurs when the windings are subject to a transient.

When a transformer or like piece of electrical apparatus such as I have disclosed is subject to a severe overload transient, the shock of the disruptive forces acting between the windings is not instantaneously transmitted to the reacting abutments such as rods 29 retaining the windings in place, since a definite interval of time corresponding to the half period

$$\pi\sqrt{\frac{M}{L}}$$

must elapse before the mass of the core and its clamps has completed its maximum displacement, which period permits the stress on the clamps to be considerably relieved in delaying the application of the maximum thrust. This period, which is substantially several times longer than the cycles of the transient, would also permit the armature

reaction of the generator supplying the transformer to reduce the force of the transient.

It is also seen that no motion will take place until the effective value of the force is greater than the weight of the mass to be moved.

I am aware that it has been heretofore proposed to use springs resiliently to maintain coils in their place in transformers and the like and to take up shrinkage, but I am not aware that this function has ever been used in conjunction with a mass to be accelerated to take advantage of the natural time element involved to delay and smooth out the action of disruptive forces occasioned by transients.

Furthermore, while I have found it of particular advantage to support the core weight upon the coils, instead of the coils on the core, because in this manner I utilize the materials of construction to provide the greatest effective mass to be accelerated in conjunction with the resilient means to give a delayed time action, still I do not desire to be understood as limiting myself to the combined use of these features for I am not aware prior to my invention that it has been proposed to support the core upon the coils in stationary induction apparatus for any purpose and I propose to use this feature separately in the practice of one aspect of my invention.

While I have here shown and described several embodiments of my invention which are, at present, the best means known to me for carrying the same into effect, I would have it understood that they are merely illustrative and that I do not mean to be limited thereby to the precise details shown, nor in the choice of equivalent arrangements except as defined in my claims hereunto annexed.

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

1. In an electrical apparatus, the combination with a base, of windings supported thereon, and a core structure exerting yielding pressure against said windings and movable relatively thereto in the direction of expansion of the windings during a transient, whereby said core structure may be moved by the forces of repulsion in the windings caused by a transient.

2. In an electrical apparatus, the combination with a base, of windings supported thereon, a core structure cooperating with said windings and bearing on and supported from said windings, and a yielding means arranged to increase the pressure of said core structure upon said windings.

3. In an electrical apparatus, the combination with a base, of windings supported thereon, a core structure cooperating with said windings and bearing on and supported from said windings, an abutment secured to said base, and a resilient element arranged to react against said abutment and yieldingly to increase the pressure of said core structure upon said windings.

4. In an electrical apparatus, the combination with a base, of windings supported thereon, a core structure cooperating with said windings and having its weight supported from and bearing upon said windings, a rod having an abutment and being secured in said base, and a spring interposed between said abutment and said core structure and arranged yieldingly to increase the pressure of said core structure upon said windings.

5. In an electrical apparatus, the combination with coaxially arranged windings, of upper and lower coil supports, a base rigidly supporting one of said supports, and a magnetic core structure cooperating with said windings, said core structure being suspended from the other of said coil supports and arranged to compress said windings between said supports.

6. In an electrical apparatus, the combination with coaxially arranged windings, of upper and lower coil supports, a base rigidly supporting said lower coil support, and a magnetic core for said windings having core structure clamps bearing on said upper coil support, whereby the weight thereof is supported by said windings.

7. An electrical apparatus comprising windings, resilient means yieldingly retaining said windings in place, and a movable mass arranged to be accelerated by the forces of repulsion in the windings due to a transient, said mass having a natural time period sufficient to delay and thereby smooth out the transmission of a shock due to said forces of repulsion.

8. An electrical apparatus comprising a movable core structure, windings supporting said core structure, and resilient means arranged to increase the pressure of said core structure upon said windings, whereby said core structure may be accelerated against yielding resistance by the forces of repulsion in the windings due to a transient.

9. An electrical apparatus comprising a core, windings thereon, and resilient means yieldingly applying the weight of said core to said windings in a manner to be accelerated against yielding resistance by the forces of repulsion in the windings, having the core mass (M) proportioned to the unit compression (L) of said resilient means so that the resulting natural period of movement denoted by $\pi\sqrt{\frac{M}{L}}$ is substantially as long in duration as several cycles of a transient causing the forces of repulsion.

10. An electrical apparatus comprising windings, a movable core structure support-

ed thereby, and resilient means arranged to increase the pressure of said core structure upon said windings, whereby said core structure may be accelerated against yielding resistance by forces of repulsion in the windings, said core structure having a mass (M) so proportioned to the unit compression (L) of said resilient means that the resulting natural period of movement denoted by $\pi\sqrt{\frac{M}{L}}$ is as long in duration as several cycles of a transient causing the forces of repulsion.

In witness whereof, I have hereunto set my hand this 10th day of March, 1919.

FREDERICK F. BRAND.