June 9, 1925. 1,540,770

M. B. FIELD

FILAR CONTROL

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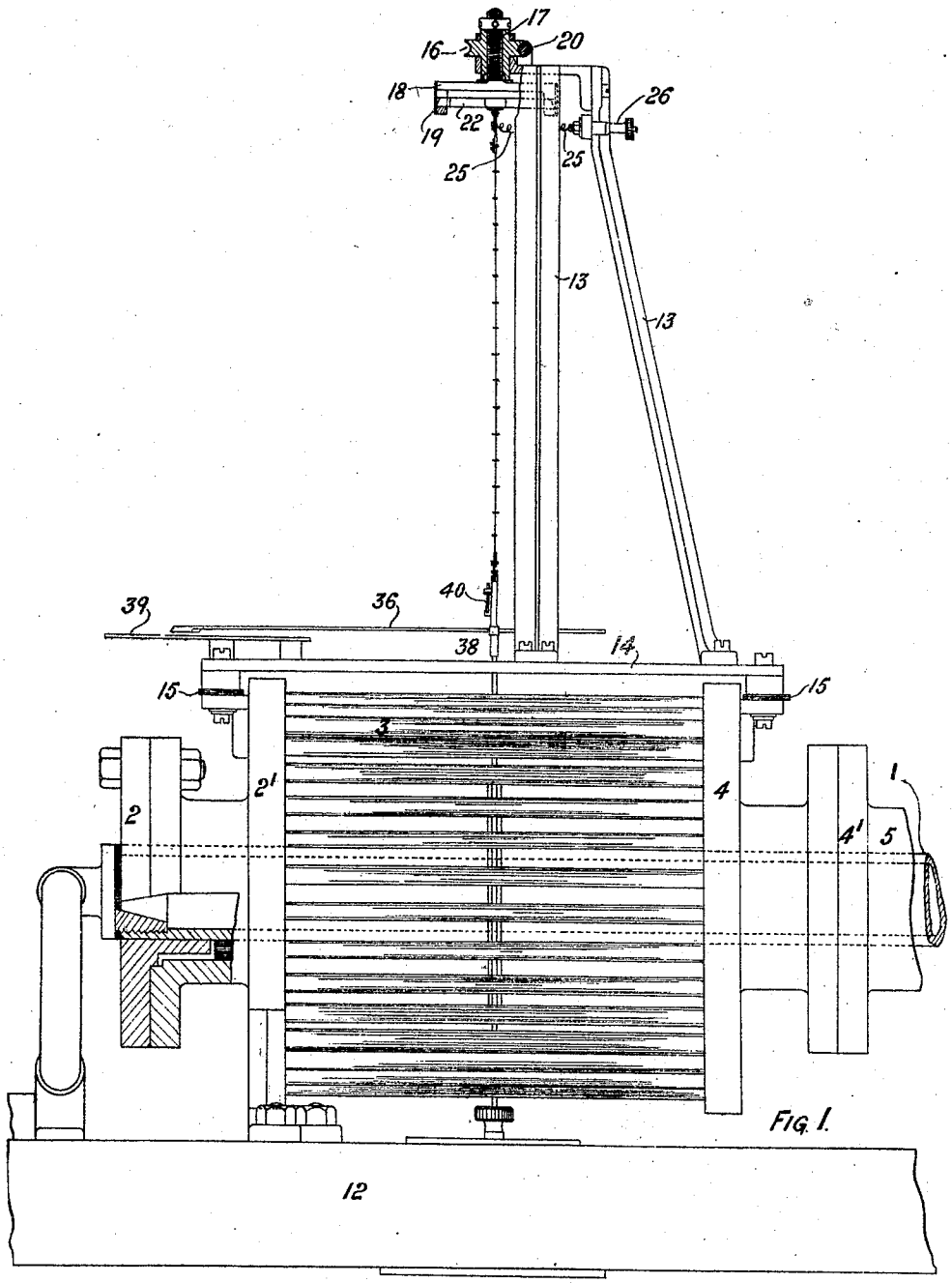


FIG. 1.

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Fig. 2

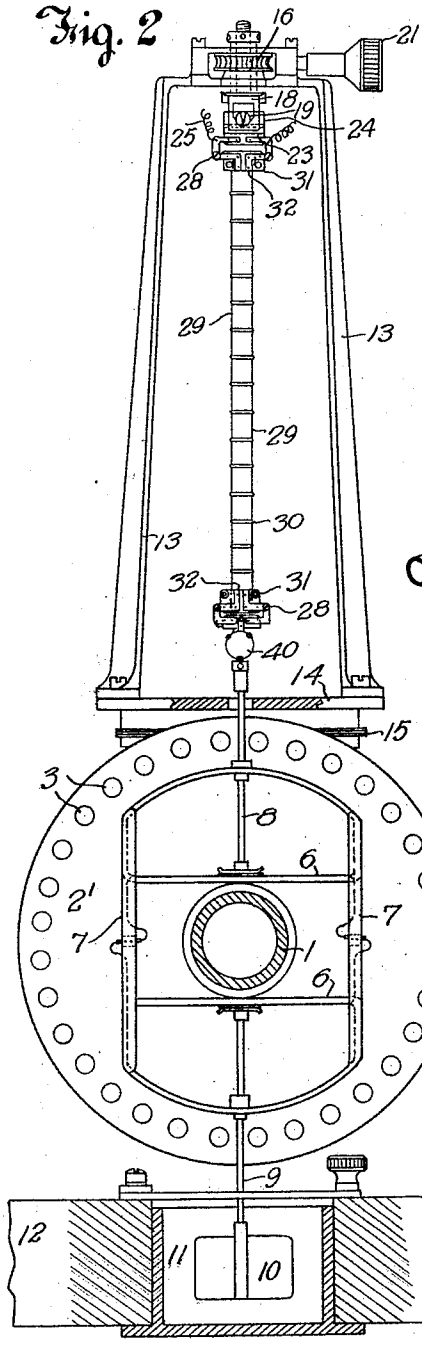


Fig. 5

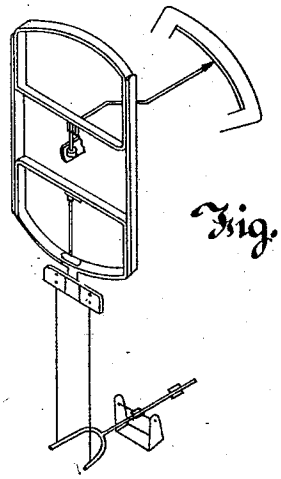


Fig. 7

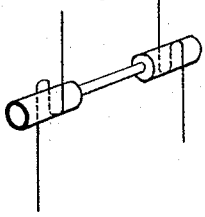
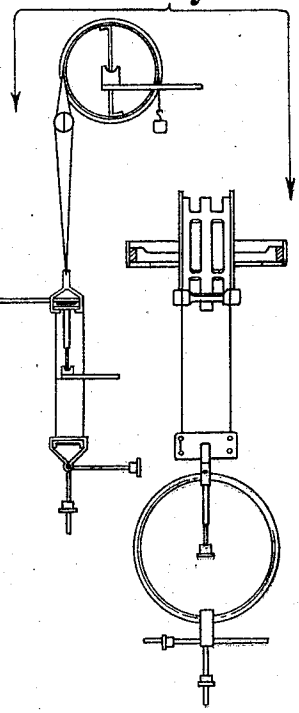


Fig. 6



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Fig. 3

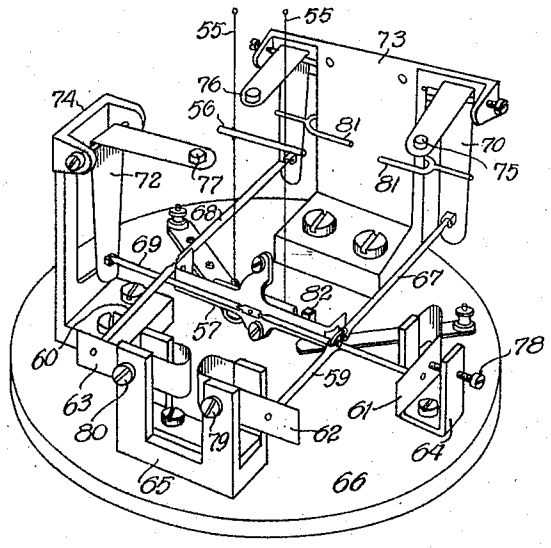
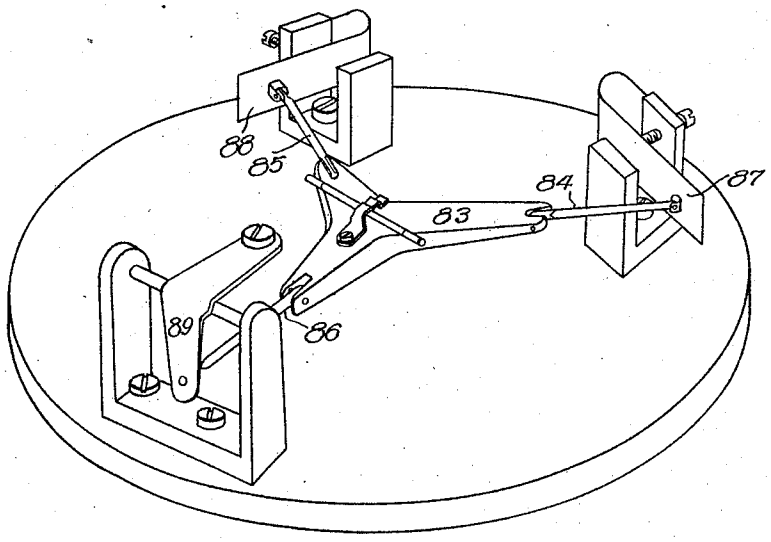


Fig. 4



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Patented June 9, 1925. 1,540,770

UNITED STATES PATENT OFFICE.

MICHAEL BIRT FIELD, OF GLASGOW, SCOTLAND, ASSIGNOR TO KELVIN BOTTOMLEY & BAIRD, LIMITED, OF GLASGOW, SCOTLAND, A CORPORATION OF GREAT BRITAIN.

FILAR CONTROL.

Application filed October 12, 1921. Serial No. 507,332.

To all whom it may concern:

Be it known that I, MICHAEL BIRT FIELD, a subject of the King of the United Kingdom of Great Britain and Ireland, and residing at Glasgow, Scotland, have invented a certain new and useful Improvement in Filar Controls, of which the following is a specification.

This invention relates to new or improved forms of instruments comprising bifilar or multi-filar suspensions or control means.

A well-known form of bifilar suspension comprises two flexible filaments or ligaments assumed for the purpose of explanation to have negligible torsional rigidity, hanging substantially vertically at a distance apart which is small in relation to the length of the filaments, the filaments being attached at the upper end to a frame and supporting the moving system from the lower end. The weight of the moving system constitutes a "load" on the filaments and produces tension therein. When the only forces acting upon the moving system are those of gravity and the tensions of the filaments, the two filaments are in a plane, the load being at its lowest level under these conditions. I shall hereafter refer to this position as the "initial" position.

As is understood, if an angular displacement about the vertical axis of the system be imparted to the suspended load, the filaments of such a bifilar suspension twist out of the original plane and the load is raised, whereby a gravitational turning moment is set up, tending to restore the system to the initial position. Thus, when the turning of the moving system or load occurs, the filaments are on a vertical surface which has a twist about the vertical axis.

The turning moment tending to restore the system to the initial position is termed the control. The amount of control depends in part on the manner in which the two filaments share the load and may, therefore, be influenced by any change of level of the apparatus.

To obviate the effect of such influence, it has been proposed so to support the bifilar suspension at its upper end that it can swing freely about a horizontal axis, passing through the vertical axis at right angles to the plane containing the filaments when in the initial position.

If the length of the filaments be great in relation to their separation, as is usual, the control is proportional to the sine of the angle of angular displacement of the load from its initial position. Thus, the maximum control occurs with an angle of twist of 90°, and with increasing angles the control decreases. If, therefore, the deflecting force be sufficient to produce a deflection greater than 90°, the system will be unstable. The use of such bifilar suspensions and control means has heretofore been confined to the first quadrant of rotatory motion, and, in fact, it has been usual to restrict the motion to comparatively small angles from the initial position.

It will further be observed that if the filaments be parallel in the initial position, when angular displacement occurs, the separation varies from point to point, the filaments being nearest together at their central points and being straight from end to end.

So far as I am aware, it has not hitherto been proposed to interpose between the filaments distance pieces distributed along their length in the manner which I shall describe and as the result of which the filaments do not follow straight line courses from end to end when in the twisted position, whereby there is obtained a useful modification of the law of control.

My invention contemplates new or improved forms of bifilar or multi-filar suspensions or control means for instruments wherein the moving system is controlled by such suspensions or control means and where the tension in the filaments controlling load is independent of the weight of the moving system; and means for anchoring the non-rotating end of the suspension or control means.

The characteristics of the bifilar or multi-filar suspensions or control means contemplated by this invention are filaments under tension, directed in general along the axis of turning, attached at one end to a rotatable member and attached at the other end

rigidly or yieldingly to the frame, so that rotation is accompanied by change in the inclination of the filaments to the plane transverse to the axis of rotation, whereby the tension components in such transverse plane give rise to a turning moment about said axis varying as the angle of rotation is varied.

A feature of my invention consists in disposing a strut or struts between the filaments at a location or locations between the ends thereof so that as the suspension or control means is twisted, a given separation is maintained at such location or locations, and the filaments do not follow straight line courses from end to end. In this way, the law of control is altered so as to render the suspension or control means more suitable for various purposes.

In the drawings Figs. 1 and 2 are elevations at right angles to one another of a concentric watt-meter for the measurement of large alternating current powers.

Fig. 3 is a perspective view illustrating one form of anchorage for the bifilar suspension.

Fig. 4 is a perspective view showing a modified form of anchorage.

Figs. 5 and 6 are diagrams of movements controlled by filar combinations.

Fig. 7 is a detail view showing a form of strut interposed between the filaments of the bifilar suspension.

Referring to Figs. 1 and 2, 1 denotes the central conductor which carries the main current. (The terminal attached to the conductor is not shown, but may be assumed to be located on the right hand side of the central conductor shown broken off in Fig. 1.) The current passes axially along the central conductor 1 into the flange 2, thence to the flange 2′ and cage bars 3 into the flanges 4 and 4′ and the neck piece 5 and thence to the second main current terminal, not shown, but also assumed to be located on the right hand side of the instrument, Fig. 1.

The shunt current coils 6 are arranged one above and one below the central conductor 1, being held together on a light insulating frame 7 and supported on a spindle 8 capable of turning about a vertical axis, as hereafter explained. A lower spindle 9 attached to the coils carries a damping vane 10 which rotates in a liquid damping pot 11 carried by the base 12. A three-legged bracket 13 is supported on a horizontal plate 14 insulated from the cage by the insulating strips 15 and carries on its upper end a rotatable head for adjusting the instrument to zero, or, in other words, for bringing the pointer to the zero mark of the scale.

The rotatable head includes a worm-wheel 16 threaded on a spindle 17 arranged to turn in a bearing formed in the upper part of the bracket 13. The spindle 17 carries an extension 18 with knife-edge bearings 19. Cooperating with the worm-wheel 16 is a worm 20 rotatable by means of the knurled head 21, whereby to rotate the axis of the knife-edge 19 in azimuth.

The general construction of such watt-meters is well understood and further explanation of the details heretofore referred to is considered unnecessary.

In the knife-edge bearings 19 is mounted a member 22 which carries an insulating plate 23. To the insulating plate 23 are attached two metallic strips 24 which are connected by fine flexible wires 25 to shunt terminals 26 carried by the bracket 13. The metallic strips 24 form the upper terminals to which a "bifilar ladder" is attached by screws 28. The bifilar ladder consists of two filaments 29 distanced apart by struts 30, the upper and lower ends of the filaments terminating in insulating plates 31 which support metallic strips 32 to which the ends of the filaments are electrically connected.

In the form shown, the path of the current entering the moving system is as follows:—

From one of the terminals 26 through one of the connections 25 to a strip 24, thence by a screw 28 into an upper strip 32, thence through one filament to the corresponding lower strip 32 and through the spindle 8 into the coil, returning through a wire (not shown) wrapped round the spindle 8, to the second terminal 26 in a manner similar to the foregoing.

36 (Fig. 1) is a pointer which is attached to a member 38 carried by the spindle 8 and which cooperates with a fixed scale 39. 40 is a mirror attached to the moving system for co-operation with a beam of light and a distant indicating scale in well known manner.

In order to avoid sharp bending or kinking of the ligament material in the immediate neighbourhood of the points of attachment to the plates 31 and to the struts 30, when the suspension is twisted, I find it desirable to constrain the ligaments to bend around or unbend from suitably curved surfaces or members formed on or attached to the struts 30 and plates 31. Sharp bending of the ligaments is undesirable since it may set up destructive distortion of the material and it may give rise to a sub-permanent set of the material which militates against precision of measurement.

In Figs. 1 and 2, the curved constraining members or surfaces are not shown on account of their smallness and the struts shown in these figures are to be considered as indicative of the principle rather than as illustrating constructional features.

In Fig. 7 is shown a desirable form of strut consisting of a round rod with enlarged cylindrical heads in the form of a dumb-bell. The heads are slotted and the ligament meeting the surface tangentially passes a quarter way round the cylindrical head, back through the slot, a further quarter way round in the opposite direction, and leaves tangentially, as indicated.

Fig. 3 illustrates a construction for anchoring the lower end of the bifilar suspension in such wise that it is free to move over a small range in the vertical direction but is restricted from rotation about a vertical axis. 55 denotes the filar pair, 56 a cross strut, and 57 the bottom member which constitutes the load on the filar pair. The member 57 is anchored, by hinged links 58, 59 and 60, to spring members 61, 62, 63, which are carried on supports 64, 65 on a base plate 66. The member 57 is also anchored, by links 67, 68, 69 to the bell-crank levers 70, 71 and 72, which are supported pivotally on brackets 73, 74. The links 67, 68, 69 are disposed normally in a horizontal plane and are under tension due to small weights at 75, 76, 77 on the horizontal arms of the bell-crank levers. The arrangement is such that vertical motion of the member is permitted while horizontal motion and rotatory motion about a vertical axis are prevented, and the tensions in the links are so adjusted by the proportionment of the weights 75, 76, 77 that the tension in the filaments remains sensibly constant throughout the range of twist to which the bifilar suspension is subjected. Screws 78, 79, 80 serve for centralizing the member 57 in the vertical axis of the instrument. Guard wires 81 serve to limit the motion of the bell-crank levers during transport etc. When current is led into and out of the moving system by means of the filaments, they are extended below the lower strut and attached with easy bends to terminal posts 82.

Fig. 4 represents another form of anchorage in which the bottom member of the bifilar suspension is a Y-shaped piece 83, anchored by three hinged links 84, 85, 86, of which the links 84 and 85 are attached to spring plates 87, 88 and the link 86 is attached to the depending arm of the bell-crank lever 89.

Figs. 5 and 6 represent diagrammatically various arrangements of movements controlled by filar combinations where the control load is independent of the weight of the moving system.

Fig. 5 shows an arrangement where the coil A is supported upon a pivot B, balanced so that its centre of gravity is at the pivot point, and the lower ends of the filaments C are attached to a pivoted or knife-edged member D mounted on the frame of the instrument so as to lie substantially horizontally and to produce tension in the filaments, by its own weight modified as may be desired by adjustment of the counterbalance weight W or by additional weighting or otherwise.

Fig. 6 shows a moving system comprising a coil A^1 supported on a single pivot B^1 where the bifilar combination C^1 is arranged above the coil, the pull being upwards and effected through the medium of an overbalanced drum E supported on a knife-edged bearing F. It will be understood that the axial tension exerted on the filaments C^1 is less than the weight of the moving system, so that there is in all circumstances a residuum of weight carried on the pivot point B^1 whereby the coil A^1 is maintained in position. The moving system is so balanced that the centre of gravity is at the centre of the coil. In Fig. 6 there is illustrated an intermediate strut H whereby the tension in the ligaments is equalized.

By the term "filaments" I intend to include not only fine threads but also extremely narrow strips.

By the term "moving system" I intend to imply the rotatable member to which one end of the suspension or control means is attached, together with the relative pointer, balance arms, and other members rigidly attached to said rotatable member.

I claim:—

1. In a measuring or like instrument, in combination, a uni-pivoted moving system so balanced that the centre of gravity of said system is at the pivot point, a filar control means for said system arranged above said system and comprising filaments connected at their lower ends to said system and anchored at their upper ends in such wise as to permit axial motion of the upper ends of said filaments while restricting rotatory motion, means for spacing said filaments apart intermediate their ends, and means for producing tension in said filaments.

2. In a measuring or like instrument, in combination, a moving system, a filar control means for said system comprising filaments each connected at one end to said system and anchored at the opposite end, and means independent of said system for producing tension in said filaments.

3. In a measuring or like instrument, in combination, a moving system, a filar control means for said system comprising filaments each connected at one end to said system and anchored at the opposite end, and a weight independent of said system exercising axial tension in said filaments.

4. In a measuring or like instrument, in combination, a pivoted moving system, a bifilar suspension above said system, and

means independent of said system exercising in said suspension axial force less than the weight of said system.

5. In a measuring or like instrument, in combination, a uni-pivoted moving system so balanced that the centre of gravity is at the pivot, filar control means comprising filaments each connected at one end to said system, and means for anchoring each of said filaments at the opposite and in such wise that the anchored ends of said filaments are free to move over a small range in axial direction but are restricted from rotation.

6. A filar control means for measuring instruments and the like comprising a system of filaments in parallel, distance means for spacing said filaments apart intermediate their ends, and means for anchoring each of said filaments flexibly at one end in such wise as to permit axial motion of the anchored ends of said filaments over the requisite range without sensibly modifying the tension of said filaments but to restrict rotation of the anchored ends of said filaments about the axis of said system.

7. A filar control means for measuring instruments and the like, comprising filaments in parallel and a strut connecting said filaments intermediate their ends in such wise as to equalize the tensions in said filaments.

8. A filar control means for measuring instruments and the like comprising filaments in parallel, attachment members at the ends of said filaments, and a distance piece connecting said filaments intermediate their ends.

9. In combination, a pivoted moving system, a pivot bearing for said system, filar control means for said system comprising ligaments connected to said system, and means for producing tension in the ligaments whereby to relieve the pivot bearing of part of the weight of said system.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

MICHAEL BIRT FIELD.

Witnesses:

ISABEL ROLLO,

MAY ROSS.