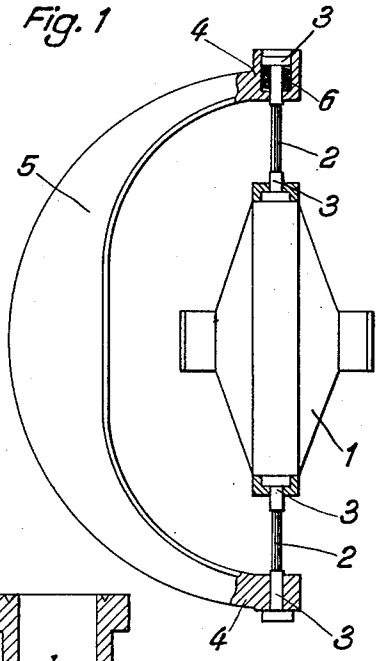
Oct. 8, 1957 P. CHRISTOPH 2,809,029

WIRE SUSPENSION

Filed Jan. 5, 1955

Fig. 1



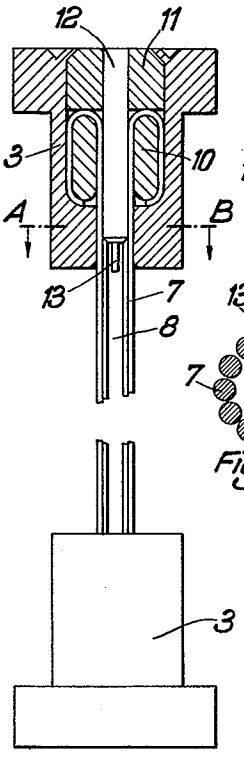




Fig. 2

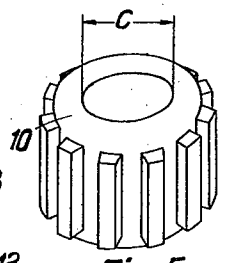



Fig. 5

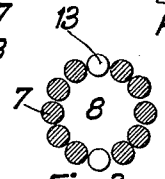



Fig. 3

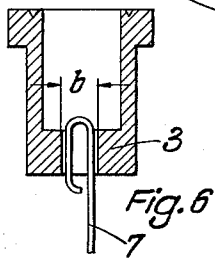



Fig. 6

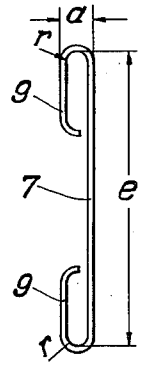



Fig. 4

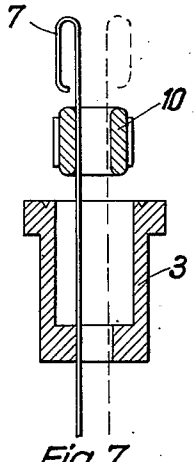



Fig. 7

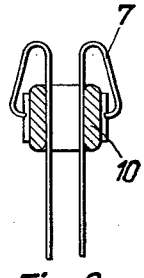



Fig. 8

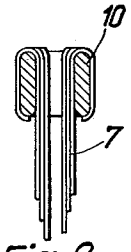



Fig. 9

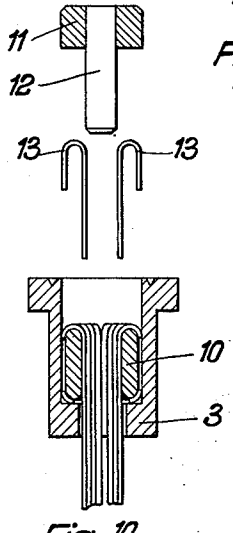



Fig. 10

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# WIRE SUSPENSION

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Application January 5, 1955, Serial No. 480,042

10 Claims. (Cl. 267—1)

The present invention relates to suspension and more particularly to suspension structures which carry devices for turning movement about a given axis.

The present application is a continuation-in-part of copending application Serial No. 296,659, filed July 1, 1952 and entitled Gyro-Compasses, now Patent No. 2,734,280, granted Feb. 14, 1956.

It is known, in gyro-compasses, for example, to suspend gyroscopes for turning movement about a given axis by means of wire or a bundle of wires, these wires becoming twisted during turning of the gyroscope.

The advantage of this arrangement is that it eliminates the necessity for ball bearings and the like. No matter how precisely these bearings are made they nevertheless will seriously detract from the operation of a precision instrument such as a gyro-compass, and the wire suspensions are far superior. However, with these suspensions now in the form of a bundle of wires, there are still certain defects. Thus, wires in the center of the bundle of wires are not stressed to the same extent as wires on the outside of the bundle of wires, and during turning these outer wires become tensioned to a greater extent than the inner wires so that the outer wires carry more of a load than the inner wires and when a failure occurs with this arrangement it is invariably the outer wires which give way. Furthermore, where the bundle of wires are woven together there are difficulties involved in the weaving of the wires which are generally made of steel. It is also common to solder the ends of the wires to a support, and soldering of steel wires also is very difficult to accomplish. The soldering decreases from the uniformity of the distribution of the load among the several wires and gives rise to corrosion of the wire ends. Where the wire ends are simply clamped mechanically they are usually bent to an extent beyond the yield point of the wires so that the load capacity of the wires are greatly reduced in this way. One of the objects of the present invention is to overcome the above drawbacks by providing a wire suspension which guarantees that the wires are uniformly loaded.

Furthermore, it is another object of the present invention to connect the wires to a support in such a way that the yield point of the wires is not exceeded by bending thereof and no soldering or the like is required so that possible corrosion is avoided.

An additional object of the present invention is to provide a plurality of wires in a suspension which are arranged in such a way that none of the wires will become shorter or tensioned to a greater extent than the other wires.

Furthermore, it is still another object of the present invention to provide an arrangement which is very easy to assemble and which is very reliable in operation while at the same time being made up of simply and ruggedly constructed parts.

With the above objects in view the present invention mainly consists of a suspension which includes a plurality



of substantially parallel wires located in substantially side by side relation and defining a substantially cylindrical space which is enclosed by the wires, each of the wires being formed at one end with a loop. A ring extends through the loops of the wires, and a sleeve is located about the loops and the ring. Finally, a support means carries the sleeve so that a device carried by the wires may turn about the axis of the cylinder while twisting the wires which tend to return the device to its starting position.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a partly sectional side elevational view illustrating the manner in which the suspension of the invention is applied to a gyroscope;

Fig. 2 is a fragmentary elevational view illustrating in section the details of the structure for connecting the ends of the wires of the suspension to a support;

Fig. 3 is a section taken along a line A—B of Fig. 2 in the direction of the arrows and showing only the wires;

Fig. 4 is a side elevational view of one wire of the suspension of the invention;

Fig. 5 is an enlarged perspective view of a holding ring of the structure of the invention; and

Figs. 6–10 illustrate diagrammatically successive steps in the assembly of the parts.

Referring now to the drawings, Fig. 1 shows a gyroscope 1 supported for turning movement about a vertical axis, as viewed in Fig. 1, of the structure of the invention. For this purpose a wire suspension 2 is provided, the ends of the wires being connected to sleeves 3, in a manner described in detail below, which are carried by the frame 5 at the ends 4 thereof, the sleeve 3 also being connected to the gyro housing as shown in Fig. 1. It will be noted from Fig. 1 that the upper end portion 4 of the frame 5 has a spring 6 located therein which engages a flange of the sleeve 3 so as to maintain the suspension in tension. It is possible to adjust the tension provided of spring 6, as by placing washers between the same and sleeve 3, for example, so that in this way the tension of the suspension 2 may be adjusted to provide the required torsional resistance to the turning of the gyro.

As is apparent from Figs. 2 and 3, each suspension 2 is made up of a number of individual wires 7 which are parallel to each other and which are arranged in side by side relation in such a way that the wires define and enclose a substantially cylindrical space 8. As is apparent from Fig. 4, each wire is bent at its opposite ends into loops 9, respectively. The smallest radius $r$ of the loops is larger than the radius of a bend which equals or exceeds the yield point of the wire so that the loops 9 do not detract from the load carrying capacity of the wire.

When assembled, a ring 10 extends through the loops 9 at each end of the wires 7, and as it is shown in Fig. 5, this ring 10 is provided at its outer face with projections which respectively extend between the several loops. The sleeve 3 is located about the loops and ring 10 and engages the loops to urge the same against the outer face of the ring 10. As is evident from Fig. 2, a plate 11 is fixed within the sleeve 3 as by being pressed or threaded thereinto, and a pin 12 which is cylindrical and has a diameter substantially equal to that of the cylindrical space 8 is fixed to the plate 11 and extends therefrom into the space 8 to engage wires 7 and press same against the inner face of ring 10. Thus, the pin

12 clamps the wires against the inner face of ring 10 while the sleeve 3 clamps the wires at the loops 9 thereof against the outer face of the ring 10. In this way soldering of the wires is avoided. The loops may be accurately formed in the wires with any suitable device so that in their operative position the wires receive the same load. Furthermore, the distribution of the wires along the cylinder prevents unequal twisting or tensioning of the wires.

It will be noted from Fig. 2 that the sleeve 3 is provided at one end with an outwardly extending flange against which the spring 6 of Fig. 1 bears and at an opposite end with an inwardly extending annular flange on which the loops 9 and the ring 10 rest.

In order that the parts may be conveniently assembled, the diameter *b* of the annular flange at the bottom end of sleeve 3, as viewed in Fig. 6, is at least as great as the maximum width *a* (Fig. 4) of the loops 9, and the same is true of the ring 10 which is provided with an inner diameter *c* at least as great as the greatest width *a* of the loops 9. Furthermore, the diameter of each wire 7 as well as the diameter *b* and *c* are of such a magnitude that an even number of wires may be easily located within the ring 10 and lower flange of sleeve 3.

Figs. 6–10 illustrate the manner in which the structure of the invention is assembled. As is shown in Fig. 6, the individual wires are first passed through the lower inwardly extending annular flange of the sleeve 3. Fig. 7 shows how with the loops 9 located beyond sleeve 3 the wires are then passed through the ring 10. When all of the wires extend through the sleeve 3 and sleeve 10 in the manner shown in Fig. 7 the wires are spread at their loops and pass downwardly about the ring 10, as indicated in Figs. 8 and 9. Then the loops and ring on the one hand and the sleeve 3 on the other hand are shifted with respect to each other in the position of Fig. 10 where the sleeve presses the loops of the wires against the outer face of the ring 10.

The diameters *b* and *c* are made only slightly greater than width *a* so that the diameter of the bundle of wires 7 may be kept as small as possible to keep the torsion of the bundle of wires down to a minimum. In the illustrated example the outer diameter of the bundle of wires is approximately equal to the width *a* of the loops 9.

Because the inwardly extending annular flange of sleeve 3 and the inner surface of ring 10 may have a diameter equal to or slightly greater than the greatest width of the loops 9, it is only possible to pass through the inwardly extending annular flange of sleeve 3 and the ring 10 a number of wires which is one less than the number of wires which can be distributed about the ring 10. This is so because the entire diameter of the ring 10 is required for passage of the wires therethrough. However, for balance purposes an even number of wires 7 are used, and in order that there may be no gap between the wires, two "dummy" wires 13 are placed in the spaces between the two groups of wires 7, as indicated in Fig. 3, these wires 13 having a length considerably shorter than the wires 7 and simply filling the space about the periphery of ring 10.

Thereafter the plate 11 with the pin 12 is moved into the position shown in Fig. 2 either by pressing or threading or the like. Because of the gaps filled by the wires 13 and because of the necessity for these gaps to be located at diametrically opposed parts of the cylindrical space it is necessary to provide an even number of wires in the suspension of the invention. If desired, it is of course possible to locate more than two "dummy" wires in the suspension. The length of these wires 13 is so chosen that they do not extend substantially beyond the sleeve 3.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of suspensions differing from the types described above.

While the invention has been illustrated and described as embodied in wire suspensions, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A suspension comprising, in combination, support means; a plurality of wires being substantially parallel to each other, and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop; and a ring carried by said support means and extending through the loops of said wires.

2. A suspension comprising, in combination, support means; a plurality of wires being substantially parallel to each other, and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop and said loop having at all parts thereof a curvature which does not stress the wire beyond its yield point; and a ring carried by said support means and extending through the loops of said wires.

3. A suspension comprising, in combination, a plurality of substantially parallel wires located in substantially side by side relation and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop; a ring extending through the loops of said wires; a sleeve located about said loops and ring; and support means carrying said sleeve.

4. A suspension comprising, in combination, a plurality of substantially parallel wires located in substantially side by side relation and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop; a ring extending through the loops of said wires and having an inner diameter at least as great as the maximum width of each loop; a sleeve located about said loops and ring and also having an inner diameter which is at least as great as the maximum width of each loop; and support means carrying said sleeve.

5. A suspension comprising, in combination, an even number of substantially parallel wires located in substantially side by side relation and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop, and two of said wires being located diametrically opposite each other and being shorter than the other wires; a ring extending through the loops of said wires; a sleeve located about said loops and ring; and support means carrying said sleeve.

6. A suspension comprising, in combination, an even number of substantially parallel wires located in substantially side by side relation and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop, and two of said wires being located diametrically opposite each other and being shorter than the other wires; a ring extending through the loops of said wires and having an inner diameter at least as great as the maximum width of each loop; a sleeve located about said loops and ring and also having an inner diameter which

is at least as great as the maximum width of each loop; and support means carrying said sleeve.

7. A suspension comprising, in combination, a plurality of substantially parallel wires located in substantially side by side relation and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop; a ring extending through the loops of said wires; a sleeve located about said loops and ring and pressing said loops against said ring; a plate fixed in the interior of said sleeve; a cylindrical pin having a diameter substantially equal to that of the cylindrical space enclosed by the wires fixed to said plate and extending therefrom into said space and engaging said wires to press the same against the inner face of said ring; and support means carrying said sleeve.

8. A suspension comprising, in combination, a plurality of substantially parallel wires located in substantially side by side relation and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop; a ring extending through the loops of said wires; a sleeve located about said loops and ring, holding said loops against the outer face of said ring, and having at one end an inwardly extending annular flange through which said wires extend and on which said loops and ring rest; and support means carrying said sleeve.

9. A suspension comprising, in combination, a ring; a plurality of wires arranged in side by side relation, each being looped at one end about said ring, and said wires extending in one direction from said ring to define a substantially cylindrical space enclosed by said wires, the greatest width of each loop being no greater than the



inner diameter of said ring; a sleeve located about said loops and ring and engaging said loops to press the same against the outer face of said ring, said sleeve having at one end an inwardly extending annular flange located at one end of said ring and loops and having an inner diameter at least as great as the greatest width of each loop; a plate fixed to the interior of said sleeve at the opposite end of said ring and loops from said annular flange of said sleeve; and a cylindrical pin fixed to said plate, having a diameter substantially equal to that of the cylindrical space defined by said wires, and extending from said plate into said space to engage said wires and press the same against the inner face of said ring.

10. A suspension comprising, in combination, a plurality of substantially parallel wires located in substantially side by side relation and defining a substantially cylindrical space which is substantially enclosed by said wires, each of said wires being formed at one end with a loop; a ring extending through the loops of said wires; a sleeve located about said loops and ring; support means carrying said sleeve; and spring means carried by said support means and engaging said sleeve for keeping said wires tensioned.

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