Oct. 25, 1949. W. M. HURST 2,486,285

ELECTRICAL CONTACT MEMBER

Filed June 16, 1948 2 Sheets-Sheet 1

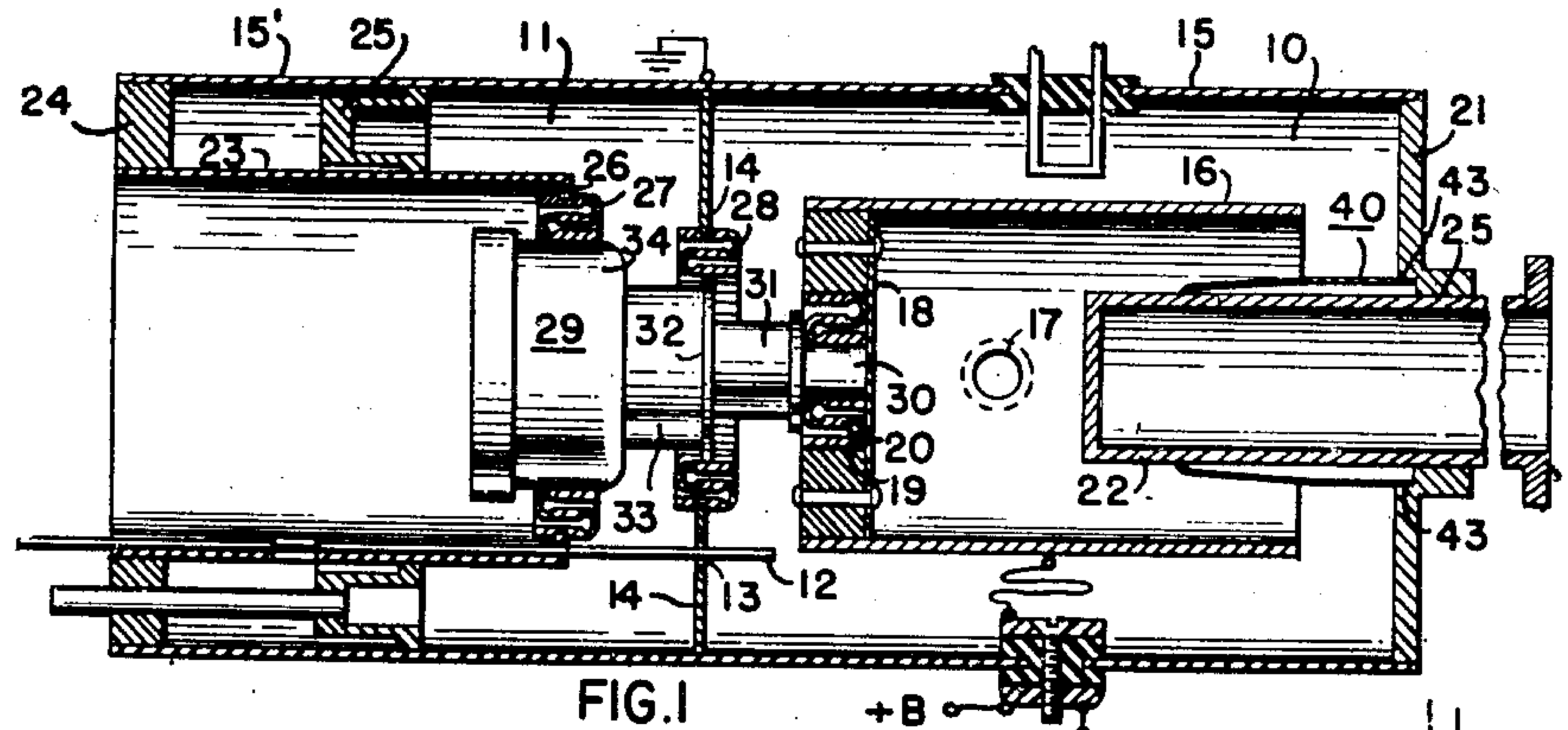
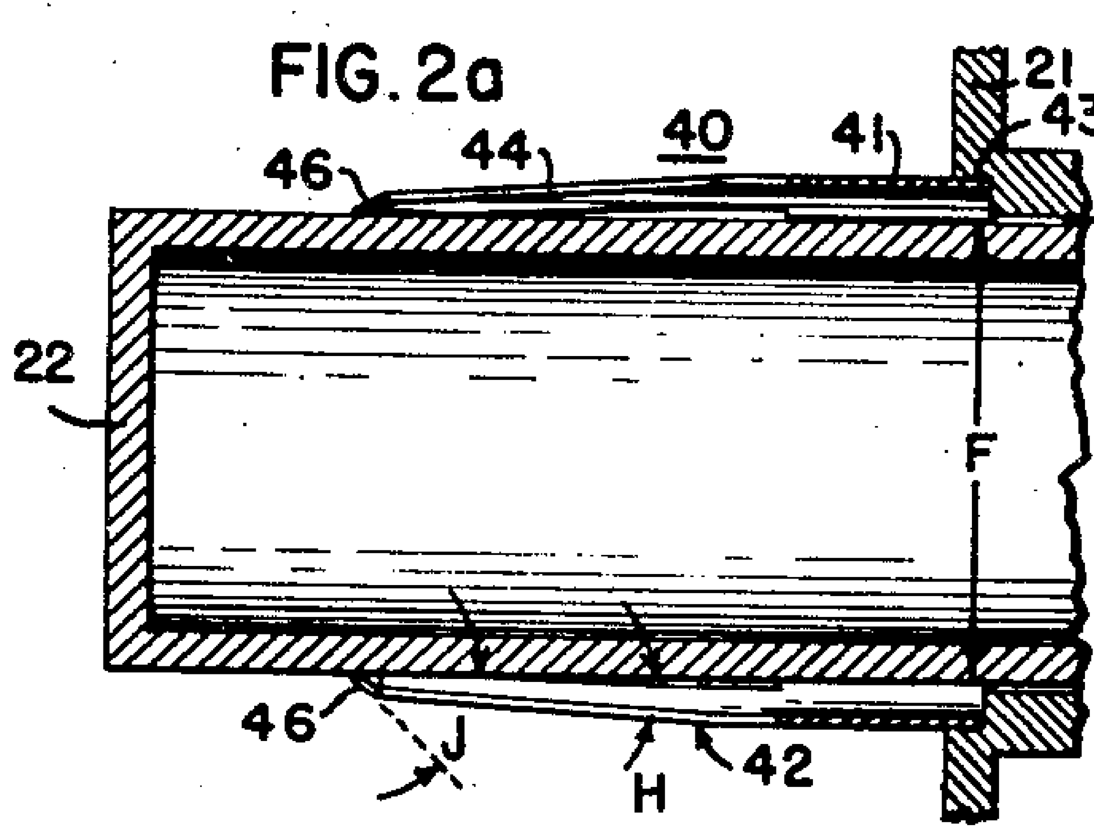


FIG. 1

FIG. 2a



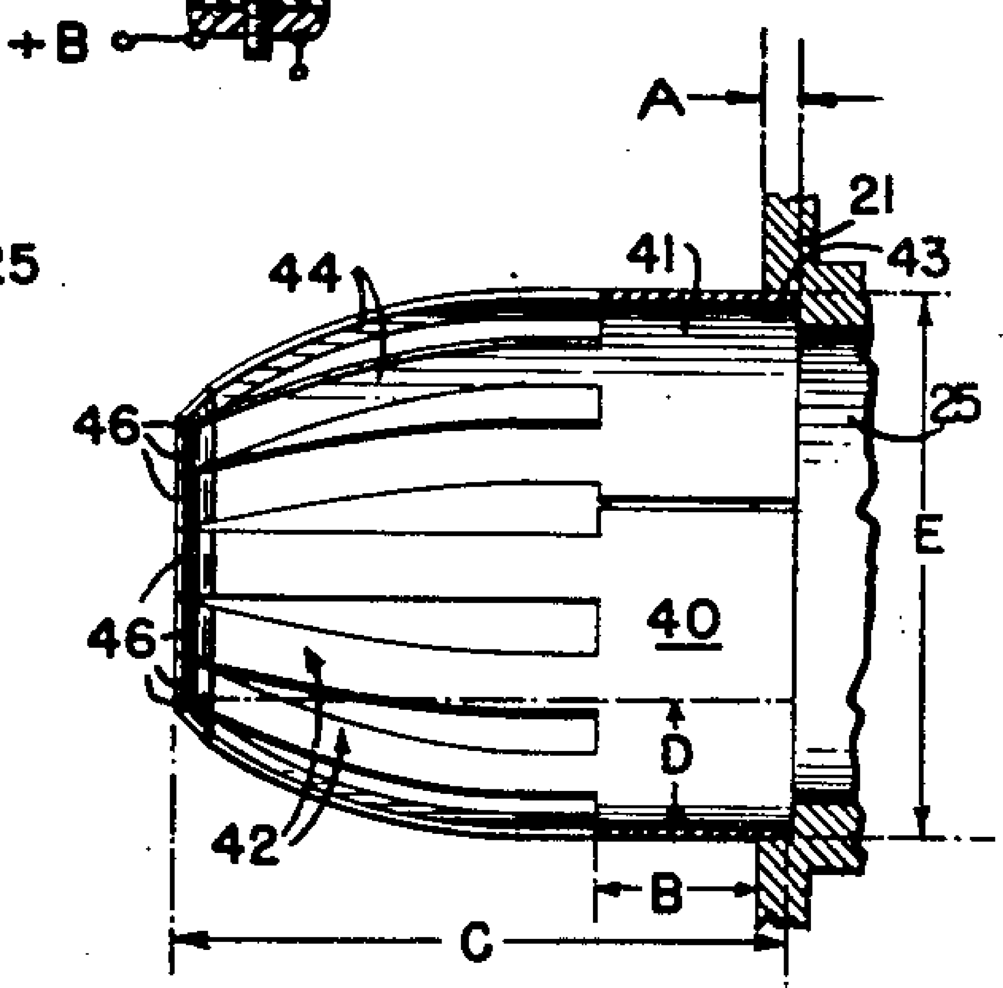


FIG. 2b

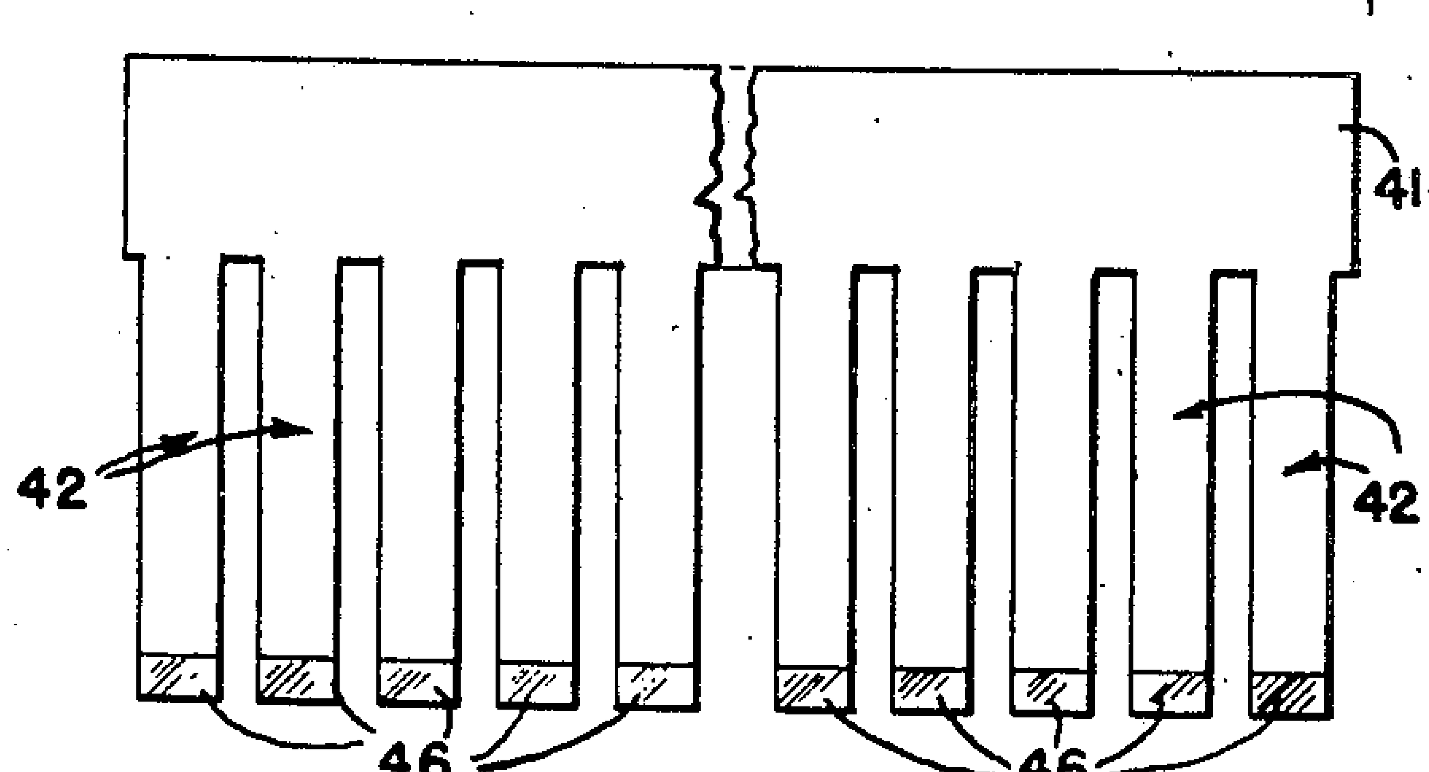


FIG. 3a

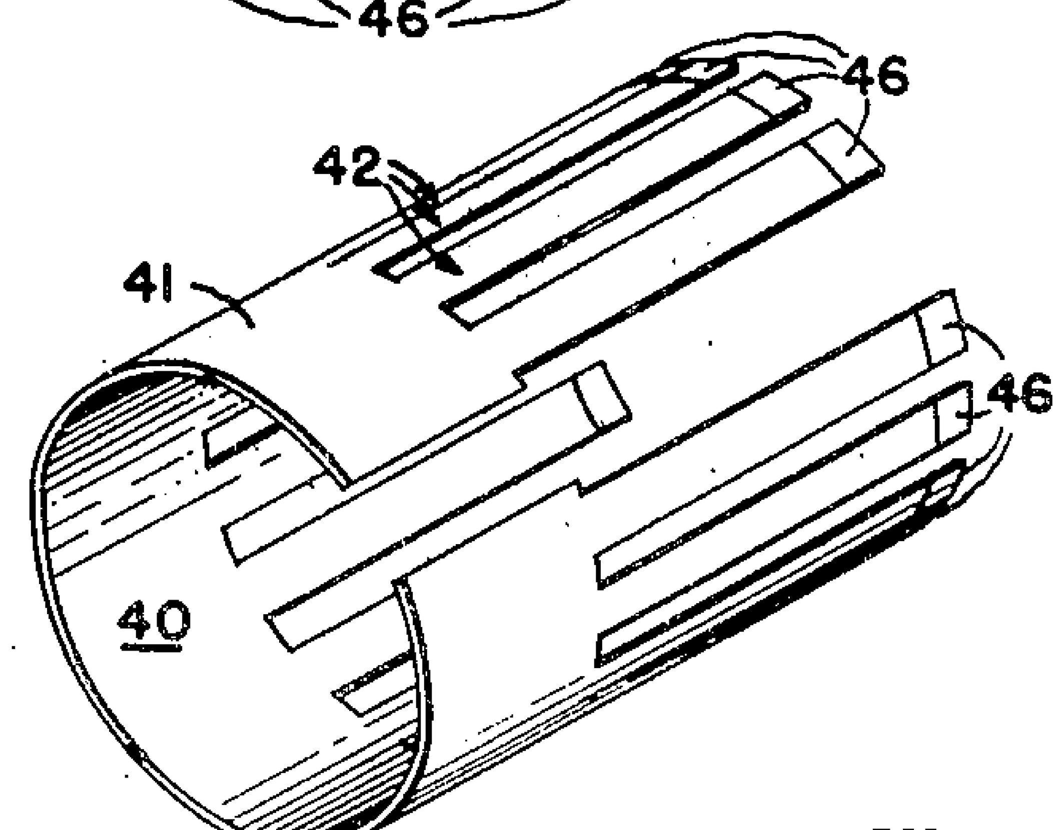


FIG. 3b

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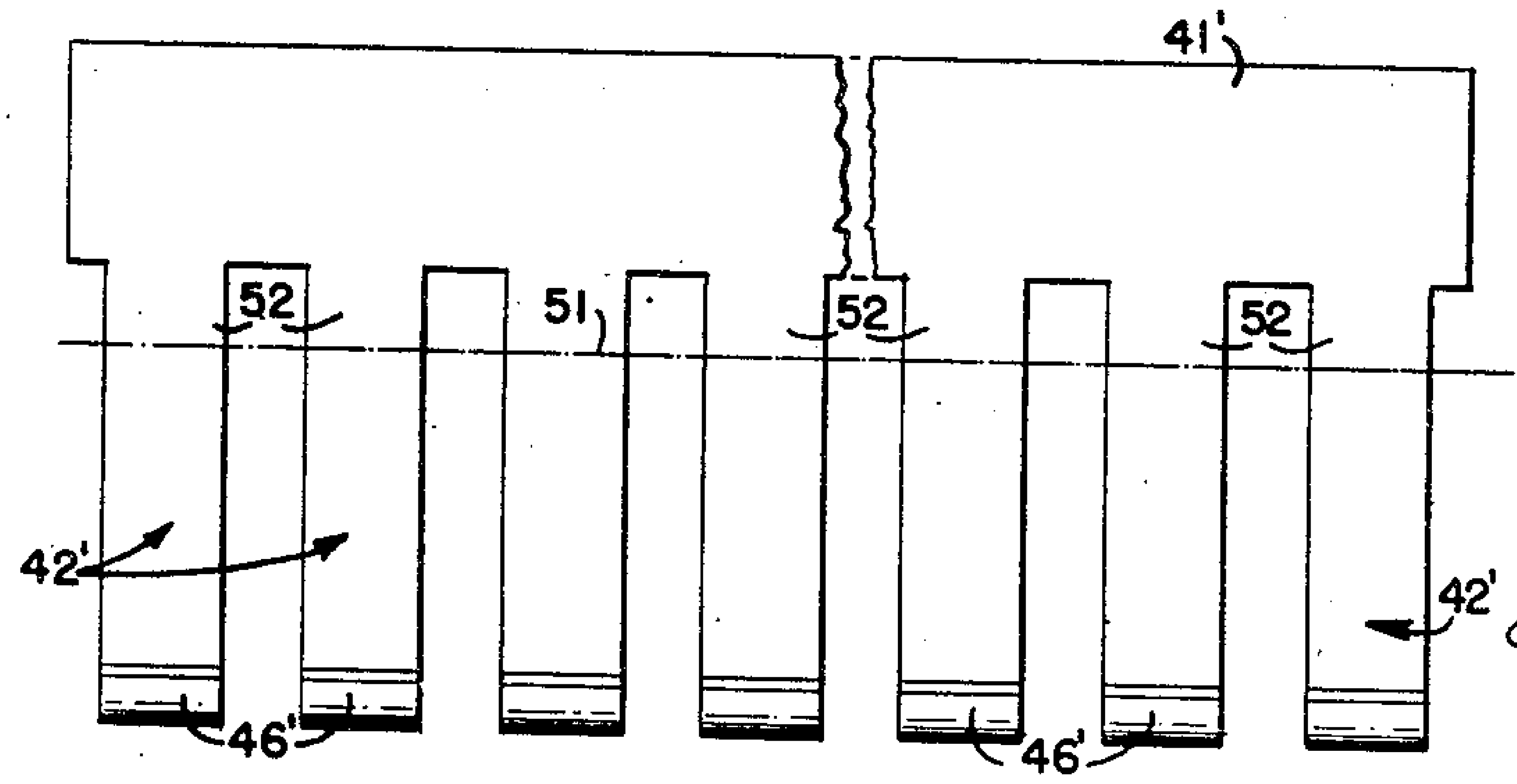

FIG. 4a

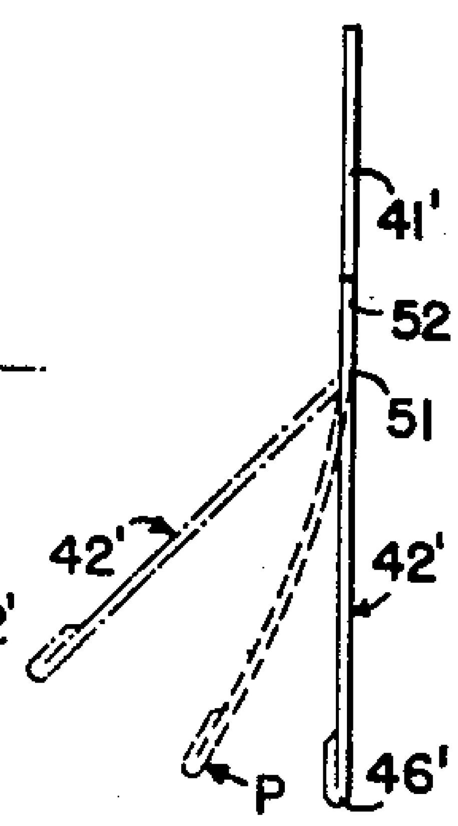

FIG. 4b

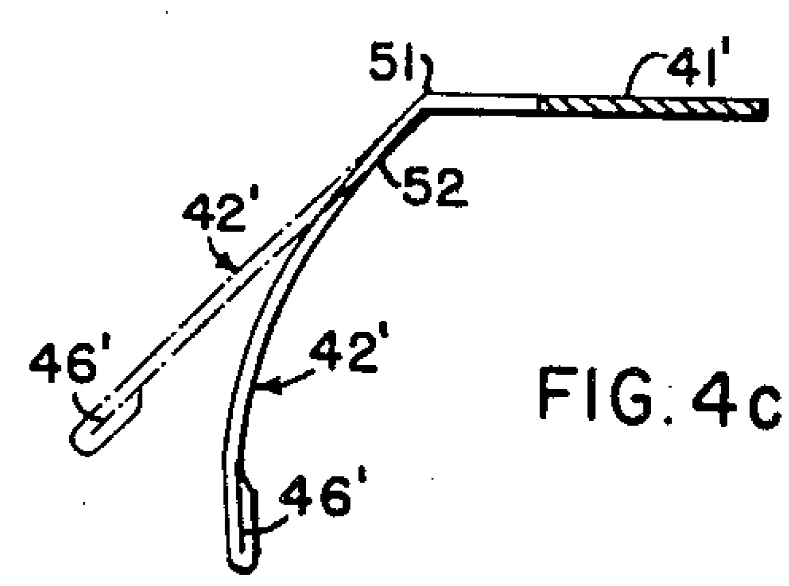

FIG. 4c

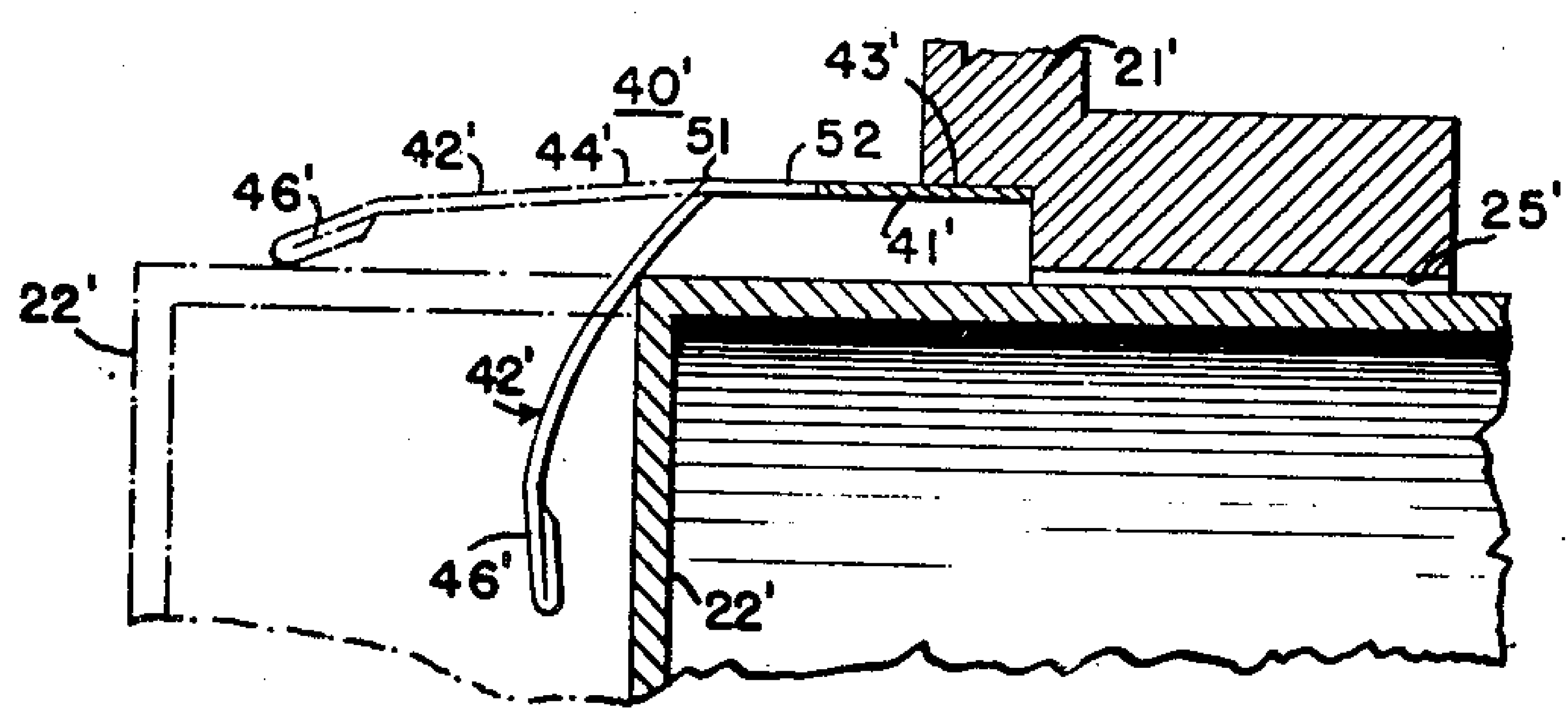

FIG. 4d

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ELECTRICAL CONTACT MEMBER

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Application June 16, 1948, Serial No. 33,367

11 Claims. (Cl. 173—324)

1

This invention relates to electrical contact members and, particularly, to electrical contact members for slidably engaging an electrically conductive member which forms therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length.

In tunable high-frequency electrical devices such as wave-signal selectors, oscillators, and wavemeters, it is frequently necessary to employ electrical contact members for slidably engaging an adjustable electrically conductive member which is employed to tune the device over the frequency range thereof. This adjustable conductive member very often is a cylindrical plunger which extends into a cavity resonator, and the distance this plunger projects into the resonator effectively determines the resonant frequency of the device. An electrical contact member, usually having a plurality of resilient fingers which engage the surface of the plunger, forms therewith a portion of the high-frequency conductive circuit of the tunable electrical device. In view of the high operating frequency of the device, this circuit has a critical electrical length in each position of adjustment of the plunger.

Heretofore, considerable difficulty has been experienced in maintaining the electrical length of such a conductive circuit at its proper value after repeated adjustments of the plunger or even after a single adjustment thereof. This difficulty was caused by faulty operation afforded by the electrical contact member because of certain undesirable characteristics thereof. Various proposals have been made to overcome this difficulty, but none has provided an operation which was as consistent and satisfactory as desired for many applications. In accordance with one such proposal, only a very small area comprising the extreme tips of the resilient fingers of the electrical contact member made a sliding contact with the surface of the adjustable plunger. This was to assure a reliable contact between the fingers and the surface of the plunger by providing high unit pressures therebetween. Prior electrical contact members of this character, however, have proved unsatisfactory for several reasons. Due to the high unit pressures applied by the resilient fingers, an electrical contact member of this sort either scratched or (after repeated adjustments of the plunger) wore completely through the customary plating of highly conductive material provided on the surface of the plunger. Since high-frequency electrical currents flow only in the extreme outer surface of a conductor due to the "skin effect" phenomenon, the described abrasive action usually materially altered the electrical length and the resistance of the high-frequency conductive path including the plunger and the electrical contact member. Furthermore, the tips of the resilient

2

fingers often showed a tendency toward excessive wear as a result of this abrasive action and the high unit pressures. This also tended to change materially the length and the resistance of the above-mentioned electrical paths after frequent adjustments of the position of the plunger. Consequently, the same adjustment or apparent setting of the plunger made on two different occasions would not necessarily result in the development of or in the proper translation by the electrical device of high-frequency wave signals having identical frequencies. Such operation was therefore unsatisfactory for many applications wherein accuracy was important.

One expedient which was adopted to reduce the extent of this difficulty consisted in plating the plunger with a rare and expensive material such as rhodium, which is characterized by its good electrical conductivity as well as exceptional hardness. This, however, was not entirely satisfactory since the extent of the described abrasive action was merely reduced.

Prior electrical contact members of the type just described also were characterized by another shortcoming. The shape of the resilient fingers and the mounting arrangement thereof with respect to the plunger were such that the fingers tended intermittently to bend slightly along their longitudinal dimension as the position of the tuning plunger of the high-frequency electrical device was changed. Consequently, the fingers of the electrical contact member moved relative to the plunger with a somewhat jerking action causing what is commonly referred to as chattering. This was extremely undesirable since the plunger might be set at a certain tuning position on one occasion and when set at the same position on a later occasion the tips of the fingers would not engage the plunger at identical positions. Consequently, the resonant frequency of the device would not be the same on two different occasions for the same apparent setting of the plunger. A further difficulty was also encountered when the device was momentarily jarred or subject to vibration since the resilient fingers, for a given position of adjustment of the frequency-determining plunger, might not be in a position of equilibrium as a result of the described binding action. Accordingly, a jar or other vibration often caused the fingers to "creep" along the plunger to a position of equilibrium, thus undesirably altering the resonant frequency of the tuning device.

In accordance with another proposal, the tips of the resilient fingers of an electrical contact member for slidably engaging an adjustable tuning plunger of a high-frequency electrical device were rounded considerably. This materially reduced the scratching of the plunger since the areas of the tips of the fingers engaging the plunger were greatly increased, thereby reducing the unit pressures which the fingers applied to the plunger. However, a reliable electrical contact was not assured, particularly after repeated adjustments of the plunger over fairly long time intervals, since dust and other foreign material which unavoidably accumulated in the high-frequency device were pushed under the rounded tips of the resilient fingers as a result of the reciprocating motion of the plunger during tuning operations. Since the unit pressure between the fingers and the plunger was not high, the fingers could not cut through this undesirable accumulation and establish a good electrical contact with the plunger. As a result, the electrical resistance of the high-frequency conductive circuit often became very uncertain and the operation of the high-frequency device became unstable or unpredictable.

There has, consequently, existed a very serious need for a satisfactory high-frequency electrical contact member for slidably engaging an electrically conductive member having relative movement with respect thereto.

It is an object of the invention, therefore, to provide a new and improved electrical contact member, for slidably engaging an electrically conductive member and forming therewith a portion of a high-frequency conductive circuit, which avoids one or more of the above-mentioned disadvantages and limitations of prior such contact members.

It is another object of the invention to provide a new and improved electrical contact member, of the type described, which is relatively free from undesirable chatter.

It is a further object of the invention to provide a new and improved electrical contact member, for slidably engaging with high unit pressure an electrically conductive member and forming therewith a portion of a high-frequency conductive circuit, which does not contribute to excessive wear of the slidably engaging members.

It is yet another object of the invention to provide a new and improved electrical contact member, for slidably engaging an electrically conductive member and forming therewith a portion of a high-frequency conductive circuit, which provides reliable performance over extended periods of operation and yet one which is relatively simple in construction and inexpensive to manufacture.

It is a still further object of the invention to provide a new and improved electrical contact member for slidably engaging an electrically conductive member with a force of predetermined substantially unvarying value and forming therewith a portion of a high-frequency conductive circuit.

In accordance with a particular form of the invention, an electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprises an elongated member of resilient conductive material having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam. Accordingly, the longitudinal portion of the elongated member assumes and maintains a substantially rectilinear elevational configuration upon adequately flexed engagement of the elongated member with the conductive member, and the elongated member is thereby effective with the conductive member to establish and to maintain in a definite and consistent manner the electrically adjustable electrical length of the conductive circuit in each relative position of the aforesaid members.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring now to the drawings, Fig. 1 is an elevational sectional view of a high-frequency wave-signal oscillator utilizing an electrical contact member in accordance with a particular form of the present invention; Fig. 2*a* is an enlarged cross-sectional view of the electrical contact member of the Fig. 1 arrangement; Fig. 2*b* is a view similar to Fig. 2*a* but showing the configuration of the contact member in an unstressed state; Figs. 3*a* and 3*b* illustrate certain steps in forming the contact member illustrated in Figs. 2*a* and 2*b*; and Figs. 4*a*, 4*b*, 4*c*, and 4*d* illustrate certain steps in the formation and the mounting of an electrical contact member embodying a modified form of the present invention.

Referring now more particularly to Fig. 1 of the drawings, there is illustrated a high-frequency wave-signal oscillator which utilizes an electrical contact member in accordance with a particular form of the present invention. Briefly considered, the oscillator includes a first or anode cavity resonator **10** and a second or cathode cavity resonator **11** which is capacitatively coupled to the resonator **10** by a probe **12** arranged to extend through an aperture **13** in a diaphragm **14** separating the cavity resonators **10** and **11**. The cavity resonator **10** includes a hollow cylindrical outer conductor **15** and a hollow cylindrical inner conductor **16** which are maintained in a fixed coaxial relationship by insulating spacers **17** secured between the conductors **15** and **16** at points suitably spaced around the circumference thereof. One end of the inner conductor **16** is closed by a disc **18** having a centrally positioned coaxial aperture **19** in which is secured by a pressed fit or other suitable means an electrical contact member **20** of the type disclosed and claimed in United States Letters Patent No. 2,426,429, granted August 26, 1947, to Basil A. Bels, entitled "Electrical connector," and assigned to the same assignee as the present invention. The outer conductor **15** of the cavity resonator **10** is closed at its end opposite the diaphragm **14** by a disc **21**. The disc **21** has a centrally disclosed aperture **25**, in which is mounted in a manner more completely to be described hereinafter, an electrical contact member **40** in accordance with one form of the present invention. The aperture **25** and the contact member **40** are effective to support in coaxial relation with the conductors **15** and **16** a substantially cylindrical conductive member or plunger **22** of diameter appreciably smaller than that of the inner conductor **16**. The conductive member **22** preferably has a thin layer of rhodium superimposed on a thin layer of silver suitably plated on the outer periphery of the conductive member. The rhodium layer not only is characterized by its good electrical conductivity but also has good wear-resistant properties with respect to members in sliding engagement therewith. The conductor **22** effectively forms a re-entrant portion of the outer conductor **15**. The electrical contact member **40** slidably engages the conductive member **22**, which is utilized for tuning the resonator 10, and forms therewith a portion of the high-frequency conductive circuit of adjustable length.

The second or a cathode resonator 11 similarly includes a hollow outer cylindrical conductor 15', which may be an extension of the conductor 15, and a hollow inner cylindrical conductor 23 which is supported by a conductive ring 24 in coaxial relation with the outer conductor 15'. The conductive ring 25 is positioned between and electrically engages the inner and outer conductors 23 and 15', this ring being adjustable axially along these conductors for purposes of tuning the cathode cavity resonator 11. The end of the inner conductor 23 adjacent the diaphragm 14 is closed by a disc 26 having a centrally positioned coaxial aperture in which is secured an electrical contact member 27 having a construction similar to that of the electrical contact member 20. The diaphragm 14 likewise has a centrally positioned coaxial aperture in which is secured an electrical contact member 28 also embodying a construction similar to that of the electrical contact member 20.

The high-frequency wave-signal oscillator also includes an electron tube 29 which has an approximately cylindrical conductive contact member or anode terminal 30 hermetically sealed to one end of a cylindrical glass envelope portion 31, a conductive grid disc 32 which is hermetically sealed between the envelope portion 31 and a second cylindrical glass envelope portion 33, and a conductive cathode terminal 34 sealed to one end of the glass envelope portion 33. The tube 29 is insertable axially through the center of the hollow conductor 23 of cathode cavity resonator 11 into an operative position with its anode terminal 30 engaging the electrical contact member 20, its grid terminal disc 32 engaging the electrical contact member 28, and its cathode terminal 34 engaging the electrical contact member 27. To simplify the representation, certain electrical terminals which extend out from the flat base of the tube 29 and also certain means for maintaining the tube 29 in this operative position have not been illustrated.

Considering now the operation of the oscillator just described, oscillations developed in the cathode cavity resonator 11 are repeated by the electron tube 29 to the anode cavity resonator 10 and a portion of the oscillatory energy developed in the latter is applied by the probe 12 back to the cathode cavity resonator 11 so that sustained oscillations are produced. An axial adjustment of the conductive member 22 in either direction is effective to alter the extent that the member projects within the hollow inner conductor 16, thereby to alter the effective length of the anode cavity resonator 10. This in turn adjusts the operating frequency of the oscillator. In a high-frequency oscillator of this character having good frequency stability, the high-frequency conductive circuit of the anode-cavity resonator 10 including the contact member 40 and the conductive member 22 is of critical electrical length. Consequently, after a desired axial adjustment of the member 22 is made, it is extremely important that the electrical length of the conductive path established by the electrical contact member 40 and the conductive member 22 be maintained exactly at the proper value under all operating conditions to which the oscillator may be subjected in operation. It is also desirable, after various adjustments of the position of the member 22, that it be possible to reset the member 22 with respect to the contact member 40 so as to provide a conductive path having its exact initial path length. The construction of the member 40 is such that it is effective to accomplish this desired result.

Considering now in greater detail the portion of the described oscillator embodying the present invention, reference is made to the enlarged sectional views shown in Figs. 2*a* and 2*b*. The contact member 40 there illustrated comprises a strip of flat, thin, resilient, conductive material such as beryllium copper and includes an approximately cylindrical body portion 41 having a plurality of elongated members or contact fingers 42, 42 extending from one edge of the body portion. The body portion 41 is secured within an enlarged portion 43 of the aperture 25 in the disc 21 in a suitable manner as by soldering. Each of the contact fingers 42 has a longitudinal portion 44 of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam. These fingers are illustrated in Fig. 2*b* in their unstressed condition, the conductive member 22 being shown withdrawn to remove all external stresses from the contact fingers. It will be observed that the longitudinal portion 44 of any contact finger 42 has a predetermined curvature approximately corresponding to that imparted to a thin, flat cantilever beam of rectangular cross section when it has a concentrated load applied to the free end thereof.

Each contact finger 42 is provided with a tip portion 46 of small transverse cross-sectional area extending from the longitudinal portion 44 inwardly toward the axis of the cylindrical body portion 41 and effectively defining with the longitudinal portion 44 a salient angle. More particularly, this angle is one which is slightly less than 180 degrees, for example one of about 165 degrees. The tip portion 46 of each finger preferably is made of silver because of its softness and good electrical conductivity, the tip portion then constituting an endlay which is butt welded in well-known manner to the end of the longitudinal portion 44.

As a result of the described construction of the contact fingers 42, 42, the tip portions 46, 46 thereof slidably engage the outer peripheral surface of the conductive member 22 while the longitudinal portions 44, 44 of the fingers assume and maintain a substantially rectilinear elevational configuration (see Fig. 2*a*) which is approximately parallel to the peripheral surface of the member 22. The flexed engagement between the fingers 42, 42 and member 22 establishes a desired value of pressure with which the tip 46 of each contact finger 42 is to engage the peripheral surface of the member 22 for a given application. This pressure may be selected for the particular application and is dependent on such factors as the hardness of the conductive sheath employed on the conductive member 22 and the maximum permissible force available to move the member 22 axially for tuning purposes such as when motor driven adjustments are made. Knowing such factors, knowing the resiliency of the particular metal employed for the contact fingers and the dimensions thereof, and also knowing the well-known deflection characteristic of an end-loaded cantilever beam having the dimensions of the longitudinal portion 44 of the finger employed, both the desired initial preset curvature of the contact fingers 42, 42 and the extent of the flexed engagement provided by the contact member 22 to distort the fingers to a substantially rectilinear configuration (as shown in Fig. 2*a*) may readily be determined.

Once these factors have been determined, the construction of the electrical contact member 40 illustrated in Figs. 2*a* and 2*b* is relatively simple. A thin rectangular flat sheet of resilient conductive material, such as beryllium copper, has a narrower sheet of silver attached to one longitudinal edge thereof by a welding operation. The composite sheet is then serrated along a longitudinal edge by punching or other suitable operation to form a serrated strip having the body portion 41 and the contact fingers 42, 42 with their tip portions 46, 46 extending therefrom as shown in plan view in Fig. 3*a*. The serrated strip is then bent into a cylinder as shown in perspective in Fig. 3*b* of the drawings. Thereafter the cylinder is inserted into an annular recess in a suitable metallic form (not shown) for a heat treating operation. The annular recess in this form is so shaped that the contact fingers are bent into a predetermined configuration corresponding to that illustrated in Fig. 2*b*. The heat treating operation is such as to remove the stresses in the contact fingers so that there results a contact member of the type shown in Fig. 2*b* wherein the longitudinal portion of the contact fingers have the desired preset curved configuration. This configuration is approximately parabolic. The contact member is then preferably plated with a good electrical conductor such as silver to provide a low resistance path for high-frequency wave-signal currents, after which the contact member is mounted for use in the manner previously described.

For the purpose of considering the manner in which the electrical contact member 40 is effective with the member 22 to establish and to maintain in a definite and consistent manner the critically adjustable electrical length of the high-frequency conductive circuit of the anode cavity resonator 10 in each relative position of the members, reference is again made to Fig. 2*a* of the drawings. The conductive member 22 makes engagement with the flexed contact fingers 42, 42 and, in effect, applies sufficient force to each thereof at their tip portions 42 that the longitudinal portion 44 assumes an approximately linear configuration. The longitudinal portion 44 of a contact finger 42 necessarily makes a very small angle, which may be about 10 degrees, with the body portion 41 by virtue of the fact that a small clearance (for example about 3/64 of an inch) is required between the member 22 and the body portion 41. The tip portion 46 of each contact finger makes a slightly greater angle, namely one of about 15 degrees, with the peripheral surface of the member 22. It will be seen that the fingers 42 of the electrical contact member 40 are, however, approximately parallel to the outer peripheral surface of the conductive member 22. For reasons which will be made clear hereinafter, this relationship is extremely beneficial.

As the conductive member 22 is adjusted axially in either direction, the contact fingers 42, 42 have longitudinal stiffness and exhibit substantially no tendency to bend or bow even though the tip portions 46, 46 of the fingers engage the surface of the member 22 with a relatively high unit pressure. Consequently the fingers 42, 42 do not chatter as the position of the member 22 is adjusted axially for tuning purposes. Hence, whenever the member 22 is adjusted to a desired setting, the fingers always have an equilibrium position and therefore do not move or creep when subsequently subjected to vibration or jarring. The oscillator represented in Fig. 1 thus develops high-frequency wave signals having a predetermined and accurately resettable frequency for each position of the member 22. Thus the contact member 40 is effective with the conductive member 22 to establish and maintain in a definite and consistent manner the critically adjustable length of the high-frequency conductive circuit of the anode cavity resonator 10 of the oscillator.

The electrical contact member 40 not only maintains the above-mentioned critical path length, but assures a reliable yet adjustable electrical connection with the contact member 22. Since a relatively small cross-sectional area of the tip portions 46, 46 of the fingers 42, 42 is in engagement with the outer peripheral surface of the member 22, high unit pressures are developed at the contacting surfaces. These, in turn, enable the contact fingers 42, 42 to exercise a self-cleaning action which effectively removes dust and other undesirable accumulations from the surface of the member 22 as the latter is adjusted axially. Consequently, the contact resistance is maintained at a desired consistently low and relatively uniform value.

While applicant does not wish to be limited to particular structural parameters, the following more important dimensions (identified in Figs. 2*a* and 2*b*) and values are given by way of example for a particular embodiment of the invention:

Dimension A ____________________inches__	1/16
Dimension B ____________________do____	0.156
Dimension C ____________________do____	0.450
Deflection D ____________________do____	7/64
Dimension E ____________________do____	13/32
Dimension F ____________________do____	1
Width of fingers 42________________do____	0.05
Width of slots between fingers_____do____	0.025
Thickness of fingers 42____________do____	0.004
Length of tip portion 46___________do____	0.031
Angle J__________approximately, degrees__	15
Angle H____________approximately, do____	10

Required curvature established by a concentrated end load of 35 grams on each finger 42.

Finger material—beryllium copper, heat treated to a modulus of elasticity of 18 million pounds per square inch, or higher.

Material of tip portions, silver.

Referring now to Figs. 4*a* to 4*d*, inclusive, there are illustrated various views showing portions of an electrical contact member constructed in accordance with a modified form of the invention and also the method of forming the contact member. Since this modified form of contact member is generally similar to the one described in connection with Figs. 1–3*b*, inclusive, corresponding elements are designated in Figs. 4*a*–4*d*, inclusive, by the same reference numerals primed. In Fig. 4*d* of the drawings, one contact finger 42′ of such an electrical contact member 40′ is shown in dash-dot lines in operative engagement with a portion of an adjustable conductive member 22′, and is also shown in full lines to illustrate its position prior to operative engagement.

The contact member 40′ may best be described by way of the method of forming the member. Referring now to Fig. 4*a*, there is illustrated in plan view a thin sheet of resilient conductive material which is serrated by well-known methods along a longitudinal edge to form a plurality of contact fingers 42', 42'. A palladium-copper alloy comprising about 90 per cent. palladium and 10 per cent. copper has been found to be a suitable material. Recurvate tip portions 46', 46' are formed on the contact fingers 42', 42' by first providing a beveled edge as by grinding and then by bending back the ends of the fingers so that the extreme tip portions thereof have a rounded end of small radius. This radius is preferably approximately equal to the thickness of the material forming the fingers.

In the next fabricating operation, the contact fingers 42', 42' are stressed along a transverse line 51 (Fig. 4*a*) near the base portions 52, 52 of the fingers and beyond the elastic limits of bending of the fingers in order that each thereof, when placed in operative engagement with the conductive member 22' in the manner shown in dash-dot lines in Fig. 4*d*, will apply to the conductive member 22' a force of preselected value. Reference is now made to Fig. 4*b* in connection with an explanation of this particular bending operation. When a flat, resilient, contact finger of a given material, width and thickness is rigidly supported at its base portion 52 and has a force less than a predetermined value applied normal to the flat surface of the finger near the free end thereof, the finger is deflected to an extent depending upon the magnitude of this force. Due to the resiliency of the finger material, the finger returns to its original position after the removal of the force. For example, when the contact finger 42' is supported near the line 51 in the manner mentioned above and has such a force P applied to its tip 46', the finger may assume the angular position shown by the broken lines in Fig. 4*b*, but returns to the full-line position when the force is released. However, there exists a greater force, which, when applied to the tip of a contact finger, is effective to deflect the finger to such an extent that deformation takes place and the finger no longer returns to its original position. The contact finger is then said to be stressed beyond the elastic limit of bending of the finger. For the purpose of this explanation, it will be assumed that such a force will bend the finger 42' with respect to its base portion 52 to the approximate 135-degree angular position represented by the dash-dot lines in Fig. 4*b*. This force may readily be calculated knowing such factors as the dimensions of the finger and the characteristics of the material thereof. It will also be clear that this force represents the maximum force or pressure which the contact finger may apply, as a result of its resiliency, to a conductive member arranged for sliding engagement with the tip portion thereof. Accordingly, the next operation in the construction of the contact member 40' is to bend the contact fingers 42', 42' beyond their elastic limit through a suitable angle such as that illustrated in Fig. 4*b*.

Fig. 4*c* is an elevational view showing in dash-dot lines a contact finger 42' angularly bent as mentioned above about the line 51 near its base portion 52. In the next operation, the contact finger 42' is so bent that, when the external bending force is removed therefrom, it assumes the curved configuration represented by the solid lines. This curved configuration corresponds to the bend which is assumed by an end-loaded cantilever beam as mentioned above in connection with the first embodiment of the invention. To procure this desired curvature, the finger is bent about a suitable form (not shown) into a curve somewhat greater than the desired curve since it must include a deflection equal to that corresponding to the desired curve plus an additional deflection which allows for the resiliency of the material. The tip portion is then given a small permanent angular bend. In the next operation the contact member 40' is formed into a cylinder.

The contact finger 42' is then mounted in the disc 21' in the manner illustrated in full lines in Fig. 4*d*. When the conductive member 22' rests against the contact finger 42' as shown in full lines, and is then thrust against the finger so that the contact member and finger assume the operative position represented in dash-dot lines, the finger is again stressed beyond the elastic limit of bending thereof. The contact finger 42' is then effective to apply to the conductive member 22' a force of predetermined substantially unvarying value. It will be manifest from the foregoing description, that the magnitude of this engaging force will be determined by the requirements for a given application. For example, the maximum force which can be developed by a motor which is to be used to reciprocate the member 22' may determine the magnitude of the aforesaid engaging force. After this force has been decided upon, the material to be used for the contact member and the dimensions and shape thereof may be established. Thereafter the fabrication and the adjustment of the contact member 40', as described above, may be performed by relatively unskilled personnel with the certainty that each contact finger 42', when brought into operative relation with the conductive member 22', will provide the exact predetermined pressure engagement therewith and yet will not be subject to undesirable chatter. Furthermore, the portion 46' of each finger presents a curved end of small radius for sliding engagement with the conductive member 22'. This not only assures a high unit pressure, but also tends to minimize wear. Additionally, the radius of the curved portion has a uniformity controlled by the sheet thickness and the curved portion is sufficiently small that the tip portion 46' affords a self-cleaning action with respect to dust or other material which may undesirably accumulate on the contact member 22'. It is unnecessary to perform the customary silver plating operation on a contact member of the type just described when the member is formed of palladium copper. This is because of the excellent electrical conductivity afforded by this material.

From the foregoing description of the invention, it will be apparent that an electrical contact member in accordance with the present invention is adapted slidably to engage an electrically conductive member having relative movement with respect thereto while being relatively free from undesired chatter which ordinarily results from such movement. At the same time it has been found in practice that the electrical contact member of the present invention is adapted to engage the conductive member with a relatively high unit pressure without subjecting the engaging members to excessive wear. Furthermore, an electrical contact member in accordance with the invention is adapted slidably to engage an electrically conductive member with a predetermined optimum contact pressure easily and readily controlled during fabrication of the member. In addition to the above-mentioned advantages, an electrical contact member in accordance with the instant invention is relatively simple in construction and inexpensive to manufacture.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length comprising: a strip of flat, thin, conductive material including a body portion having a plurality of contact fingers extending from one edge thereof, each of said contact fingers when viewed in elevation having a preset unstressed longitudinal portion substantially corresponding in curvature to that of an end-loaded cantilever beam and having a tip portion extending from said longitudinal portion and effectively defining therewith an angle of approximately 165 degrees; whereby said longitudinal portion of said each finger assumes and maintains a substantially rectilinear elevational configuration upon adequately flexed engagement of said contact fingers at the end of the tip portion thereof with said conductive member, and said body portion and said each contact finger are thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said contact fingers and said conductive member.

2. An electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: an elongated member of resilient conductive material having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam; whereby said portion of said elongated member assumes and maintains a substantially rectilinear elevational configuration upon adequately flexed engagement of said elongated member with said conductive member, and said elongated member is thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said members.

3. An electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: an elongated member of flat, thin, resilient conductive material having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam; whereby said portion of said elongated member assumes and maintains a substantially rectilinear elevational configuration upon adequately flexed engagement of said elongated member with said conductive member, and said elongated member is thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said members.

4. An electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: an elongated member of resilient conductive material having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam and having a tip portion of small transverse cross-sectional area extending from said longitudinal portion and effectively defining therewith a salient angle; whereby said longitudinal portion of said elongated member assumes and maintains a substantially rectilinear elevational configuration upon adequately flexed engagement of said elongated member with said conductive member at said area of said tip portion, and said elongated member is thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said members.

5. An electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: an elongated member of resilient conductive material having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam and having a rounded tip portion of small radius extending from said elongated portion, said tip portion effectively defining with said longitudinal portion a salient angle; whereby said longitudinal portion of said elongated member assumes and maintains a substantially rectilinear elevational configuration upon adequately flexed engagement of said elongated member at said rounded tip portion with said conductive member, and said elongated member is thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said members.

6. An electrical contact member, for slidably engaging an electrical conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: an elongated member of flat, thin, resilient conductive material having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam and having a recurvate tip portion with a radius approximately equal to the thickness of said elongated member, said tip portion effectively defining with said longitudinal portion a salient angle; whereby said longitudinal portion of said elongated member assumes and maintains a substantially rectilinear elevational configuration upon adequately flexed engagement of said elongated member with said conductive member at the curve of said tip portion, and said elongated member is thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said members.

7. An electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency

conductive circuit of critically adjustable electrical length, comprising: a strip of flat, thin, resilient conductive material including a body portion having a plurality of contact fingers extending from one edge thereof, each of said contact fingers having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam and having a tip portion extending from said elongated portion and effectively defining therewith a salient angle; whereby said longitudinal portion of said each contact finger assumes and maintains a substantially rectilinear elevational configuration upon adequately flexed engagement of said each contact finger at said tip portion thereof with said conductive member, and said body portion and said contact fingers are thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said contact fingers and said conductive member.

8. An electrical contact member, for slidably engaging an approximately cylindrical electrically conductive and axially movable member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: a strip of resilient conductive material including an approximately cylindrical body portion having a plurality of contact fingers extending from one edge thereof, each of said contact fingers having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam; whereby said longitudinal portion of said each contact finger assumes and maintains a substantially rectilinear elevational configuration approximately parallel to the axis of said conductive member upon adequately flexed engagement of said each contact finger with said conductive member, and said body portion and said contact fingers are thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said contact fingers and said conductive member.

9. An electrical contact member, for slidably engaging the outer peripheral surface of an approximately cylindrical and axially movable electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: a strip of resilient conductive material including an approximately cylindrical body portion having a plurality of contact fingers extending from one edge thereof inwardly toward the axis of said body portion having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam; whereby said longitudinal portion of said each contact finger assumes and maintains a substantially rectilinear elevational configuration approximately parallel to said peripheral surface of said conductive member upon adequately flexed engagement of said each contact finger with said peripheral surface of said conductive member, and said body portion and said contact fingers are thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said contact fingers and said conductive member.

10. An electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: a strip of resilient conductive material including a body portion having an elongated member extending from one edge thereof, said member having a base portion and having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam and defining with said base portion a predetermined angle; whereby said elongated member upon adequately flexed engagement with said conductive member is stressed at the angular region thereof beyond the elastic limit of bending of said elongated member and said longitudinal portion thereof assumes and maintains a substantially rectilinear elevational configuration and is effective to apply to said conductive member a force of predetermined value, and said body portion and said elongated member are thereby effective with said conductive member to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said members.

11. An electrical contact member, for slidably engaging an electrically conductive member to form therewith a portion of a high-frequency conductive circuit of critically adjustable electrical length, comprising: a strip of resilient conductive material including a body portion having a plurality of contact fingers extending from one edge thereof, each of said contact fingers having a base portion and having a longitudinal portion of preset unstressed configuration in elevation substantially corresponding to that of an end-loaded cantilever beam and defining with said base portion an angle of predetermined minimum value; whereby each of said contact fingers upon adequately flexed engagement with said conductive member is stressed at the angular region thereof beyond the elastic limit of bending of said contact fingers and said longitudinal portion thereof assumes and maintains a substantially rectilinear configuration and is effective to apply to said conductive member a force of predetermined value corresponding to that just required to exceed said elastic limit of bending, and said body portion and said contact finger are thereby effective with said contact finger to establish and to maintain in a definite and consistent manner said critically adjustable electrical length of said conductive circuit in each relative position of said contact fingers and said conductive member.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,034,870	Judson	Mar. 14, 1936
2,273,069	Rossman	Feb. 17, 1942
2,407,147	Fedotoff	Sept. 3, 1946