

[54] **ELECTRICAL CONTACT AND
RECEPTACLE**

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[21] Appl. No.: **158,072**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 577,466, Sept. 6,
1966, abandoned.

[52] U.S. Cl. **339/59 M**, 339/164 M, 339/258 P,
339/277 R

[51] Int. Cl. **H01r 13/48**

[58] Field of Search 339/59-61, 95, 157,
164, 257-259, 277

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[57]

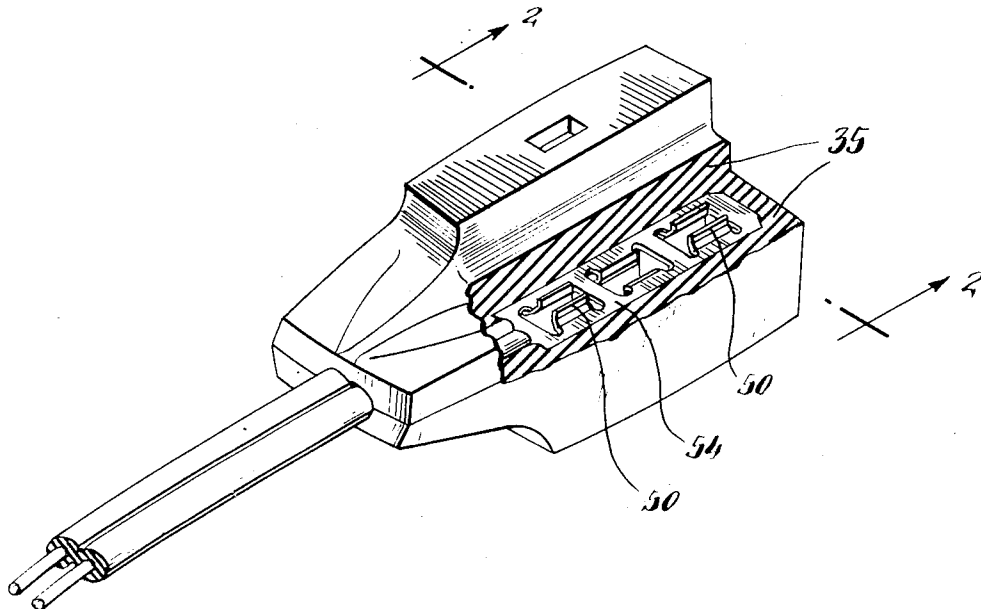
ABSTRACT

An electrical contact is provided capable of numerous make and break electrical connections, which contact has a relatively shallow depth and is adapted to receive an elongated power blade or electrical contact to be gripped.

The shallow dimension of the contact is generally normal to the longitudinal axis of the prong to receive power.

The contact is preferably formed from a sheet of metal by displacing metal out of the plane of said sheet to serve as contact cams to frictionally engage the power prong. The cam makes contact with the prong end preferably after the prong end has passed through the plane of the sheet from which the contact was formed.

7 Claims, 36 Drawing Figures



Patented Sept. 25, 1973

3,761,864

7 Sheets-Sheet 1

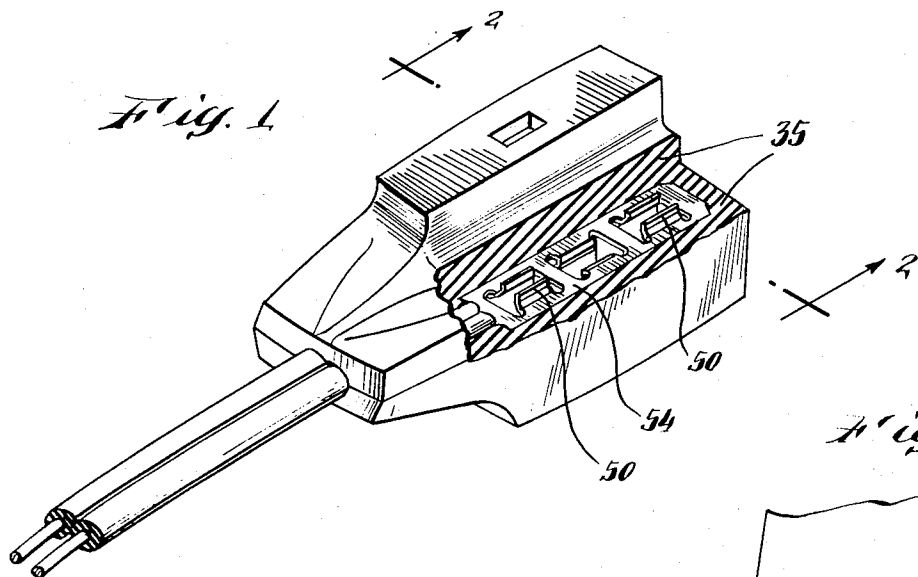


Fig. 2

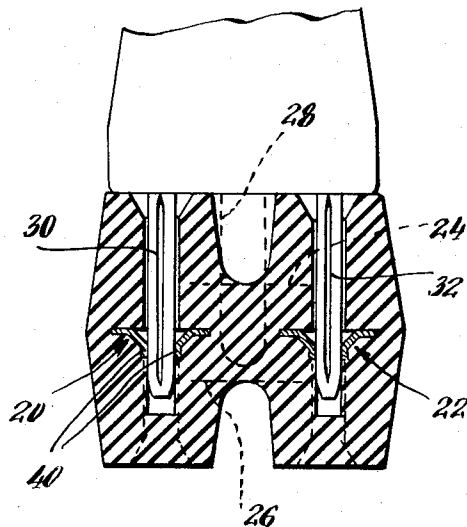


Fig. 3

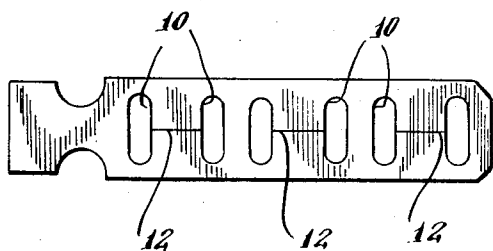


Fig. 4

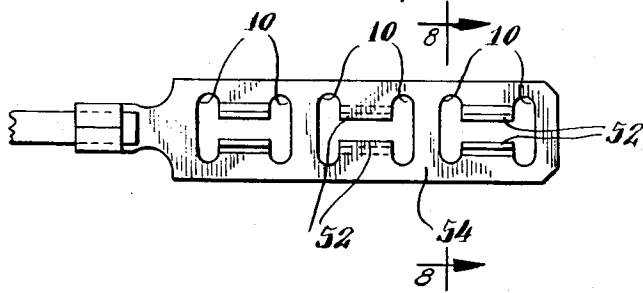


Fig. 5

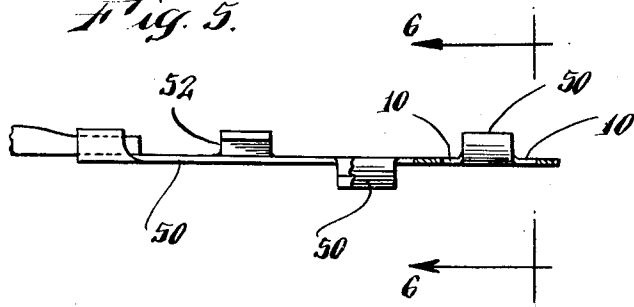
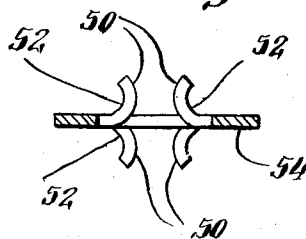


Fig. 6



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Fig. 8.

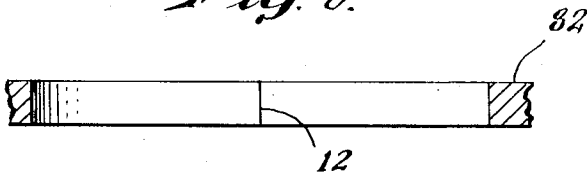


Fig. 9.

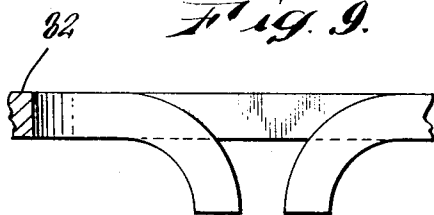


Fig. 10.

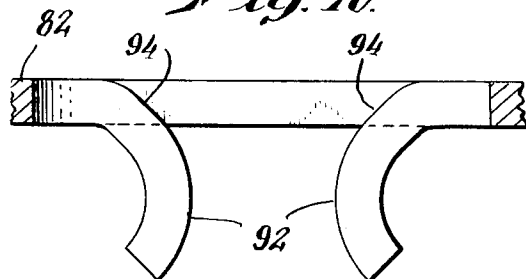
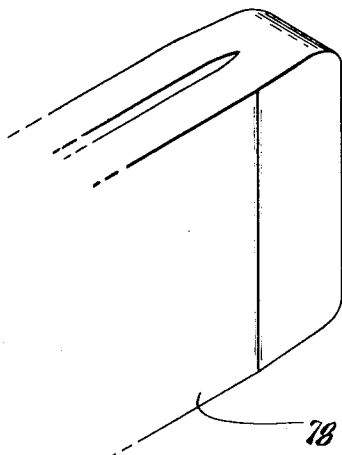
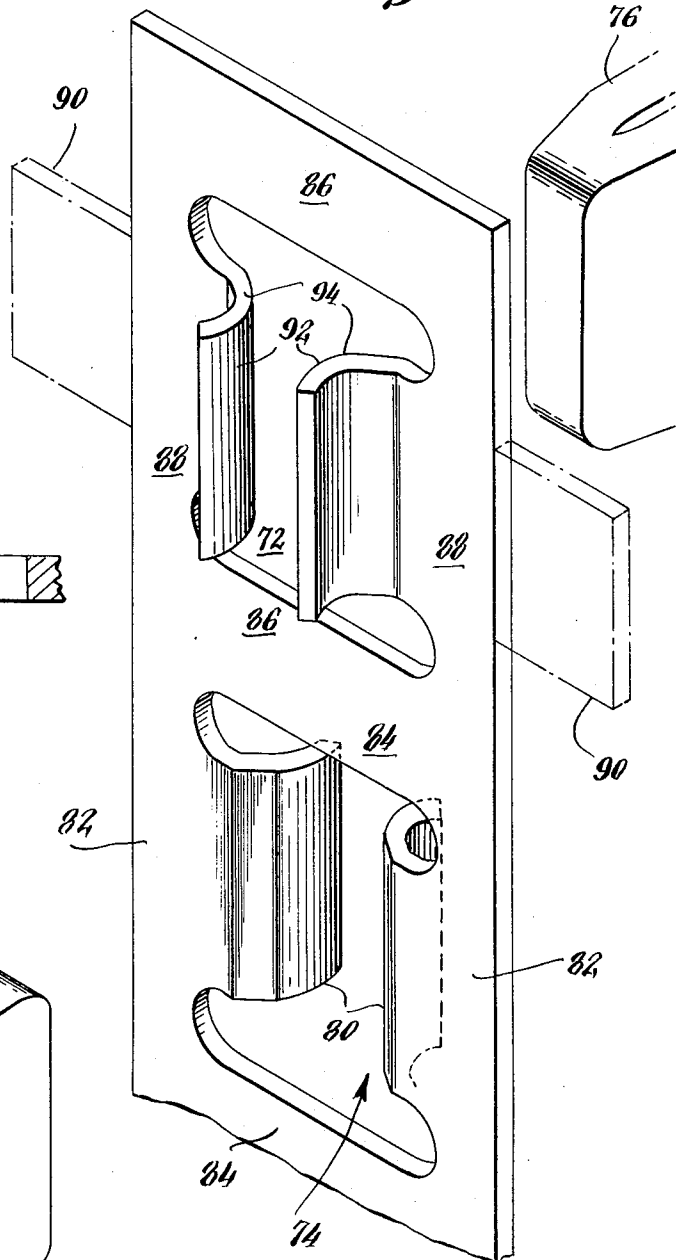


Fig. 7.



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Fig. 11.

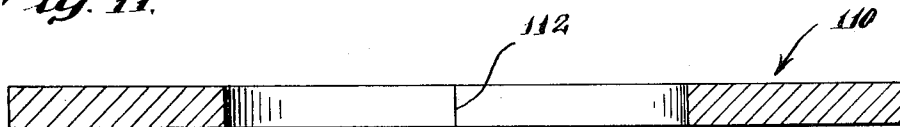


Fig. 12.

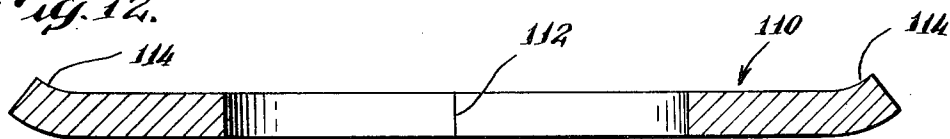


Fig. 13.

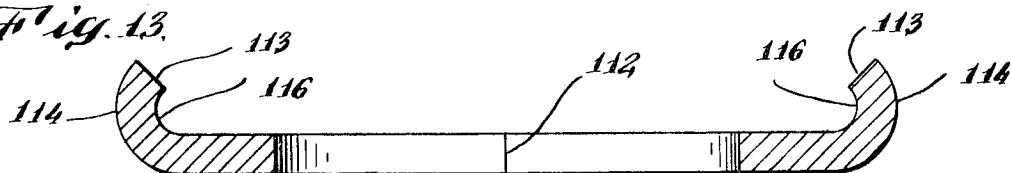


Fig. 14.

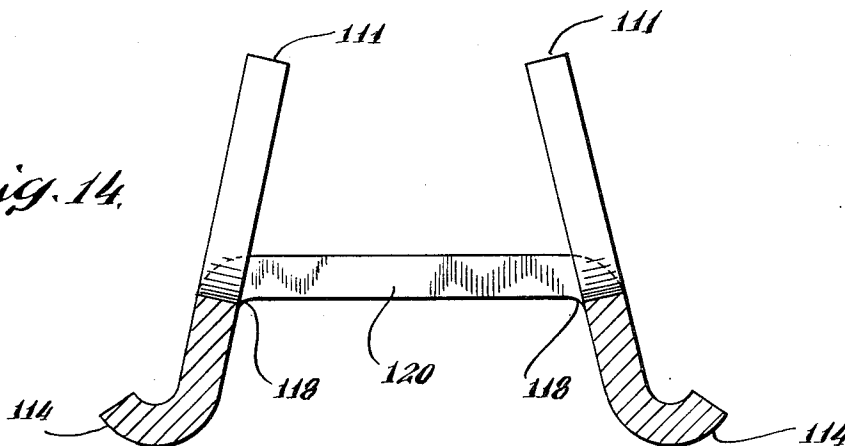
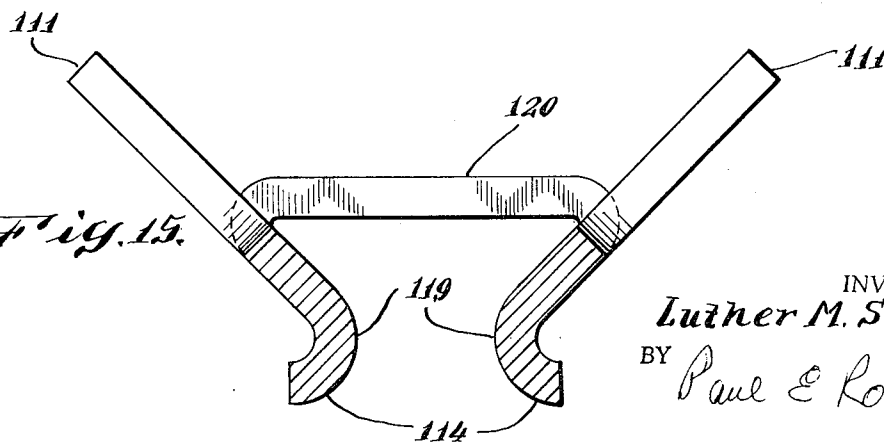
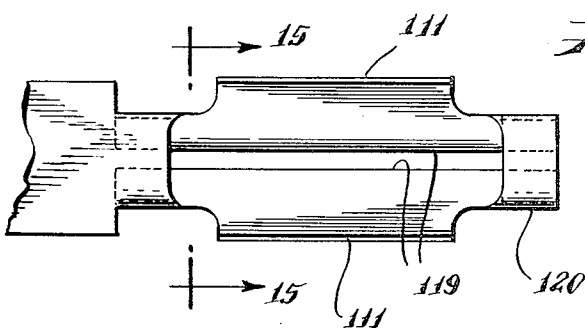
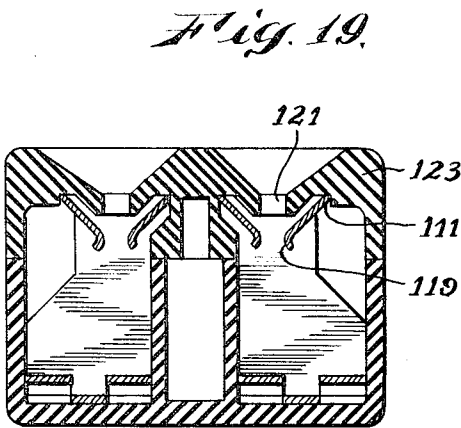
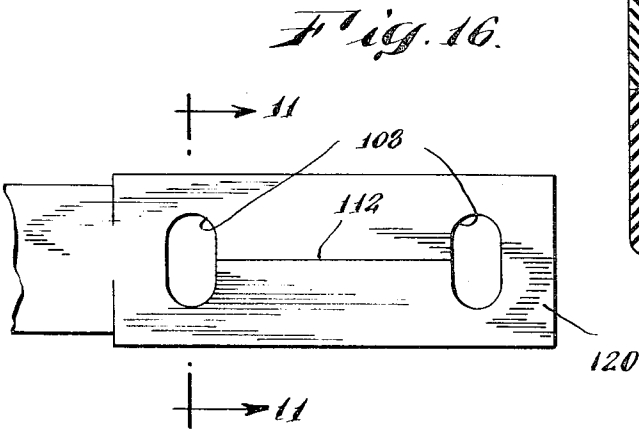
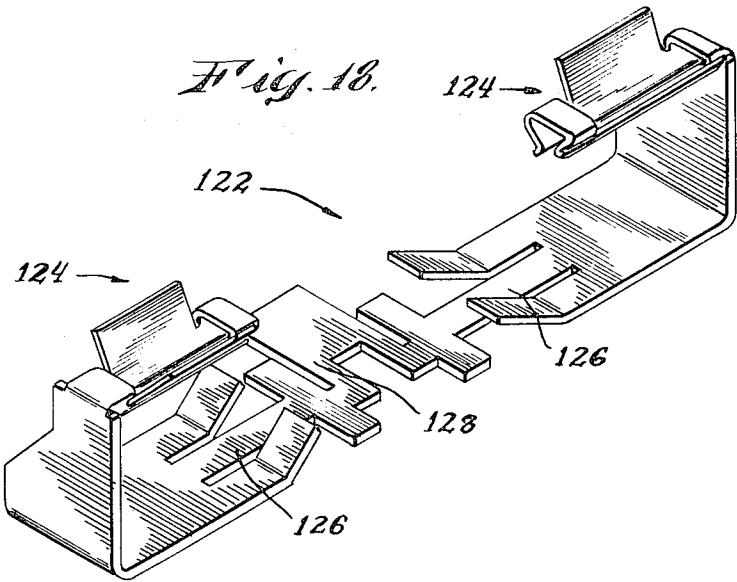


Fig. 15.



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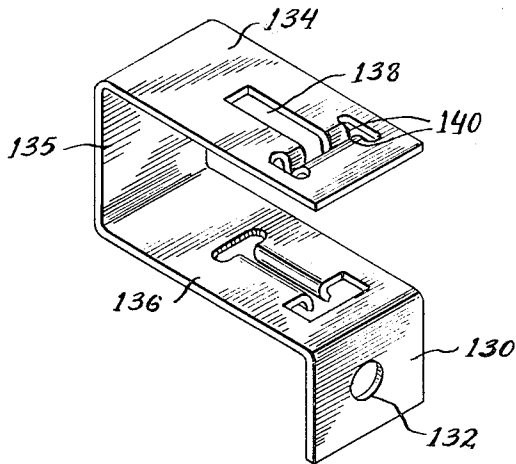


Fig. 20.

Fig. 21.

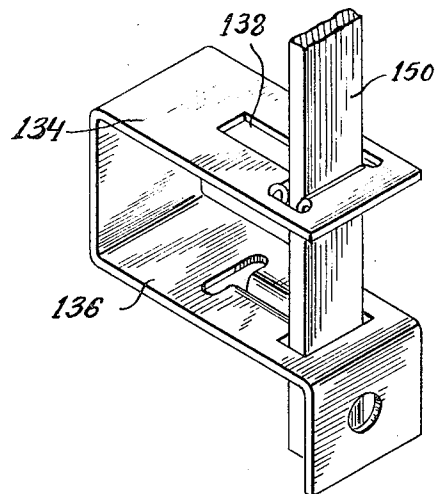
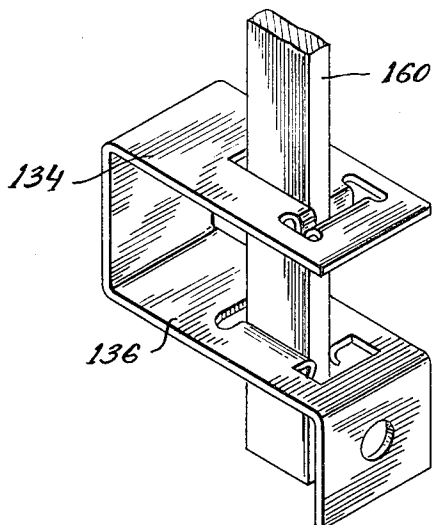
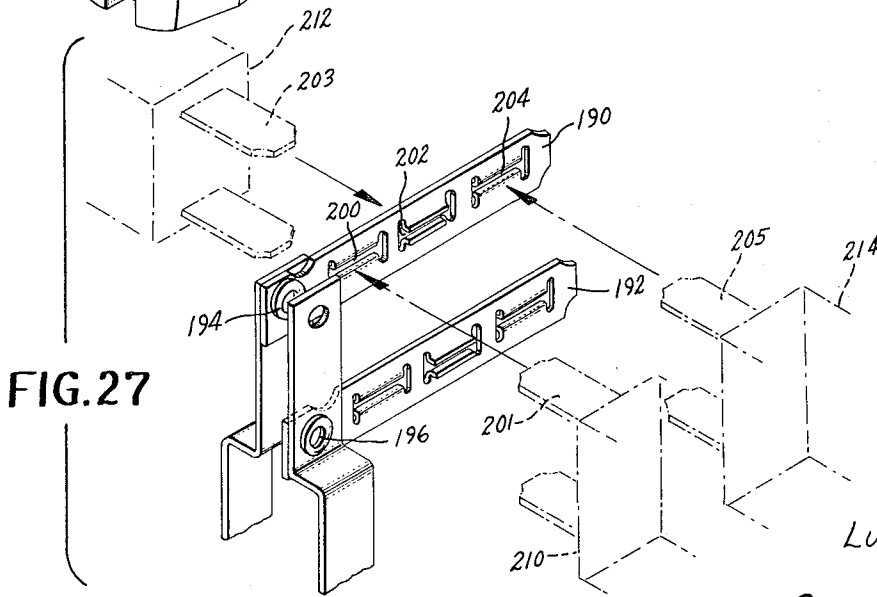
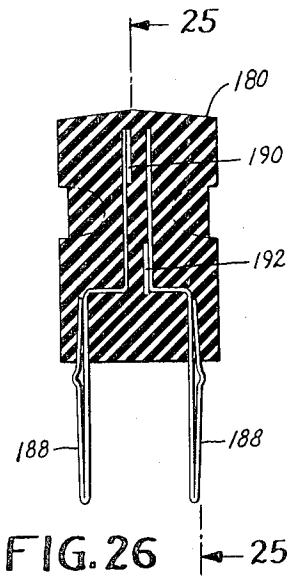
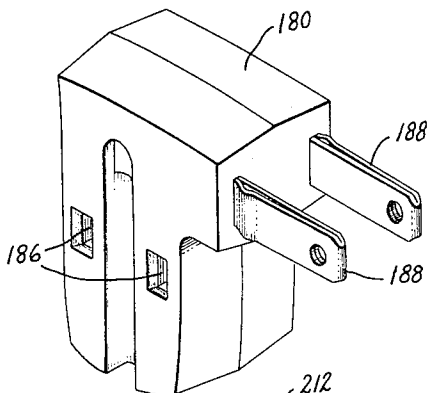
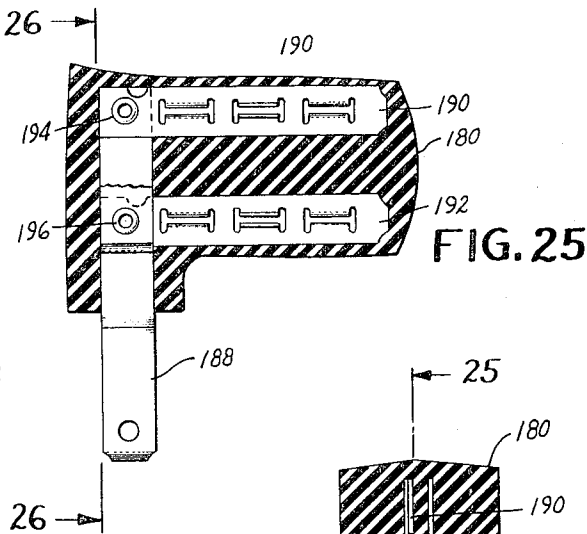
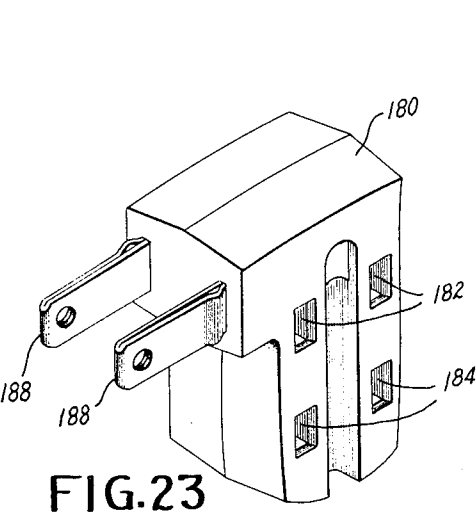


Fig. 22.



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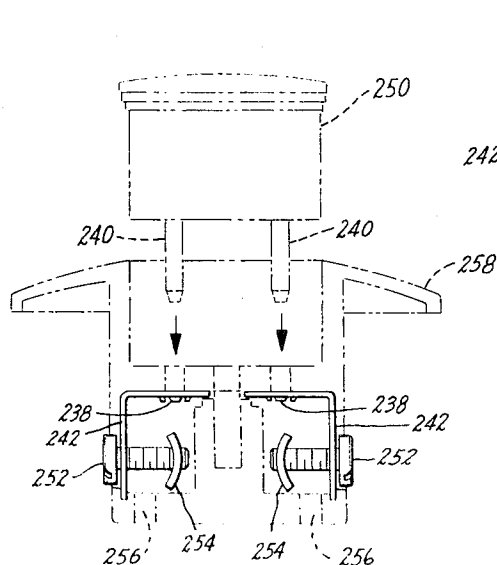


FIG. 30

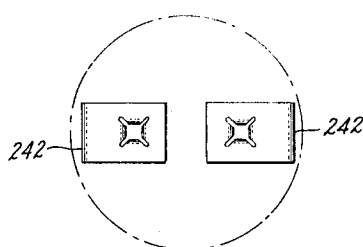


FIG. 29

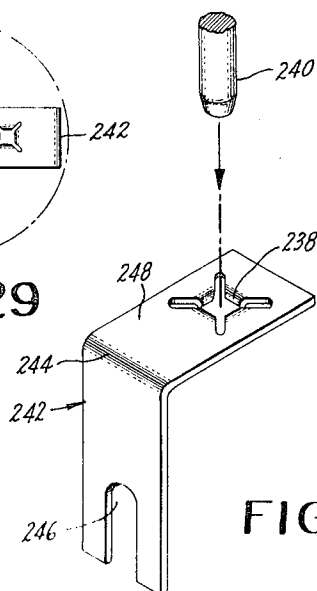


FIG. 28

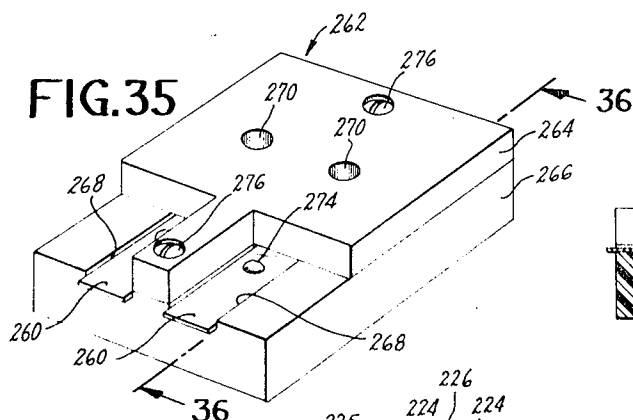


FIG. 35

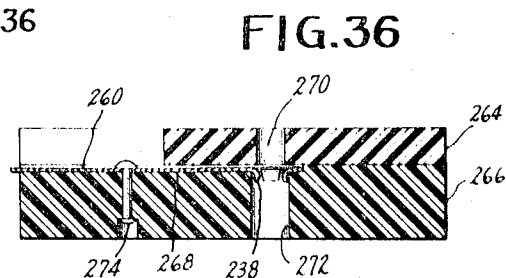


FIG. 36

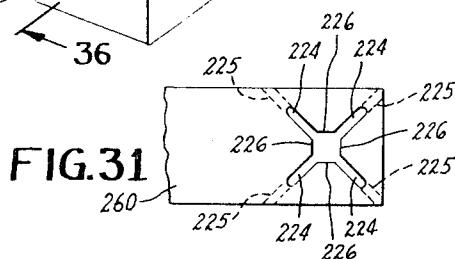


FIG. 31

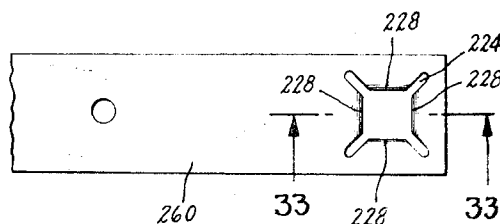


FIG. 32

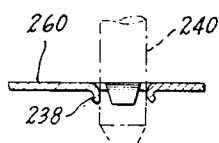


FIG. 33

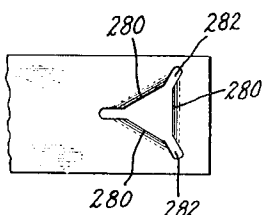


FIG. 34

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ELECTRICAL CONTACT AND RECEPTACLE

The present application is a continuation-in-part of application Ser. No. 577,466 filed Sept. 6, 1966, and now abandoned, and assigned to the same assignee as this application.

This invention relates to contact elements for electric wiring devices and particularly to contact elements capable of requiring a higher force for withdrawal of a power receiving cap than for insertion of the cap.

The current carrying portions of wiring devices are conventionally housed or partially housed within insulating materials. Additionally, when the devices are adapted for mounting within wall receptacles they may be provided with support or mounting members of metal and these members may provide the additional feature of a grounding element.

The insulating material conventionally must provide insulating separation of current carrying elements. In wall mounted devices the insulating material conventionally receives structural support mainly from the metal elements of the housing. Conventionally also the plastic insulating material furnishes structural support mainly to the current carrying elements.

A feature which is highly desirable in a convenience outlet to be mounted in a wall receptacle is a general thinness or small depth of the body of plastic housing containing the metal and insulator parts of the outlet inasmuch as the connections which supply power to the outlet are normally made to the ends of relatively heavy gauge wire which can be extended out of a wall box by a sufficient length to permit the connections to be made with the outlet structure of the wall. An appreciable open volume in the wall box to receive the outlet is an advantage in the wiring of the outlet as it accommodates multiple folded lengths of heavy gauge wire which are pressed into the rear of the box when the outlet is installed in place in the wall box.

When the wiring devices are of the portable variety as, for example, extension cords, cube taps, and the like, the yieldable insulating material may perform the function of mechanical support for the current carrying elements as well as providing the mechanical load-bearing capability of the device itself.

It is deemed desirable to provide grounding contacts on portable wiring devices but to date difficulty has been experienced in providing portable grounded devices of the multiple tap variety, i.e., a grounded connector which can receive a plurality of grounded caps.

Further, even for the case of the connector of the more conventional extension cord, certain performance characteristics are desirable in such connectors but have not been available because of the excessive cost or technical difficulty of achieving these characteristics with adequate reliability and safety.

Specifically, the reliability of electrical contact is improved by a double wipe of the current supplying electrical contact on the power prong or blade to receive the current, i.e., a pressure contact on both sides of the blade.

Where the power receiving element is a prong of round cross-section or regular geometric cross-section such as a square or octagon, or an article referred to herein generally as a blade to indicate a flattened cross-section as one of rectangular cross-section or the like, it is preferred to establish contact on opposite surfaces of the prong to apply a compressive force through the

cross-section configuration generally whether the prong is solid or hollow in cross-section.

Also, increased pressure of contact is desirable both to improve transfer of current and to provide better mechanical holding of the power prongs in the connector.

Further, it is desirable that the connector be capable of developing higher holding force against withdrawal of a power prong as compared to the force needed to insert it into the connector. Moreover, the action of the connector contact is desirably one which provides an essentially reproducible holding action on the power prong, i.e., it should not be subject to being "sprung" or "set" by repeated insertion and withdrawal of the power prong or blade in the sense of applying substantially lower contact pressure over an extended period of usage.

Accordingly, one object of the present invention is to provide a contact for an electrical receptacle or connector which is simple in construction and yet has many of the performance characteristics of contacts of more complex construction.

Another object is to provide a contact in which the development of contact pressure is accompanied by generation of releasable tensile forces in the contact.

An additional object is to provide a connector which can require a higher holding force against withdrawal of a power receiving cap as compared to the force required for insertion of the cap. For the purposes of this application a cap may be considered as a device which provides the terminus of a power cable or cord and which includes insulatedly separated means for connection of a plurality of conductors of the cable or cord to a plurality of spaced power receiving prongs adapted to receive power at different voltage levels.

Another object is to provide a convenience outlet of generally thinner cross section.

A further object of the present invention is to provide an electrical contact having a high pressure to mass ratio, i.e., one capable of exerting a high contact pressure against a power prong or blade relative to the mass of material in the portion of the contact within which the contact pressure is exerted.

Still another object of the invention is to provide an electrical connector incorporating the novel electrical contact.

Additional objects and advantages of the present invention will be in part apparent and in part pointed out in the description which follows.

In one of its broader aspects the objects of the present invention are achieved by providing a cammed electrical contact having at least one metal cam adapted to exert spring pressure on an elongated element to receive power, said cam presenting a formed face at the free end thereof for contact with said element to develop frictional engagement therewith,

said cam being supported at the fixed end thereof from a metal land disposed to at least partially surround said elongated element as it approaches contact with the free end of said cam,

said free end being adapted to follow said elongated article as it is withdrawn from a gripped electrical contact and to undergo rotary like motion about the fixed end thereof serving as an axis of rotation to increase the frictional gripping pressure of said free end on said elongated element, and

said cam being capable of deflection to limit the increase of frictional gripping force to a value at which said elongated element may be withdrawn.

In another of its broader aspects the objects of the present invention are achieved by providing a land of metal to surround at least three sides of an opening adapted to receive a power blade of rectangular cross section, said land including component portions which comprise an electrical contact structure having a generalized C form and having spring properties, the opposed prongs of the C form being provided with gripping surfaces disposed to grip the blade under spring pressure, said gripping surfaces being adapted to undergo a limited follower motion generally parallel to the motion of a gripped surface responsive to a tractive force received from said gripped surface, and said C form being cammed to increase the gripping pressure on an inserted blade responsive to a follower motion of said gripping surfaces toward the fixed end of a blade.

In one of its narrower aspects the objects of the present invention are accomplished by providing a land of metal capable of receiving relatively high tensile forces within a relatively small thickness thereof, providing within this land an opening adapted to receive a generally rectangular power blade, said opening being defined at least in part by generally parallel confronting metal surfaces formed from the metal of the land and positioned to bear against the broader surfaces of said blade, and being defined in an additional part by curved surfaces disposed to be proximate and spaced from the narrower surfaces of said blade and disposed to distribute tensile forces developed in the metal of said land as the spacial separation of the generally parallel metal surfaces is increased.

In another of its narrower aspects the objects of the invention are achieved by providing a connector which comprises an insulating housing, a generally planar metal member supported at its outer portions, within said insulating housing, an opening in the metal member and a port in the insulating housing communicating with said opening, said port and opening being adapted to receive an elongated power prong of longitudinally regular cross section, said opening being formed at least in part by displacing metal of said generally planar member out of the plane thereof to provide two essentially parallel confronting surfaces adapted to apply compressive force against the surfaces of said prong, and the non parallel portion of said opening being defined at least in part by curved surfaces disposed to distribute tensile forces in the generally planar member.

In still another of its narrower aspects the objects of the invention are achieved by providing a connector which comprises an insulating housing, a generally planar metal member supported at its outer portions, within said insulating housing, an opening in the metal member and a port in the insulating housing communicating with said opening, said port and opening being adapted to receive an elongated power blade of generally rectangular cross section, said opening being formed at least in part by displacing metal of said generally planar member out of the plane thereof to provide two essentially parallel confronting surfaces adapted to apply compressive force against the broader surfaces of one section of said blade, and the portion of said opening adapted to receive the narrower surfaces of said blade being defined at least in part by curved surfaces disposed to distribute tensile forces in

the generally planar member, and said insulating housing bearing against outer portions of the generally planar member to limit deflection of portions of said member out of its generally planar configuration.

In the description which follows it will be evident that the contact structure of the present invention may be provided in numerous alternative forms and an illustrative group of such forms is specifically described in the material that follows. However, in order to understand the relationships between the different forms which are taught pursuant to this invention an explanation is given here first of a number of factors, the presence of which in several combinations taught is of controlling importance in the operation of contacts pursuant to the present invention.

I. The first factor is the form and character of the surfaces which bear against the blade surface and principally which permit the blade surface to be frictionally gripped. At least one of the surfaces must provide the electrical contact to deliver electric power to the blade. Also at least one surface must provide a gripping action on the blade sufficient to receive tractive force from the blade as a result of a pulling force in the blade, i.e., one tending to withdraw the blade.

The term traction as it is used herein will be understood to mean the adhesive friction of a body on a surface against which it bears and on which it moves. The traction of principal concern in carrying out this invention is the adhesive friction of the power blade on the gripping surface against which it bears and on which it moves.

As will be more evident from the description which follows, it is the motion of the power blade itself which gives rise to the increased gripping force even though it is this increased gripping force which tends to restrain withdrawal of the blade. However, the invention resides in providing a structure which is capable of increasing the level of restraint by converting a part of the force applied to withdraw the blade into a force which resists its withdrawal but does not prevent the withdrawal. Preferably the force to withdraw the blades of a conventional bladed cap is increased to a range of between 5 and 12 pounds of pull to release both power blades. Accordingly the invention provides a need for use of increased force in withdrawing it. It does not reside in preventing or prohibiting the withdrawal of the blade in the sense of locking the blade in place.

Accordingly, the gripping surface must be capable of developing increased traction with increased pressure but must nevertheless allow the blade to be withdrawn by a higher pulling force sufficient to overcome the higher friction resulting from the higher pressure. As used in the application the term tractive force indicates the force delivered to the gripping surface from the blade due to a withdrawal force applied to the blade. As the pressure of the gripping surface on the blade is increased, the tractive force received by the gripping surface can be increased due to the higher traction between the surfaces at the higher pressure.

The term friction is used to indicate the force needed to overcome the resistance to slippage, or in other words the resistance to movement of the blade surface relative to the gripping surface generally parallel to the plane of their contact.

What is required pursuant to this invention is a friction grip in the sense that increased pressure of the gripping surface on that blade results in increased fric-

tion but does not result in significant indentation or deformation of the blade.

Where the gripping surface is at the end of a metal cam, the gripping surface must not have a form which will lock the power blade in place in the manner for example in which the locking tongue of the cams of U.S. Pat. No. 2,705,785 lock a wire in place. Rather the gripping surface of a cam must be one which will yield to a higher withdrawal force to allow movement of the power blade in frictional contact with the gripping surface of the cam, even though the frictional contact is at the higher friction level induced by the higher pressing force generated between the gripping surface of the cam and blade by a cam action explained more fully below. It is for this reason, i.e., to distinguish from a locking action that the surface and cam are referred to herein as a gripping surface or gripping cam rather than as a locking surface or locking cam.

In a preferred form of the present invention a gripping surface is formed at or near the end of a gripping cam by so forming the end of the cam as to permit withdrawal of the blade under the higher pressure induced by the cam action. The forming of the cam end may be the result of the bending or folding of the cam end on which the gripping surface is formed. When the cam is formed from a metal strip as by stamping the gripping surface may be the result of a secondary forming action on the end section of metal as by peening or coining or the like to round it and eliminate the sharp edge normally produced by shearing of the strip to establish cam edges. It may be formed by extending the cam edges as by a cupping-like extension of the cam surfaces before the shear of the affected section of the strip occurs and the folding back or bending of the extended cams at the end of the cupping-like stroke.

In another preferred embodiment of the invention described more fully below the sheared surface may be bent out of the expected path of the power blade and the portion of the cam proximate but not immediately at the cam end may be used as the gripping surface. When this is done it is preferred to bend the sheared edge through more than 90° in order to preclude its presenting its sharp edge to the blade or to any irregularity of the blade as the blade is withdrawn as this can result in a locking type of cam action.

It is important to understand that the contacting and gripping actions provided in accordance with the present invention are suitable for use a large number of times and over a long period of time without significant change to the surface of a conventional smooth surfaced power blade contacted and gripped.

II. A second factor is the presence of a minimum electrical contact pressure. This factor is essential because when the blade is first inserted there must be sufficient force tending to press the blade against the electrical contact to ensure that electrical contact will be established and maintained. Further although changes in gripping strength may be induced pursuant to this invention these changes, whether increases or reductions in gripping strength, must not interfere with or interrupt adequate electrical contact pressure on which supply of electric power to the power blade depends.

A preferred mode for producing and ensuring a continuation of a minimum contact pressure is through use of spring pressure between the contact surface supplying electric power and the blade.

Further the initial friction of the gripping surface on the blade surface is preferably provided by a spring pressure sufficient to cause the gripping surface to be so frictionally engaged as to serve as a follower to the blade surface serving as a driver and to receive tractive force from the blade surface and to follow motion of the blade generally parallel to its longitudinal axis.

III. A third factor is that of the relative freedom of the gripping surface in contact with the surface of the power blade to move generally parallel to the direction of movement of the power blade as the power blade is pulled so as to withdraw it. This gripping surface should generally be sufficiently free to undergo this movement so that the frictional contact of the cam against the blade surface due to the available spring or other residual pressure between the contacting cam surface and the blade surface will be sufficient to provide a minimum tractive force and to initiate this movement. Based on the movement of the gripping surface responsive to this tractive force the gripping pressure may be increased to a pressure level above that due to the spring alone.

IV. The fourth factor is the capability of the body supporting the gripping surface to generate an increased gripping force as a result of the follower motion imparted to the gripping surface. Essentially this is a capacity of the member supporting the gripping surface to translate a tractive force transmitted from the blade to the supporting member into increased pressure of the gripping surface on the blade surface.

In the description which follows this will be described in terms of a cam action. While the third factor is essentially symmetrical in its action the cam action is principally asymmetric in that it amounts to an increase of force received from or taken from blade during blade withdrawal relative to that taken during insertion.

The cam action of the present invention, stated in a somewhat oversimplified fashion, involves a cam being turned through an essentially rotary movement as a result of an essentially linear movement of the contacting surface of the contacting cam end for a distance and in a direction generally parallel to the surface of the blade being withdrawn. Pursuant to this somewhat oversimplified view both the power blade and the cam are viewed as each having a fixed end and a free end. The fixed end of the cam is more remote from the plane of the contacted blade surface than the free end of the cam. Further, the fixed cam end is disposed on the side of an imaginary plane normal to the longitudinal axis of the power blade and intersecting the point where the blade surface is contacted by the fixed cam end which is closest to the fixed end of the power blade.

Accordingly a line extending from the free end of the cam to the fixed end of the cam will describe an acute angle with reference to both of two planes which intersect at 90°. The first is the plane of the blade surface contacted and the second is the plane normal to the longitudinal axis of the blade and passing through the blade surface at the point of contact of the free end of the cam with the blade surface. If the cam and blade start in this spacial relation, the contacting surface of the free end of the cam essentially "follows" the contacted portion of the surface of the power blade. This generally linear following movement of the free cam end results in a tendency toward an at least partial rotary movement of the cam about its fixed end, i.e., a tendency to increase the acute angle between the line

Joining the free and fixed ends of the cam and the plane of the blade surface.

If we depart from the oversimplified view it will be evident that the values of parameters on which the cam action described above depends may be changed. For example, the cam may itself undergo a deflection particularly when it is formed of a strip or part of a strip of spring metal and as a result one of more of several parameters may simultaneously or sequentially change as follows:

A. The point of contact of the free cam end with the blade surface can be changed;

B. The length of line between the contacting surface at the free end and the fixed end may be shortened; and

C. The location of the fixed end as indicated by the point about which the cam tends to be rotated, may be moved.

However, if the described essential relationships are present, namely the initial spring pressure of the cam against the blade surface, freedom of the free cam end to follow the blade, based on friction generated by the spring pressure, and the enlargement of the acute angle described by the blade surface and the line joining the fixed end of the cam with the point of contact of the cam with the blade surface, it will also be evident that the cam action to increase pressure of the free end of the cam against the blade surface in accordance with the present invention will occur.

V. The fifth factor in the operation of the increased pressure contact of the present invention is the control and limitation of the rate of increase of the increased gripping force. This factor includes control of the angle at which the cams are disposed to the blade surfaces which they contact under conventional spring pressure, and the provision of any boss or stop to limit the extent of movement of the cam. This may be explained more clearly by reference first to conventional fingered contact operation.

For the conventional spring pressure contact of a conventional fingered contact, the general longitudinal axis of the spring loaded fingers are disposed generally parallel to the longitudinal axis of the blade. When this is the case, essentially all pressure between the blade and the contacts will be the result of the spring force applied through the spring action which is generated when the contact fingers are separated by the wedging force of the entering power blade.

The difference between the conventional generation of contact pressure and that generated pursuant to the present invention is evident from the observation that in the use of the conventional fingered contact the greatest force is normally needed to separate the fingers against a combined spring force in the fingers being separated, and a frictional force at the finger surfaces. Both forces are applied to resist the spreading of the fingers by the tip of the entering blade, and normally constitute the highest force used in using the contact. The frictional force between parallel surfaces of a fully inserted blade and the contacted surfaces of the fingers, as withdrawal of the blade is started, is usually not increased because the frictional force depends on the level of spring force applied through the fingers and this does not increase as parallel smooth surfaces of a power blade are withdrawn. An increase in the spring force of the fingers as withdrawal occurs cannot normally generate a wider separation of the fingers on

which an increase of spring pressure must normally depend.

By contrast and pursuant to the present invention contact or gripping pressure may be increased within a wide range of increments by establishing spring pressure on the blade as an initial force which resists withdrawal of the blade, and by using the outward movement of the blade to impart motion to the contact, and further by employing this motion of the contact to increase the pressure acting on the blade surface to a level above that applied by the initial spring pressure alone.

The amount of increase of the contact pressure is subject to control within a wide range by adjustment of the angle at which the cams are disposed to the blade when the withdrawal of the blade initiates a rotation or deflection of the cams such as is responsible for increasing contact pressure on the blade. For example if the cams are set at an angle slightly less than 90° with respect to the blade surface and are free to turn as indicated in 1 above, then as the power blade is withdrawn an enormous increase in pressure between the blade and the cam will occur because of the very high mechanical advantage at work as the cam is rotated through the small angle which multiplies and magnifies its pressing power. This enormous increase can be offset in part by employing cams which themselves are subject to spring deflection as this can allow the cams to deflect and thus limit the actual pressure applied to the blade that inherent in the spring qualities of the cam.

Except for a limiting mechanism to limit the actual pressure applied to the cams as described above, if more than half of an increased pulling force is converted to increased gripping force the net effect of increasing the pull can be to so magnify the gripping force as to tend to lock the blade in the grip of the device. However, pursuant to one embodiment of this invention the locking result is avoided by limiting the level of increase of pull to between 50 and 300 percent of an initial level and by limiting the initial level to 7 pounds and the upper level to 12 pounds.

VI. The sixth and last factor is the provision of a means to contain the increased compressive forces generated in the blade due to the increased gripping pressure generated by the cam action of the contact of the present invention. This is preferably accomplished in the internally cammed contacts described below by providing a land of metal, and by disposing the cams relative to the land so that they generate compressive forces in the metal of the land where the cams are affixed and opposed tensile forces in the land metal portions which join the portions under compression. It is this ability of the land to absorb the combination of increased tensile and compressive forces without buckling or being deformed or broken which is the essence of the sixth or pressure containment factor.

In the externally cammed contact also described below the tensile force is contained partly in the metal land proximate the blade edges and partly in an insulating cover of the device against which the fixed ends of the cams bear.

For blades of rectangular cross section the increased gripping pressure of the contact structures of the present invention are at least partially offset, balanced or "contained" by increased tensile forces in the material proximate the blade edges and closer to the fixed end

of the blade than the portion of the blade at which the increased gripping force is applied.

While the foregoing explanation of the combination of principles of operation of cams and cam contacts operating in accordance with the combination of requirements and features of this invention is given principally with reference to contacting of power blades it will be evident particularly from consideration of the cams and contacts of FIGS. 28 through 36 that the combination of principles of the present invention may be applied as well to power prongs of cross section other than the rectangular cross section referred to generally herein as power blades.

The concepts of the present invention and the manner in which they may be most advantageously embodied in wiring devices may be explained most clearly by reference to the following drawings in which:

FIG. 1 is a perspective view in part in section of a connector formed pursuant to the present invention to contain a contact as provided pursuant to the invention;

FIG. 2 is a section of FIG. 1 taken along 2—2 of FIG. 1 and showing a cap mounted in place in the connector;

FIG. 3 is a plan view of a contact strip at one stage of its formation;

FIG. 4 is a similar view of the strip after formation has been completed;

FIG. 5 is an elevational view of the contact of FIG. 4 a portion of the right end of which is broken away;

FIG. 6 is a vertical section of the contact of FIG. 5 taken along the line 6—6 of FIG. 5;

FIG. 7 is a perspective view of a detail of a contact such as that shown in FIG. 4 emphasizing certain constructional details of the contact strip and the relation of the contact to power blades to be brought into electrical contact with the contact structure;

FIG. 8 is a sectional view of a detail of the contact strip of FIG. 3 taken along the line 8—8 of FIG. 3;

FIG. 9 is a detail of a first step in the formation of the strip as shown in FIG. 4;

FIG. 10 is a similar detailed view of a section of the completed strip as shown in FIG. 4;

FIG. 11 is a transverse sectional view of the strip of FIG. 16 taken along the line 11—11 of FIG. 16 showing the first stage of formation of an externally cammed contact;

FIG. 12 is a similar detailed sectional view of the strip after a first step of formation has been completed;

FIG. 13 is a similar detailed view of the strip after a second formation step has been completed;

FIG. 14 is a detailed sectional view of a later step in the formation of a completed contact;

FIG. 15 is a detailed sectional view of the contact essentially in its completely formed condition;

FIG. 16 is a top plan view of the contact at a first stage of its preparation as also illustrated in FIG. 11;

FIG. 17 is a top plan view of the contact after formation has been completed as illustrated also in FIG. 15;

FIG. 18 is a perspective view of a contact strip for a rigid walled outlet which incorporates a contact element such as are shown in FIGS. 15 and 17 as the blade receiving elements;

FIG. 19 is a vertical transverse section of a conventional rigid walled outlet showing the relationship between the contact of FIG. 18 and the rigid walled insulating housing of the outlet;

FIG. 20 is a perspective view of a contact adapted to receive power blades at either of two alignments essentially at right angles;

FIG. 21 illustrates the contact of FIG. 20 with a first blade in place; and

FIG. 22 illustrates the contact of FIG. 20 with the alternate blade in place at right angles to the blade shown in FIG. 21;

FIG. 23 is a perspective view of a cube tap form of connector;

FIG. 24 is an alternative perspective view of the cube tap of FIG. 23 showing the opposite face of the tap;

FIG. 25 is a sectional view taken along the line 25—25 of FIG. 26 showing two prong terminals exposed in their embedded positions in the tap;

FIG. 26 is a sectional view of the tap taken along the line 26—26 of FIG. 25;

FIG. 27 is a perspective view of the contacts of the cube tap in the same relative position as they occupy in the tap and with caps shown in phantom poised to enter the respective contact slots;

FIG. 28 is a perspective view of a form of contact formed to accommodate a power prong of round cross section;

FIG. 29 is a plan view of two such contacts positioned to receive a pair of power prongs;

FIG. 30 is an elevational view in part in section of the relation of a cap and receptacle having contacts as shown in FIGS. 28 and 29;

FIG. 31 is a plan view of a contact blank prior to forming the contact cams;

FIG. 32 is a plan view of the contact such as is formed from a blank as shown in FIG. 31;

FIG. 33 is a vertical section of the contact as shown in FIG. 32 taken along the line B—B of FIG. 32;

FIG. 34 is a plan view of a contact having three cams;

FIG. 35 is a perspective view of a test connector structure;

FIG. 36 is a vertical sectional view of the structure of FIG. 35 taken along the line A—A of FIG. 35.

Pursuant to the present invention contact structures may be provided in what may be indicated for convenience of reference as internally cammed structures and as externally cammed structures. Internally cammed structures are those formed with an essentially planar section of material surrounding a blade or prong receiving opening and having at least one prong or blade gripping cam extending toward the blade or prong from the inner portion of the planar section. An internally cammed structure is exemplified by that illustrated in FIG. 4.

The externally cammed structures are formed to have an essentially planar section of material surrounding a prong receiving opening and having a prong gripping cam supported by said section from the outer portions thereof.

An externally cammed structure is exemplified by that illustrated in FIG. 17.

Reference will be made to these two distinct types in the description which follows to add to the clarity of the description, but it will be realized that other forms of contact including combinations of the above are within the scope of the present invention.

A description is given first in the text which follows of the internally cammed form of contact as this forms in unique in requiring the lowest mass of material of

any contact known to provide a reliable and reproducible high contact pressure.

Referring first to FIG. 2, there is seen in this vertical section through the connector an alignment of the two internally cammed contact strips 20 and 22 in a single plane.

An important feature of the present invention is found in the rather remarkable ability of the contacts to furnish power to a power receiving blade from a very thin plane of contacting material.

Still another feature which is complementary to that recited above is the capability of internally cammed connector structures of the present invention to develop a high contact pressure on power receiving prongs or blades although the material of the contact strip of the connector is of thin gauge. Connector structures have been formed pursuant to the present invention from 70-30 brass of 0.016 inches thickness to provide a double wipe action on a power blade. Moreover, the retaining force of this contact when properly embedded, as illustrated in the accompanying figures, in a yieldable material is higher than that of contacts which employ greater thickness of essentially the same metal in contact strips of other constructions.

A connector formed in essentially the configuration shown in FIG. 1, with a pair of contact strips each having a thickness of 0.016 inches and each having a clearance between the opposed cams of fifty-five thousandths of an inch, required a force of about 7.5 pounds to extract a pair of smooth surfaced brass power blades of a conventional cap from the grip of the corresponding pair of opposed cams in the connector. In performing this extraction force measurement, the cap blades were first withdrawn slightly, the withdrawal was interrupted and the measurement was made as the withdrawal was again started to avoid in this way any excessive pull due to locking of the contacting insulating portions of the cap and connector respectively.

A further remarkable feature of the connector of this invention is that due to the construction of the contact strip and the fact that it is embedded in the yieldable plastic, substantially less force is needed to insert the power prong into the connector than is required to withdraw it. In an insertion test essentially the converse of the extraction test described above it was found that only 5.2 pounds of force was needed to resume the insertion of the same prongs starting from an at rest position, once the insertion had been initiated, into the same connector opening which required the 7.5 pounds of extraction force referred to above.

To continue now with an explanation of the advantages inherent in the planar array of the internally cammed contacts of the present invention, it will be apparent by referring again to FIG. 2 that because the two contacts lie in a single plane, it is feasible to employ a third contact, which may also be of the planar configuration illustrated by the dashed horizontal line 24 of the Figure, in close proximity to but insulatedly separated from the two contacts 22 and 24. Similarly a fourth contact 26, preferably also of planar formation, may be disposed in a plane slightly below but insulatedly separated from that containing the coplanar contacts 20 and 22. The significance of this array of contacts is appreciated in connection with providing a grounding contact for a connector such as that containing the two power contacts 20 and 22.

To ensure maximum safety in use Underwriters' Laboratories requires that the grounding prong or blade, of the conventional three pronged grounding cap, contact the grounding contact of a connector before the power prongs contact the power contacts of the connector.

Referring to the Figure it will be seen that a grounding prong inserted into a cavity, such as cavity 28 shown in phantom in the body of the connector, will provide a contact of the grounding prong with grounding contact 24 before the power prongs can contact the power contacts 20 and 22 because of the greater proximity of the grounding contact to the external surface of the connector body, i.e., the surface at which the prongs enter the cavities.

Referring now to FIG. 6, some characteristics of the contact structure important to its capability to perform with high efficiency as an electrical contact will be described.

First it is noted that the contact surfaces 50 are confronting but are also essentially parallel to each other. It is important to note that the parallelism is not simply between edges of the cams, i.e., a linear parallelism, but is a parallelism between essentially planar surfaces obtained in forming the cams. In other words, the portions of the cams which are confronting and which will bear against a power blade inserted therebetween might be described in an ideal configuration as plane parallel surfaces in that they are essentially planar surfaces which do not intersect.

Wide variation from the plane parallel configuration described above may be tolerated without loss of the advantages of the present invention. However, the presentation of confronting edges which are so remote from parallel planes as to constitute edges such as can bite into the power blade surface are to be avoided in a contact structure prepared in accordance with this invention.

An important feature of the internally cammed structures of the present invention may accordingly be seen to be the provision of a high contact pressure and the provision of a cammed structure which requires a withdrawal force to remove a power blade which is higher than the force needed to insert the same blade between the same pair of contact surfaces.

Particularly it is important that this is accomplished with smooth surfaced power blades and without appreciable "biting" of the power blade surface by any sharp edges of the contact which scrape or bite into the power blade surface as the blade is withdrawn from the contact.

Accordingly, a particularly valuable feature of the article of the present invention is found in its capability to receive a power blade with greater facility than it releases the same blade.

Specifically, when a power blade is urged against or inserted in the contact structure of the present invention the action of the blade on the structure is that of forcing the contacts in a direction in which they are disposed to move with minimum resistance, i.e., in the direction in which the blade itself is urged. Because in the internally cammed structure the opposed cam springs are integral with the leaf spring from which they are formed and are supported more at the outer longitudinal edges thereof than at the longitudinal center by the yieldable material in which they are embedded, the result is a tendency toward forming a central longitudinal

"fold" of the plate which tends to separate the contacting surfaces 50 of the spring cams 52.

Accordingly, a feature of the internally cammed structure of the present invention may be seen to be that of supporting said spring cams at their outer ends so that force applied to the tips tends to urge the cams in the direction in which they are best able to be deflected by the force applied. Further, it will be seen that by supporting the spring cams in the yieldable material the deflection thereof occurs also at least partly through deflection of the surrounding land of leaf spring from which they are supported.

Accordingly, several advantages of the present invention are gained by supporting the surrounding land portion of said leaf spring in which the cams are disposed to permit deflection of both the cams and the land thereof responsive to the tractive force applied to the cams by the power blade.

Because of this capability of the land to cooperate with the yieldable material in which it is embedded it will be evident that substantial advantage is gained where a land of leaf spring material is supported at its periphery in a yieldable material such as a vinyl chloride thermoplastic polymer and where spring cams are formed internally of and integrally with the supported land.

Considering now the action of the contact cams as the power blade is withdrawn from a connector having a cross section as shown in FIG. 2, it will be seen that as the withdrawal of blades 30 and 32 is started the upper surfaces of the planar section of the land surrounding the blades will be drawn into higher pressure contact with the yieldable insulating material 35 of the connector. Accordingly, some yielding of the plastic material and some deflection of the land of the contact strip will occur.

As will be evident from the form of the contact, withdrawal of the blades will result in a combination of compression of the yieldable material bearing against upper surfaces of the land portions of the contact and a deflection of the material of the land, the net effect of which will be to increase the pressure exerted by the parallel gripping surfaces 40 on opposite sides of blade 30. This increased pressure will be due to a tendency of the contact to form a central longitudinal "fold" the converse of that described above in explaining the effect of inserting the power blade into the contact.

While the internally cammed contact structure of the present invention is seemingly simple in design it will be realized from the foregoing description and from the preceding explanation of the significant factors on which its functioning depends that the contact strip of this invention will function as a power delivering contact to power receiving blades with the advantages inherent in the construction and at optimum efficiency only if a balance is maintained between the factors explained to be important to the provision of these advantages.

Through careful balance of factors outlined above the internally cammed contact structure of the present invention attains an unusually high level of use of the high tensile forces and the reciprocally opposing high compressive or gripping forces which can be generated within a planar section of metal. However, this high level of use can be obtained only if the planar section is restrained from deflecting, buckling, folding, tearing or splitting as the tensile force is increased. For a rela-

tively thin section of metal it is necessary to restrain the movement of the portions of the section out of the plane where portions of the metal tend to undergo such movement as the tensile and compressive forces within the section are increased.

However, in restraining this movement it is not intended that the deflection be entirely eliminated or prevented. Some deflection can be beneficial inasmuch as it can permit a very short cam, such as cam 52 shown in FIG. 6, to itself deflect as part of the deflecting movement of the planar section of the strip and thereby to exert the strong pressure against the surfaces of a power blade without an excessive bending or deflection of the cams themselves. Such excessive deflection could result in their being "set" or permanently bent to a substantial degree beyond the limits of their original alignment and spacing.

The cams shown in FIG. 6 are enlarged in comparison to those shown in FIGS. 1 or 2 and are shown in proportions more representative of cams as they would be employed than the smaller representation of FIGS. 1 and 2. In particular the cams as shown in FIG. 6 emphasize the fact that the holding or gripping power of the structures of the present invention do not depend on the pressing of a pointed or sharp edge into the surface of the gripped blade to restrain its withdrawal.

From the foregoing it will be evident that for optimum results it is necessary to establish a balance of factors indicated herein to be important to the successful application of the present invention in wiring device technology.

An idea of which is optimum may be gained by considering the ratio of the mass of metal used in a contact strip providing three contact openings which accommodate power blades of conventional dimensions to that of other contacts serving a comparable function. The successful balancing of forces acting through the land between the embedding material and the short internal cam is, of course, essential to minimizing the amount of metal contained in the contact strip.

Further, an idea the optimization is also gained by comparing the ease of operation of the contact, i.e., the facility to the user of making and breaking electrical connection combined with the firm gripping force exerted on the power blade, with the ease of operation of other comparable connectors known in the art. The greater ease of inserting the power blades of a conventional cap as compared to the ease of withdrawal are particularly indicative of the achievement of this optimization.

As is pointed out above, one of the features of the power delivering structure of the present invention is its capability, although of such small overall dimensions, to develop high pressure against the power blade inserted into contact therewith. The capability of this structure to generate high contact pressure is the result partly of the fact that the structure in developing the high compression against the blade utilizes principally the tensile property of the strip material to "contain" and offset the high compression.

The tensile property can be utilized because the contact or gripping surface is integral with a cam and the cam is formed by forming metal out of the plane of a section of strip, the remainder of which section retains said essentially planar configuration. The cam in pressing on the broad faces of the blade delivers compressive forces to the blade and to the longitudinal portions

of the blade contiguous to the fixed ends of the cams, the lateral portions of the blade accordingly being placed in tension.

In their preferred forms both the internally and externally cammed contacts of this invention are adapted to receive a power blade through an opening in a planar section of metal, the planar section essentially surrounding the opening through which the blade is to pass and the planar section being subjected to tensile forces in the region thereof proximate the edges of the blade.

An essential feature of the contact of the present invention is that the gripping force, or the force tending to resist the withdrawal of the power blade, can be stored in large degree in portions of an essentially planar section of metal surrounding the blade receiving opening, proximate the portion of the opening which receives the narrower faces of the blade.

The balance of a number of factors important to the success of the internally cammed structure of the present invention may be more clearly described and illustrated with reference now to FIG. 7 which is an enlarged perspective view of a contact strip having the general form of those provided in accordance with this invention.

Two blade receiving openings 72 and 74 are shown in their relation to the tips of illustrative power blades 76 and 78 poised for entry into the openings.

The action of the power blades will be described with reference to the general nature of their interaction with the contacts inasmuch as the contacts are shown are formed from a metal of thin section and otherwise in a form suitable for use embedded in a polymeric material having the plastic or yielding properties similar to those of vinyl chloride.

A feature of the invention is the capability of forming an internally cammed contact structure of very low mass. The low mass contact is formed from stock or relatively thin initial cross section and as evident from the figures above by removal of a small amount of metal from the stock.

To form an internally cammed contact structure of minimum lateral cross section from a strip of metal having spring metal characteristics the metal strip must itself be of both a minimum thickness which permits development of the residual spring pressure needed to provide electrical contact with the cam, and of a minimum width which accommodates the conventional blade thickness of about fifty-five thousandths of an inch.

Referring now particularly to FIG. 7, it will be appreciated that for contacts of the general configurations shown in the figures some deflection of the essentially planar section of the contact strip out of the plane will result from the insertion of the power blade, or from the spreading of the cams by some other application of pressure at the respective opposed pressure transmitting or gripping surfaces of the cams of the contact.

Where the contact is not formed to be embedded within a plastic material as illustrated in FIGS. 1 and 2, but is to be held within a more rigid insulating structure as a structure of a conventional type of thermoset polymer, the gauge or thickness of the metal of the strip stock from which the contact is formed is generally heavier than when the reinforcing effect of the more yieldable thermoplastic is employed. The width of the strip need be no greater than that employed in produc-

ing the contact to be embedded except if externally supporting tabs 90 shown in phantom in FIG. 7 are employed.

For either the heavier or lighter gauge contact spreading of the gripping surfaces will tend to produce a bowing or tendency toward a folding as mentioned above of the essentially planar section surrounding the prong receiving opening. For the internally cammed contact particularly, the insertion of a power prong can have the effect of tending to fold the strip contact, that is, to bring the ends of the cams of the strip further out of the plane of the strip in a direction opposite to the direction in which the portions of the strip remote from, but parallel to, the gripping surface of the cams are moved as the power prongs are inserted in the contact. The tabs 90 are accordingly positioned to accommodate the folding type of flexing of a contact strip.

This deflection or flexing of the contact strip from the inside out produces a very high contact pressure.

There is in effect a mechanical advantage employed in the structure of the present invention in utilizing the movement of the short beam internal portion of a leaf spring section to apply a pressure, and in utilizing the movement of the long beam outer portions of the spring to develop the pressure. The extent of pressure which is applied is controlled by controlling the relation of the degree of spring biasing and spring deflection to the yielding of the yieldable material.

Returning now to FIG. 7, as the blade 78, for example, approaches and enters opening 74 it comes into contact first with the wedge shaped cam surfaces 80.

These surfaces perform the usual function of locating the blade tip to press with essentially equal force against each cam and to facilitate in this way passage of the blade through the opening.

The cams perform the function of transmitting to the longitudinal flat sections 82 the force acting on the cam surfaces 80.

In turn, the longitudinal flat sections transmit to the transverse flat sections 84 a portion of the force received from the cams.

The manner in which the tension develops in these flat sections 84, which in combination constitute a planar annulus, and in which they will be flexed depends on the nature of the material and the manner in which it is held.

For example, where the material is a copper beryllium alloy formed and then hardened in the manner described in the copending application Ser. No. 546,273 filed Apr. 29, 1966 and assigned to the same assignee as the instant application, the flexure will be lessened due to the greater stiffness of the copper beryllium alloy material.

Further, where one planar section is contiguous to another, and the cam surfaces accommodate blades entering from opposite directions, the flexing of one planar section can balance with that of the other as illustrated by the contiguous transverse connecting sections 84 and 86 of FIG. 7. Thus, the openings such as 72 and 74 having a length between transverse connecting sections of slightly over one quarter of an inch, sufficient to accommodate a power blade having a width of one quarter of an inch, can be placed on centers in a contact strip of 0.36 inches. The width of the transverse connecting strips connecting the openings can be as small as 0.08 inches and still give high efficiency performance.

This high efficiency is due in part to the fact that the transverse connecting strip is subjected to tensile force from insertion of blades 76 and 78 into the respective openings of the contact structure.

In forming the contact of the present invention, particularly the internally cammed structures, care must be given to avoiding forming structures which will result in the concentration of stress at locations in the contact which could lead to permanent deformation of the metal of the finished contact when the contacts are eventually placed in use.

The manner in which this is conveniently accomplished in accordance with this invention is illustrated in FIGS. 3 and 4.

Referring first to FIG. 3, a contact strip is first formed from a blank strip of suitable metal, such as 70-30 brass of spring temper, by punching out the pairs of openings 10. The edges defining the openings are curved at locations where stress concentration might occur. For a contact strip having the dimensions described above, a radius of curvature of 0.03 inches serves very well to curve the ends of the generally oval shaped openings having a largest dimension of about 0.16 inches, the width of such openings being about 0.06 inches. The edges are also kept free of sharp corners or other configurations at which stress might be concentrated. The high degree of utilization of the metal strip is evident from the combination of the small dimensions of the strip from which the contact is formed together with the small amount of metal removed from the strip.

Referring next to FIGS. 3 and 8, a shear is formed at the midline 12 between the pairs of openings 10 to permit the metal to be bent to form two cams extending out of the plane in which the surrounding metal of the strip is disposed.

Referring now to FIG. 8, there is illustrated a section through a sheet from which a contact strip is formed taken along a line, for example 8-8 of FIG. 3; that is, viewing the strip section through a punched opening 10 of FIG. 3, it will be seen that a sheared midline 12 is provided. The longitudinal portion 82 of the strip beyond the opening 10 is accordingly seen in section.

Referring now to FIG. 9, the first step in the formation of the contact elements such as that illustrated in FIG. 7 is carried out by bending the internal cam ends formed by shearing at the midline 12 down through an angle of approximately 90° from the original plane in which the midline 12 is disposed. The bending or forming of the metal of the cam ends is preferably accomplished to impart to the cross section of the cam a radius as is evident from the cross section of the cam as shown in the Figure. The reason for formation of the radius in the cam is evident from consideration of FIGS. 10 and 7 with regard to the surface of the cam which is presented to and bears against power blades brought into contact therewith.

Referring now to FIG. 10 it is evident that the cam edges formed by shearing as seen in FIG. 8 and bent through 90° as seen in FIG. 9, are bent through an angle beyond the 90° imparting a further forming action to the cams to add a further angle of bend to that shown in FIG. 9. The surface 94 for example is formed by bending the cam through a 45° angle although this need not be done with formation of a curvature in the bent section. Whether the second forming is done to impart a curvature to the formed section or not, however, the

net result is a bending of the sheared surface of the cam edge through an angle of more than 90° sufficient to eliminate the possibility of any of the sharp cam edges resulting from the shearing being brought or pressed against the blade.

The relationship of the curved section 92 of the cam to be pressed against the blade to the straighter section 94 may be seen best by reference to FIGS. 7 and 10.

In preparing contacts in accordance with this invention it will be sufficient if the metal is bent to an angle which will provide a cam-like surface to receive the surfaces of an entering power blade and which will also permit the force received by the cam to be transmitted to the land of the surrounding metal strip to substantially increase the tensile forces in the portion of the land proximate the narrower faces or longitudinal edges of the power blade. The portion of the cam which actually bears against the power blade should not be flat as shown in FIG. 2, unless the cam edges are specifically formed so as to prevent any biting of the cam into the blade surface. The more economical way to accomplish this is to bend the sharp edges out of the way as taught above. By the land metal of the internally cammed structure of this invention is meant the metal of the original strip from which the contact is formed, which remains essentially in the plane of the original strip after the contact opening is formed, which surrounds this opening, and which extends out from the cams to the extent of contributing to the containment or application of contacting or gripping force through the cams onto a blade once a blade is inserted through the contact opening.

Accordingly, the surface actually bearing on the blade may be rounded or formed with a plurality of angles and it may even be shaped specifically to increase the pressure on a limited area of the blade surface.

What is submitted to be a desirable accomplishment of this invention is as explained more fully above the increase of force which is applicable to a blade surface as a gripping force operating through increasing the pressure and the accompanied frictional resistance on the blade as an effort is made to withdraw it. What is distinct about the pressing of the holding surface of the cams against the blade surfaces pursuant to this invention is that an increased force is applied over a sufficiently large area as to result in a sufficiently low pressure to avoid an appreciable indentation, removal or deformation of the metal of either the blades or the contact. Accordingly, in forming the cams it is not necessary to resort to the use of protuberances or the use of a combination of protuberance in the contact surface with a depression or hole in the blade surface. Accordingly, the main increase which must result pursuant to this invention at the contacting surfaces of the cams and blades, as a blade is withdrawn from the grip of a contact, is the increase in the frictional engagement between the surfaces and, accordingly, of the force needed to make the surface slide relative to each other.

While it is generally true that in a connector such as that illustrated in FIGS. 1 and 2, a part of the holding of the blade can be due to the frictional engagement between the blade and that portion of the plastic material 34 extending beyond the tips of the engaging surfaces 40 of the contact, the increased frictional engagement will be due primarily to the cam action.

How this is accomplished may be seen with reference again to FIG. 7. If the land of contact opening 72 is supported at its longitudinal portion by integrally formed tabs 90, it will be evident that an asymmetrical gripping force will be applied to the surfaces of a power blade by the essentially parallel surfaces 92 of the cams 94 if the tabs are held by supports of relatively more rigid material, such as the conventional thermoset resins including phenolic resins or the like used in conventional wall mounted convenience outlets.

By an asymmetrical frictional gripping force is meant one which changes in value when the direction of movement of a frictionally engaged power blade is reversed.

For such a construction the remaining portions of the lands 86 and 88 of the contact will serve to contain to a large extent the force applied centrally of the land and accordingly many of the advantages of the construction of contacts in accordance with this invention will be preserved.

Additional modifications of the structure and additions thereto may be made without departing from the spirit and scope of the present invention.

It will be evident that because of the relatively thin depth of the contact of the present invention relative to the longitudinal axis of the power blade the construction of outlets of smaller depth may be accomplished. For example at the present time the outer dimensions of the depth of insulating housing of wall mounted outlets are normally expected to run in the order of one inch or more. This depth of insulation housing accommodates a length of power blade inserted into the outlet which is only approximately five-eighths of an inch. Employing the contact structure of the present invention, convenience outlets can be fashioned which permit the maximum depth of the outlet to be determined by the necessity for the fully inserted blade to be housed in insulation which is integral with the outlet. Where the fully inserted blades of a power receiving cap are permitted to extend beyond the insulated housing of the outlet, the outer depth dimension of the insulating housing for the outlet less than the depth of the fully inserted blades is made feasible by the contact structure such as is provided in accordance with the present invention.

While it might at first appear that the advantages made possible as discussed above would for some reason necessitate a sacrifice of some other properties of the outlet, the reverse is found to be the case. This latter surprising result obtains because each of the functions which the outlet is to perform is performed with equal or greater reliability and convenience than in structures available heretofore. Of particular significance is the capability of the device to resist the tendency found in contacts operating through spring pressure alone to develop a fatigue in the spring action on which maintenance of contact with the inserted power blade depends. Because the contact structure of the present invention is capable of exerting greater holding force, i.e., a force to resist withdrawal of an inserted smooth surfaced power receiving blade greater than the force needed to insert the blade, the contact of the present invention does not depend for its holding of the blade only on the spring action such as is essential for other contacts. Accordingly it is not subject to the loss of holding ability due to development of fatigue, or to

a "set" or permanent bending of the fingers of the contact.

As explained above an externally cammed contact structure is an alternative of the internally cammed contact of thin vertical section and we turn now to a description of the externally cammed structure.

Referring now to FIGS. 11 and 16, an alternative form of the contact of the present invention is formed from a strip such as 110 by first removing metal from the strip to form two stress relieving openings 108 and by then shearing the midline 112 of the metal separating these two openings. The next step in formation of this alternative form of contact is illustrated in FIG. 12 and involves bending up the ends of the strip 114 to form an acute angle preferably of the order of 90° with the horizontal. This is similar to the forming step given with relation to FIG. 9 above.

The next step involves bending the next inner portion of the strip edges 116 to bring the end portions 114 through a further angle and to cause the edge 113 to be rotated through a total of more than a 90° angle and essentially bring it into an obtuse angle with respect to the horizontal mid plane of the strip. This forming step also corresponds generally to that described with reference to FIG. 10 above.

The following step shown in FIG. 14 is a dual folding of the strip along two longitudinally extending fold lines 118 to separate the central opposed edges 111 formed along the central shear line 112, and to bring the outer edges 114 closer together as shown in FIG. 14. The connecting end section 120 of the contact strip 110 supports the two rotated cam portions, i.e., the portions extending between the edges 111 and 114 respectively of the strip as best seen in FIG. 17 form the tensile plane of the contact. The relation of the connecting portion 120 of the original strip to that of the completed contact may be seen from a comparison of these portions in FIGS. 16 and 17. It is evident that the connector portion 120 forms the vertical of a C-spring, the confronting contact surfaces 119 forming the opposed jaws of the C configuration from which spring pressure is applicable.

The space between the contact surfaces 119 is adapted to receive a power blade such that the contact surfaces will be pressed against opposite sides of the blade due to the spring action of the C springs at each end of the contact.

The disposition of contacts such as are described above in one form of outlet provided in accordance with this invention may be explained with reference now to FIGS. 18 and 19.

Referring now to FIG. 18, the cammed structure of FIGS. 15 and 16 is seen formed integrally with and at the ends of a contact strip 122. The strip includes the two end contact portions 124 and two wire locking cam portions 126 similar to those described and claimed in copending application Ser. No. 417,740 filed Dec. 11, 1964 assigned to the same assignee as the instant application. Between the two sets of contacts and wire locking cams is a break off tab 128 which may be removed so as to split the strip into two electrically separated pairs of wire locking cams and cammed contacts.

The form in which the contact strip is shown is adapted for insertion into a rigid plastic housing as conventionally used in enclosing a convenience outlet for wall mounting.

Referring now specifically to FIG. 19, the two contact strips as described with reference to FIG. 18 are shown in place in an insulated housing.

To assure the desired cam action the gripping edges 119 of the cams are free to move in the direction of movement of a power blade entering the housing and do not abut against the inner surfaces of the housing entrance 121.

The clearance between the gripping surfaces 119 is smaller than the width of the power blade inserted therebetween so that a spring pressure from the C spring member described with reference to FIG. 15 is exerted on a power blade inserted between a pair of gripping surfaces 119.

However, as the blade is urged out of the grip of the contact the strength of the grip is increased by the following movement of the gripping surfaces 119 as explained more fully above with reference to the cam operation of the gripping cams.

It is evident that the plane in which the compressive gripping force is applied in the blades is below the level at which tension is generated in the cross member 120, referring to FIG. 15, and at which the tension is generated in the cover 123 of the plastic housing of the outlet shown in FIG. 19. The tension in the housing cover is generated by the spreading force of the upper edges 111 of the cams in the internal seat on the underside of the housing cover 111.

Referring now particularly to FIGS. 20, 21 and 22 another modification of the contact of the present invention is shown.

In this modification the contact is adapted to receive a power blade at either of two alignments, the two alignments being essentially at right angles in a "T" formation.

Referring to FIG. 20, the contact is formed with two layers of metal, one disposed over the other so that a power blade passes through both as it makes contact at either level. In the illustration shown the two layers are parts of a single strip of metal, the same strip also being bent to provide a vertically extending terminal 130 to which a contact screw or other similar wire connection may be mounted as through screw receiving hole 132.

Both the blade receiving of the upper contact 134 and that of the lower contact 136 are provided with the internally cammed contacts similar to those described with reference to FIGS. 4, 5 and 6 above.

A major difference is the addition of enlarged non-cammed openings through which a blade may pass without application of a gripping contact.

Thus the upper contact portion 134 is provided with opening 138 through which a power blade, shown more clearly as blade 160 of FIG. 22, may pass without the application of a cammed gripping contact of the type described with reference to FIG. 7. This blade is aligned as the vertical member of the T formation.

However, a blade which is inserted through contact portion 134 in the other permitted alignment, seen best as blade 150 in FIG. 21, does make contact with the cams 140 extending from the inner edges of the upper cross member of the T-shaped opening. The cam 140 formed on the edge in which the vertical opening 138 of the T-form opening is located is split so that cammed contact with a blade such as 150 of FIG. 21 is made on each side of the opening 138.

The converse is true of the lower contact 136 in that a blade aligned as 150 in FIG. 21 does not make the

cammed contact with the blade 150 but a blade aligned as 160 in FIG. 22 does make cammed contact with the blade 160.

The two contacts 134 and 136 are shown separated by a distance which is chosen to show clearly the two layers and the relations between the cammed and uncammed openings and the blades inserted therein. However, it will be appreciated that the contacts need be separated by no more than the distance needed to allow the flexing and camming action of the two superposed strip portions.

The two may be superposed in contact by shortening the connecting portion 135 or by forming the two portions from separate strips and then by electrically connecting the two together.

Referring now specifically to FIGS. 23 through 27 an alternative use of contacts as described with reference FIGS. 3, 4, 5, and 6 is now described. The contacts are used in a cube tap shown in perspective in FIGS. 23 and 24 as having an insulating casing 180 having two pairs of openings 182 and 184 on one side and a single pair 186 on the other.

The general configuration of the insulating casing is similar to that seen in FIGS. 1 and 2 with the notable exception that the upper section of FIGS. 23 and 24 show the end of the insulation casing which encloses the inner portion of a pair of power blades 188 as being squared rather than tapered as is the end of the casing of FIG. 1 at which the wire enters.

The positioning of the contacts in the cube tap casing is seen best in the two sectional views of FIGS. 25 and 26, FIG. 26 being a vertical section taken along the line 26 — 26 of FIG. 25 and FIG. 25 being a vertical section taken along the line 25 — 25 of FIG. 26.

The contacts 190 and 192 are essentially the same as those shown in FIGS. 4, 5 and 6 with the exception that the end, normally folded or crimped as shown in FIG. 4 to grip a wire end, is not folded as they are used in the cube tap. Rather they are joined by rivets 194 or 196 to the respective inner portions of the blades 188 as shown.

The relationship of the blades and contacts and their positioning relative to the caps of entering power blades is seen best in FIG. 27 where details of the contacts are seen with the casing 180 removed. As evident from earlier disclosure the two end contact slots 200 and 204 of each contact strip 190 is formed to receive power blades such as 201 and 205 in the same orientation as illustrated by the positions in which the phantom caps 210 and 214 are shown.

Cap 212 approaches contact strip 190 from the opposite side to position blade 203 in contact slot 202.

The foregoing illustrates another of numerous possible combinations in which the contact strip of the present invention can be utilized.

Referring now specifically to FIGS. 28 through 36 a form of contact is taught which operates according to the principles set forth above but which is particularly well suited for contacting power prongs of generally round cross section.

Referring now first specifically to FIG. 28 a strip of metal which may be brass of the type normally used in electrical contact structures is formed into a contact element by first punching out a figure x to have an enlarged square center 220 as seen best in FIG. 31 and four slots 224 extending outward from the corners of the square 220.

Following the punching of the x the inner tips of the cams 226 are bent downward to an approximate form illustrated best in FIG. 9 and are then bent further downward to the approximate form illustrated in FIG. 10. The plan view of a contact adapted to receive round prongs after it has been formed in the manner described is illustrated in FIG. 32 by which it may be seen that four cams 228 are presented to an entering power receiving prong of round cross section. The relation of the poised prong 240 to the contact is best seen by reference again to FIG. 28. The cams 238 make contact at a small area of a generally cylindrical prong such as 240 but the contact is at a sufficiently high pressure that high power can be passed between the prong 240 and contact cams 238.

The metal strip 242 in which the cammed contact is formed may conveniently have the form of a contact strip. Thus for example it may be bent at a mid-portion 244 to provide a vertical section having a terminal screw receiving slot 246 at the lower end thereof and a horizontal portion 248 in which the cam is formed.

In FIG. 29 two such formed contact strips 242 are shown in side by side relation. This positioning of the contacts permits the two spaced power prongs of a power receiving cap to be used in connection with a receptacle in which such a pair of contacts 242 may be insulatedly mounted.

In FIG. 30 a housing for one such receptacle is shown in phantom as it would house a pair of contacts 242 shown in solid lines. The relationship of a descending pair of prongs 240 of cap 250 to receive power from cams 238 of contacts 242 is readily evident from the Figure. The terminal screws 252 and associated wire clamps 254 cooperate to attach a conductor (not shown) entering an opening 256 in the insulating housing to supply electric power to the contact 242 of the receptacle. The contoured flange 258 of the insulating housing is used in the conventional manner in mounting the receptacle in an appropriate wall or other location.

Turning now to FIG. 35 a test apparatus is illustrated as it was used in testing and demonstrating the remarkable ability of the contact of the present invention to supply comparatively high levels of electric power to receiving prongs of the round cross section as shown.

In this test apparatus two contact strips 260 similar to those shown in FIGS. 31 and 32 were mounted in an insulated test housing 262 of poly methyl methacrylate. The housing is formed of a lid 264 and base 266 and the contact strips 260 are mounted therebetween in conforming recesses formed 268 formed in the upper surface of the base member 266.

As seen more clearly with reference to FIG. 36 which is a vertical section taken along the line A — A of FIG. 35, two prong receiving apertures in the cover member 264 are superposed over two openings 272 of larger diameter formed in the base member 266. Also as seen best in FIG. 36 slight vertical motion of the cammed end of contact strip 260 is feasible as the depth of the recess was approximately double the thickness of the strip disposed therein. The actual thickness of the strip stock from which the contact was formed was in one case 0.016 inches and the depth of recess was 0.030 inches.

The contact is held in place in recess 268 by rivet 274 but due in part to the comparative thinness of the strip stock the end of the strip in which the contact is formed

is free to move or "float" in the cavity formed by the recess 268 and overlaying cover member. The cover 264 and base 266 are held together by the screws 276.

Referring again to FIG. 36 the hole 272 which is oversized relative to the prong diameter and to the diameter of holes 270 must be large enough to accommodate the cams 238 depending from the contact strip 260. Moreover it must be able to accommodate the cams when they are expressed under the influence of the entering prong. The relation of prong 240 and cams 238 of contact strip 260 is seen best in the vertical sectional view of FIG. 33 which is a vertical section of the contact end of strip 260 taken along the section line B — B of FIG. 32. It is evident from FIG. 33 that as the cams 238 undergo the types of motion described above in stating the principles of operation of contacts of this invention that they must have room to move and flex in order to obtain the sought for improved electrical contact and gripping action.

It has been found for example in tests of the contact described with reference to the test apparatus of FIGS. 35 and 36 that a cap or plug such as 250 of FIG. 30 could be plugged into the test apparatus and unplugged fifty times where the contactor was energized with DC voltage at 125 volts and where the cap was connected to a load which required at least 22.5 amperes of current to pass through the contacts at a voltage of 125 volts. When this fifty cycle connect and disconnect test was completed the contact was subjected to a heat rise test by measuring the heat rise of the strip between the rivet and the cammed contact while 15 amperes of current at a voltage of 125° C were passed through the contact to an inserted plug. A 16° C temperature rise was measured in each contact strip after four hours of conducting this level of electricity at an ambient temperature of 25° C.

From the foregoing it is evident that an unusually effective electrical contact is provided pursuant to this invention.

Obviously other forms of the contact may be made which provide cam action as explained above. One such contact is illustrated in FIG. 34 and it will be noted that it is also useful in providing electrical contact to power receiving prongs of generally round cross section. Such contact can also be made with a two cam contact but the three cams center the prong or are centered by it. The cams 280 are formed much in the same manner as previously described with reference to FIGS. 8, 9 and 10. The outwardly extending slots 282 have rounded ends to minimize stress concentration.

When prongs of smaller dimensions are used it is feasible to bring the cams into closer proximity to a central point by performing a secondary forming action on the strip to channel the metal of the contact strip along a portion thereof representing an extension of the slots. This portion is illustrated by the dotted lines 225 extending outward from the slots 224 of FIG. 31. By depressing the metal between the dotted lines to form a channel of the metal aligned with the slots the two sides of the slot may be brought closer together. The channel formed by such depression can provide a spring like structure which spring can operate to deliver yieldable spring pressure to a prong of smaller cross section while preserving in essence the action of the cams in gripping an inserted power receiving prong of smaller cross section.

What is claimed is:

1. An electrical contact adapted to receive and frictionally engage a plurality of power blades, said contact comprising a generally planar land of metal at least partially surrounding each of a plurality of blade receiving openings, said openings being partially defined by two opposed cams extending at an acute angle out of the general plane of said surrounding land, the direction of extension of a pair of cams out of the plane of a first land being opposite to that of an adjoining land of the same strip, and the edges of said opening subject to stress due to deflection of said cams being shaped to reduce concentration of said stress, and said land being supported to permit deflection thereof accompanying deflection of said cams, the contacting surface of a blade deflected cam lying generally in a plane which is approximately plane parallel to that defining the surface of the blade against which it bears.
2. The electrical connector of claim 1 in which a plurality of openings are aligned with a plurality of blade receiving ports of a plastic housing at least two of which are disposed on opposite faces of the plastic housing.
3. A cammed electrical contact said contact comprising
 - a land of conductive spring metal,
 - a generally rectangular opening in said land,
 - a tab of land metal extending from at least one of the longer sides of said opening,
 - at least the major portion of said tab extending below the general plane of said land to form a cam,
 - the end portion of said cam extending further below the plane of said land and having a reverse bend to point the edge of said cam away from said opening,
 - and
 - said cam having a curved outer surface at said reverse bend,
 - said contact being supported at outer portions of said land in a housing.
4. The contact of claim 3 in which the edges of said opening subject to stress due to deflection of said cam

are rounded to reduce concentration of said stress.

5. The contact of claim 3 in which the land is part of a metal strip which includes a plurality of such openings.

6. An electrical connector comprising,
 - a cammed electrical contact said contact comprising
 - a land of conductive spring metal,
 - a generally rectangular opening in said land,
 - a tab of land metal extending from at least one of the longer sides of said opening,
 - at least the major portion of said tab extending below the general plane of said land to form a cam,
 - the end portion of said cam extending further below the plane of said land and having a reverse bend to point the edge of said cam away from said opening,
 - and
 - said cam having a curved outer surface at said reverse bend,
 - said electrical contact being embedded in a yieldable insulating plastic housing, said housing having a blade receiving port aligned for entry of a blade through said opening into contact with said cam.
7. An electrical connector comprising a cammed electrical contact said contact comprising
 - a land of conductive spring metal,
 - a generally rectangular opening in said land,
 - a tab of land metal extending from at least one of the longer sides of said opening,
 - at least the major portion of said tab extending below the general plane of said land to form a cam,
 - the end portion of said cam extending further below the plane of said land and having a reverse bend to point the edge of said cam away from said opening,
 - and
 - said cam having a curved outer surface at said reverse bend,
 - an insulating housing,
 - said contact being supported at outer portions of said land in such insulating housing, and
 - a port in the insulating housing communicating with said opening.

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