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(54) **Electric circuit connecting devices.**

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(73) Proprietor: **International Business Machines Corporation**
Old Orchard Road
Armonk, N.Y. 10504 (US)

(72) Inventor: **Hammer, Robert**
36 Knollcrest Drive
Brookfield Center Connecticut 06805 (US)
Inventor: **Hollis, Ralph LeRoy, Jr.**
2601 Evergreen Street
Yorktown Heights New York 10598 (US)

(74) Representative: **Lewis, Alan John**
IBM United Kingdom Patent Operations Hursley Park
Winchester, Hants, S021 2JN (GB)

Courier Press, Leamington Spa, England.

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Description

The invention relates to devices for interconnecting two parts of an electric circuit, and is particularly, but not exclusively concerned with such devices that are ganged for interconnecting a multiple of electric circuits.

The development of electric circuit connecting devices has a long history. A great number of different mechanisms for interconnecting electric circuits have been devised and used. As electric circuit arts have advanced, new requirements have been imposed on the circuit connecting devices. One of the vexing problems prior to this invention is that of providing a satisfactory coupling device for interconnecting a multiple of electric circuits simultaneously by means of a simple manually operated device. As an example, a device is needed for interconnecting hundreds or thousands of individual electric circuits with little effort by use of a two-dimensional array of connectors.

Prior art

Although the inventors are not aware of any prior art arrangements coming within the definition of the electric circuit-connecting device defined in the appended claims, some of the structural features thereof, taken out of context of course, are to be found in the following US patents:

RE11,968	2/1902	Greil et al	—
663,750	12/1900	Greil et al	—
2,156,272	5/1939	Bell	174/94
2,969,520	1/1961	Waldo	339/105
3,427,551	2/1969	Oshima	339/47
3,560,909	2/1971	Wyatt et al	339/100
3,725,844	4/1973	McKeown et al	339/49R
4,050,773	9/1977	Newell	339/224

In the European patented art:

1,045,735	10/1966	Chandler	Great Britain
1,224,281	6/1960	Bergner	France
1,387,274	12/1964	Amp (Co.)	France
361,525	5/1905	Gourju	France

The two patents to Greil and Audiger disclose electric circuit connecting devices comprising two parts similar in some respects to the parts of the invention. A bundle of elongated conductors is arranged in a well, and a relatively large diameter convex conductive prong is inserted into the bundle of conductors for completing the contact between two parts of an electric circuit. The convex prongs require considerable pressure to insert into a bundle of conductors, and there is no suggestion of a concave prong as contemplated by the instant invention.

The patent to Bell, and that to Newell as well, discloses a conical conductive prong for insertion into an end of a length of stranded electric wire. The same disadvantages apply and there is no suggestion of a concave prong as contemplated by the invention.

The patent to Waldo is directed to a strain relief but also shows a conductive conical prong and stranded wire connecting arrangement such that some displacement can be tolerated. The patent to Wyatt and Wright discloses an arrangement similar to that of Waldo. These arrangements do not use a concave prong as contemplated according to the invention.

The Oskima and McKeown et al patents each show mating electric conductors having wiping contact areas of considerable length. Oskima is concerned with rather inflexible contactors, and McKeown et al join a number of fine flexible beryllium copper wires (as in a pair of stranded wires) by directly interlaying. The concept of a concave tapered conductor inserted into a bundle of elastic wires is absent.

The Bergner (French) patent is not particularly pertinent other than for the use of one tapered sleeve placed over one conductor of a group for expanding the bundle in a surrounding cylindrical sleeve. Likewise the connector shown in the French patent to the AMP Co discloses little more than the use of a conical wedge, which may even be an insulator, for expanding the ends of a stranded wire against the inside wall of a conical conductive tube to obtain a permanent connection. In the instant invention a temporary, reusable connection is contemplated. Furthermore, no showing of a concave pronglike wedge is seen.

None of the foregoing prior art discloses an electrical connector having a concave prong. U.K. specification No. 214,525 (Martin) published in 1924, discloses a barbed electrical connector designed in the manner of a fish hook and intended to be difficult to pull out. The Martin specification pays no particular attention to the exact profile of the barbs and in no way foreshadows the precise profile according to the Applicants invention or the advantages thereof. Thus, heretofore there is no suggestion of any kind that the curve defining the prong be in any way related to the deformation of the several conductors in the stand as is the case with the connector according to the invention as will be described hereinafter.

Accordingly the invention provides an electric circuit connecting device comprising a stand of elongated electric conductors each having one end connected in common to one part of said electric circuit and extending substantially parallel to one another, and an electrically conductive prong having one end thereof electrically connected to another part of said electric circuit to be connected and having the other end thereof of reduced diameter for inserting said prong into said stand of conductor for completing said electric circuit, characterised by said prong having a configuration comprising a surface of revolution about the longitudinal axis defined by said ends of said prong, said surface of revolution being defined by a curve concave with respect to said axis, progressing from substantially zero at said other end to the maximum dimension at said one end and conforming to the longitudinal shape assumed by a said conductor when deformed as a uniformly load cantilever beam anchored substantially at the undisplaced end.

Preferably the prong has a peripheral contour in the form of a surface of revolution about the longitudinal axis lying on the curve

$$Y=(WX^2/24EI)\ (X^2-4XL+6L^2) \qquad (1)$$

where

X is the dimension along said axis,

Y is the distance from that axis to a point on said curve

W is the constant force per unit length along said prong,

E is Young's Modulus of said conductors,

I is the sectional moment of inertia of said conductors, and

L is the length of said conductors.

The invention will now be further described with reference to the accompanying drawings, in which:—

Figure 1 is a cross-sectional side view of a pair of complementary electric circuit connecting members according to the invention;

Figure 2 is a cross-sectional view of a stand of conductors according to the invention;

Figure 3 is a plan view of an array of stands of conductors as contemplated for use in a connector and illustrating different conditions of alignment according to the invention;

Figure 4—sections (a), (b), and (c) being taken together—is a schematic diagram illustrating the fundamental concepts of a complementary prong and conductors according to the invention in comparison with prior art structures;

Figure 5—sections (a), (b), and (c) being taken together—is an illustration of one particular condition occurring in use of the connecting members according to the invention; and

Figure 6 is a graphical representation of force v. insertion depth useful in an understanding of the invention.

Description

A side-view in cross-section of cooperating complementary and dissimilar counterpart electric circuit connecting members according to the invention is shown in Figure 1. The members comprise a substantially rigid conductive prong 10 and a multiple of substantially flexible conductors 12 into a stand of which the prong 10 is inserted. Two or more of the conductors 12 will wipe along the surface of the prong 10 as shown. The conductors 12 are imbedded in a pad 14 to which an electric circuit conductor, usually in the form of a printed circuit wiring trace 16, is attached. A stand of conductors 12 is held in place by an insulating member 18 and protected by an insulating member 19, the latter members forming no part of the invention in and of themselves. Similarly, the conductive prong 10 is fitted with a head 20 to which a conductor 22, also usually in the form of a printed circuit wiring trace, is fitted, and the prong is mechanically and electrically connected to the above printed wiring structure 24. Figure 2 shows a stand of conductors 12 prior to the insertion of a prong. Preferably, the conductors 12 are spaced apart at a center-to-center distance of the order of twice the diameter of the conductors.

A plan view of an array of multiple stands of conductors is shown in Figure 3. As will be seen hereinafter, the connection according to the invention is especially advantageous in large arrays. The simplicity of the connector makes small dimensions possible, allowing a large number of connections per unit area. A stand 30 is a cross-section top view of the stand shown in elevation in Figure 2. A similar stand 32 is shown with a prong 10 inserted corresponding to the cross-section along the line 3—3 as shown in cross-section in Figure 1. A slightly different situation is shown wherein a stand 34 has inserted therein a prong 10, which is considerably off-center due to misalignment for one reason or another. Thus it is seen that the connector is highly tolerant to dimensional variations. The insulating member 19 acts as a stop for the insertion of the prong 10, and also protects the conductors 12 from damage. It is also contemplated for some applications, that a plug having a multiple of prongs 10 be fitted with a telescoping sleeve to protect the prongs when the plug is not in a socket. A pair of pins, or like indexing means, longer than the prongs are arranged in the plug for inserting into bores 36 and 38 for guiding the plug into the socket. This feature is not otherwise illustrated as it is believed to be well known in the art.

The mating action of the components of the connector is shown in Figure 1. For low resistance contacts and flexibility, the conductors 12 in each stand are made of phosphor bronze or a beryllium copper alloy or like material. The material should have a high Young's modulus and high yield strength to provide the required spring action without permanent deformation. The conductor is preferably plated with gold or palladium or other suitable material for good contact properties.

The conductors 12 are preferably fabricated with 0.00635—0.00762 cm. (0.0025 to 0.0030 inch) diameter Neyoro-G wire having a composition of 71.5% gold, 14.5% copper, 8.5% platinum, 4.5% silver and 1.0% zinc. The conductors may be joined by welding, brazing or soldering one end of each to a pad 14 on a mother board. Mechanical crimping within a cylindrical tube or a one-piece forming operation is also contemplated. The length of the conductors 12 is 0.15 to 0.20 cm. (or 0.060 to 0.080 inch). These dimensions allow an array of connects to be spaced on a 0.12 cm. (or 0.050 inch) square grid as shown in Figure 3.

The conductive prong 10 is mechanically formed to the required shape to produce a low force, low contact angle "parting" action upon insertion. The shape of the prong 10 derives from the elastic line equation for the uniformly loaded cantilever beam hereinbefore given by equation (1).

The coordinates for the curve defined by equation (1) are based on an origin at the point of the prong 10 for X_0 and substantially at the fixed end of the conductors 12 for Y_0 as shown in Figure 4. The X-Y coordinates are oriented for agreement with the more conventional orientation for depicting the bending of cantilever beams. In the context of the connector, a mating prong of this shape will cause the conductor in the stand to be uniformly loaded as shown in Figure 4, which is a graphical representation of a plot of prong radius against the distance from the point for an arbitrary fixed set of parameters. The preferred shape is shown in Figure 4(c). The shape is that of a surface of revolution formed by revolving the quartic curve of Equation (1) about the x axis, which is also the longitudinal axis of the prong 10. The curvature is such as to provide a large contact area and a long wiping length. As the connector becomes fully engaged, a larger number of conductors contact the prong and each other providing additional electric pathways tending toward a reliable low resistance connection.

The advantages of the quartic prong 10 over the conical 50 or ogive 40 configurations is that it allows the maximum insertion depth to be realized and therefore minimizing connector inductance. Conductors in the stands are uniformly stressed for a longer connect-disconnect cycle life. The stress per unit length along the conductors is low, thereby minimizing the thickness of precious metal plating used. The wiped length of the conductors remains stressed and in contact with the prong, providing a high tolerance to contamination.

Figure 4 graphically illustrates the mating action for these three types of prongs. In the case of the ogive 40, there is a concentrated stress and wire splaying which interferes with adjacent conductors in the stand. For the straight cone 50, the conductors remain in contact with the prong but there are no contact forces above the rather small curved contact region. For the quartic prong 10, according to the invention, there is a uniform stress along the entire length of the conductors.

There is some possibility, especially in multi-connector arrays, of one or more prongs abutting a conductor as shown in Figure 5. This is minimized by using as small a conductor diameter as possible. With the ends of the conductors rounded or pointed as by an etching process, there is less of a problem here. Also, a high aspect ratio and springy conductors have a tendency to help move the members into place.

A graphical representation of the insertion force required for inserting a prong according to the invention into a stand of conductors and a comparison with prongs of other configuration is made in Figure 6. A curve 60 depicts the force required with a prong of ogive shape 40 as indicated. Another curve 62 depicts the force required by a substantially conical prong 50, while a further curve 64 represents the force required with a concave prong 10 according to the invention. The latter curve indicates a lower insertion force which is a distinct advantage is using the concave prong 10 in multiple circuit plugs and sockets.

Claims

1. An electric circuit connecting device comprising a stand of elongated electric conductors (12) each having one end connected in common to one part (16) of said electric circuit and extending substantially parallel to one another, and an electrically conductive prong (10) having one end thereof electrically connected to another part (22) of said electric circuit to be connected and having the other end thereof of reduced diameter for inserting said prong (10) into said stand of conductor (12) for completing said electric circuit, characterised by said prong (10) having a configuration comprising a surface of revolution about the longitudinal axis defined by said ends of said prong, said surface of revolution

being defined by a curve concave with respect to said axis, progressing from substantially zero at said other end to the maximum dimension at said one end and conforming to the longitudinal shape assumed by a said conductor when deformed as a uniformly load centilever beam anchored substantially at the undisplaced end.

2. An electric circuit connecting device as claimed in claim 1, further characterised in that said prong has a peripheral contour in the form of a surface of revolution about the longitudinal axis lying in the curve

$$Y=(WX^2/24EI)\ (X^2-4XL+6L^2)$$

where

X is the dimension along said axis,

Y is the distance from that axis to a point on said curve,

W is the constant force per unit length along said prong,

E is Young's Modulus of said conductors,

I is the sectional moment of inertia of said conductors, and

L is the length of said conductors.

Patentansprüche

1. Verbindungsvorrichtung für elektrische Schaltungen mit einer Aufstellung aus langgestreckten elektrischen Leitern (12), welche alle mit einem Ende gemainsam mit einem Teil (16) der elektrischen Schaltung verbunden sind und im wesentlichen parallel zueinander verlaufen, und einer elektrisch leitenden Zinke (10), die mit einem Ende mit einem zu verbindenden anderen Teil (22) der elektrischen Schaltung elektrisch verbunden ist und deren anderes Ende für ein Einsetzen der Zinke (10) in die Aufstellung von Leitern (12) zur Vervollständigung der elektrischen Schaltung einen verminderten Durchmesser aufweist, dadurch gekennzeichnet, daß die Zinke (10) einen Aufbau aufweist, welcher eine Rotationsfläche in Bezug auf die durch die Enden der Zinke definierte Längsachse umfaßt, wobei die Rotationsfläche durch eine in Bezug auf diese Achse konkave Kurve definiert ist, die von im wesentlichen null an dem anderen Ende zu Maximalabmessung an dem einen Ende fortschreitet und der Längsform des Leiters angepaßt ist, die dieser einnimmt, wenn er als gleichförmig belasteter Freiträger mit Verankerung im wesentlichen am unversetzten Ende verformt wird.

2. Vorrichtung nach Anspruch 1, ferner dadurch gekennzeichnet, daß die Zinke eine Umfangskontur in Form einer Rotationsfläche in Bezug auf die Längsachse hat, die in der Kurve

$$Y=(WX^2/24EI)\ (X^2-4XL+6L^2)\ \text{liegt,}$$

wobei

X die Abmessung längs der Achse,

Y der Abstand von der Achse zu einem Punkt der Kurve,

W die konstante Kraft pro Einheitslänge längs der Zinke,

E der Elastizitätsmodul oder Leiter,

I das sektionale Trägheitsmoment der Leiter, und

L die Länge der Leiter ist.

Revendications

1. Un dispositif connecteur de circuit électrique comprenant un faisceau de conducteurs électriques allongés (12) ayant chacun une extrémité connectée en commun à une pièce (16) dudit circuit électrique et qui s'étendent dans une direction sensiblement parallèle les uns aux autres, et une pointe électriquement conductrice (10) dont une extrémité est connectée électriquement à une autre pièce (22) dudit circuit électrique à connecter et dont l'autre extrémité est de diamètre réduit pour introduire ladite pointe (10) dans ledit faisceau de conducteurs (12) pour compléter le circuit électrique, caractérisé par le fait que ladite pointe (10) a une configuration comprenant une surface de révolution autour de l'axe longitudinal délimité par lesdites extrémités de ladite pointe, ladite surface de révolution étant délimitée par une courbe concave par rapport audit axe, progressant de sensiblement zéro à ladite autre extrémité jusqu'à la dimension maximale à l'extrémité première nommée et prenant la forme longitudinale prise par l'un desdits conducteurs lorsqu'il est déformé à la façon d'une poutre en porte-à-faux sous charge uniforme, ancré essentiellement à l'extrémité non déplacée.

2. Un dispositif connecteur pour circuit électrique conforme à la revendication 1, caractérisé en outre par le fait que ladite pointe a un contour périphérique se présentant sous la forme d'une surface de révolution autour de l'axe longitudinal définit par la courbe:

$$Y=(WX^2/24EI)\ (X^2-4XL+6L^2)$$

où

X est la dimension le long dudit axe

Y est la distance de cet axe à une point de ladite courbe

W est la force constante par unité de longueur le long de ladite pointe

E est le Module de Yound desdits conducteurs

I est le moment d'inertie de la section desdits conducteurs et

L est la longueur desdits conducteurs.

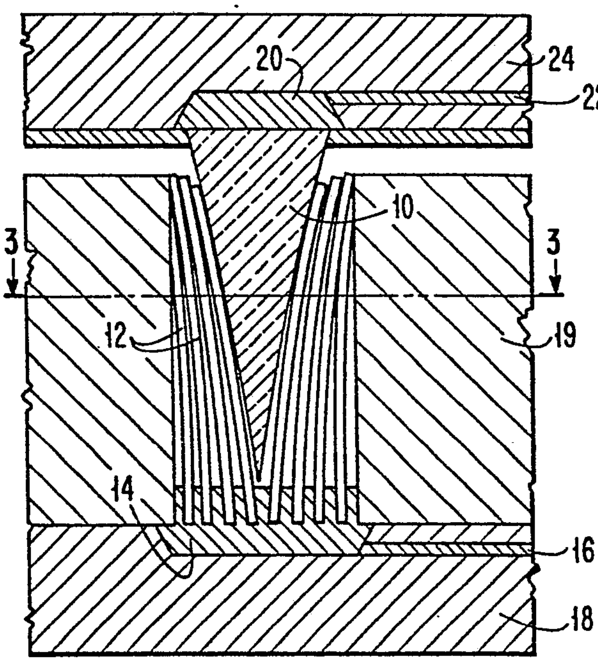

FIG. 1

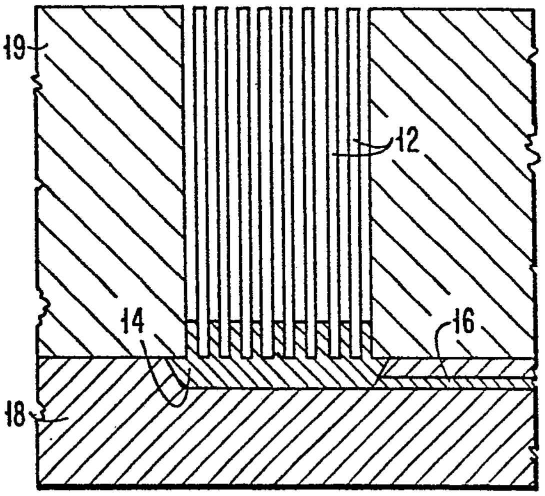

FIG. 2

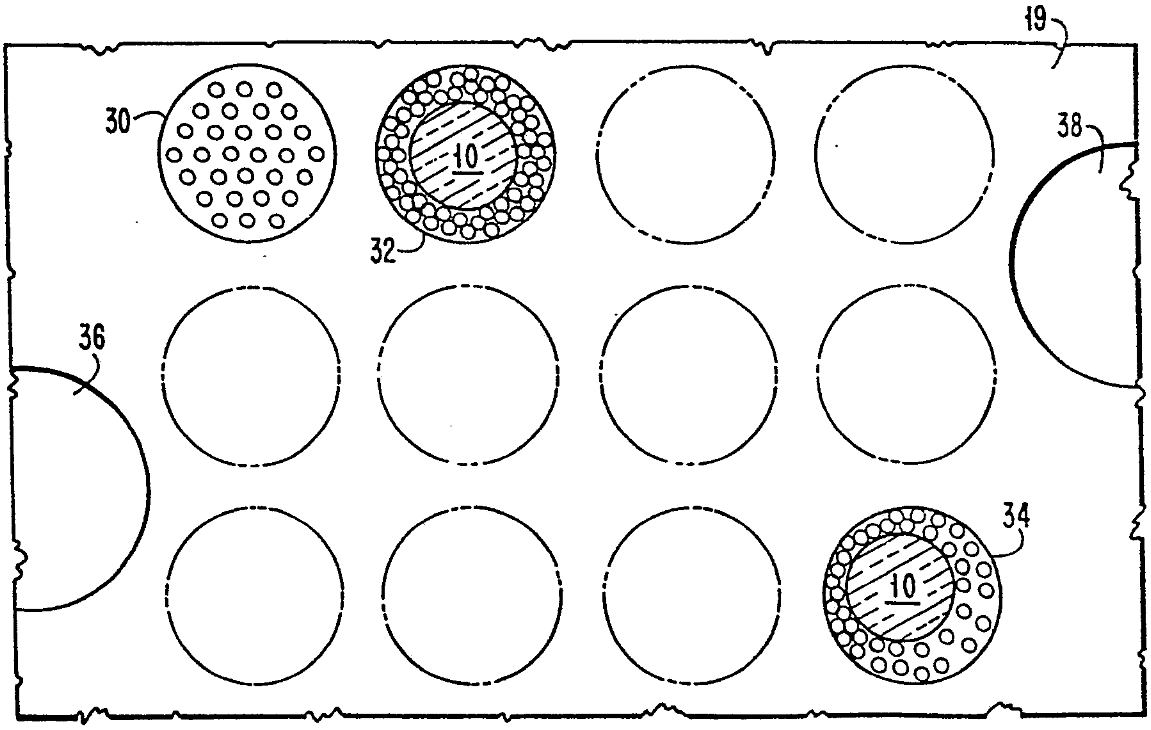

FIG. 3

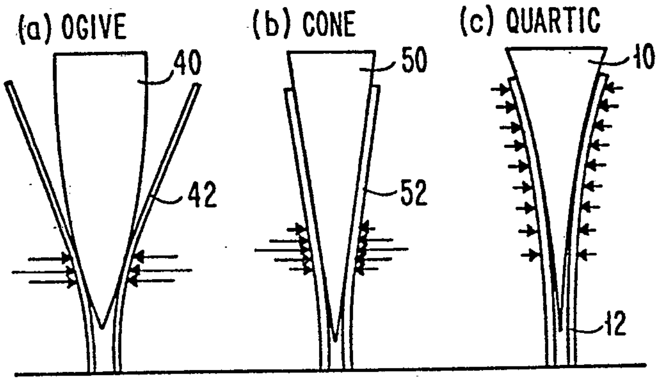

FIG. 4

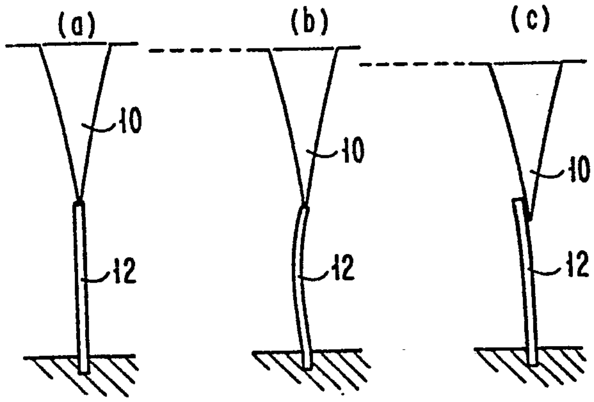

FIG. 5

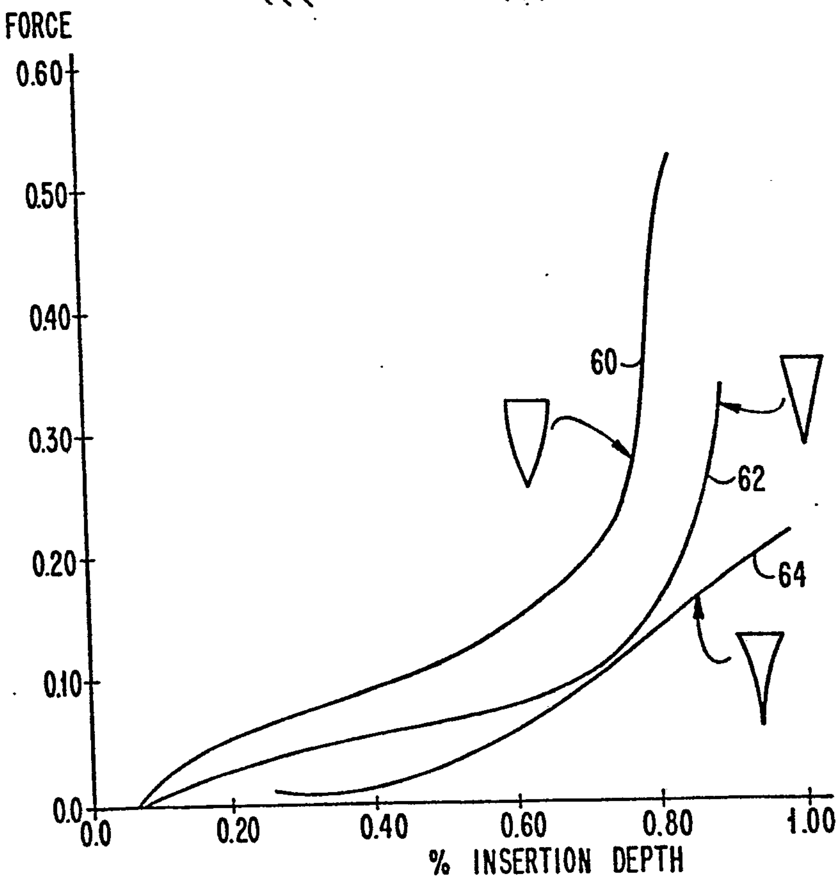

FIG. 6