

[54] **UNIVERSAL ELECTRICAL CONNECTOR**

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Related U.S. Application Data

[63] Continuation of Ser. No. 313,885, Dec. 11, 1972, abandoned, which is a continuation-in-part of Ser. No. 268,335, July 3, 1972, abandoned.

[52] U.S. Cl. **339/64 R; 339/176 R; 339/258 R**

[51] Int. Cl.² **H01R 13/62**

[58] Field of Search **339/17, 64-66, 339/75, 176, 217, 220, 221, 256, 258**

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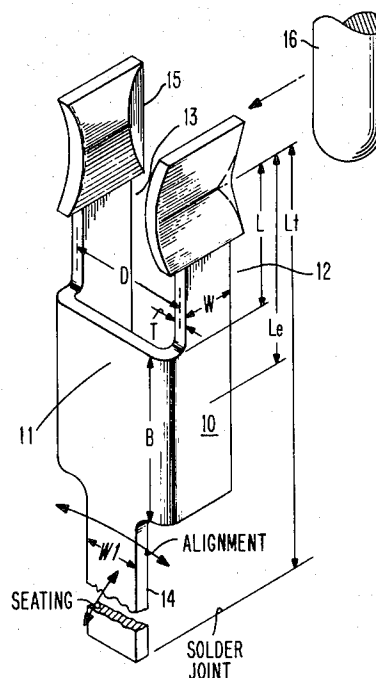
Primary Examiner—Joseph H. McGlynn
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[57] **ABSTRACT**

A zero or low insertion force, low actuation force electrical connector adapted for incorporation into a printed circuit board, connector housing or the like and suitable for card edge, input/output, array or dual-in-line module applications. The connector comprises a bifurcated spring yoke having a pair of complementary, flat, longitudinally and upwardly extending arms, each with a cylindrical or barrel-shaped contact surface in opposing and spaced apart relationship at a distance less than the diameter of a male connector pin to be introduced therebetween. The connector has a post or stem portion extending downwardly to create a multispring rate device with a floating action that enables up to 1600 pins per module to be accommodated on 0.050 inch centers despite slight misalignments of the pins.

For zero longitudinal insertion force of the male electrical pin, the pin is introduced into the connector area at a position adjacent the contact surfaces and is then guided slideably and transversely between the opposing contact surfaces. Alternatively, the shaping of the contact surfaces and the resiliency of the upwardly extending arms provides an electrical connector having a low insertion force when the pin is longitudinally introduced between the contact surfaces.

2 Claims, 7 Drawing Figures



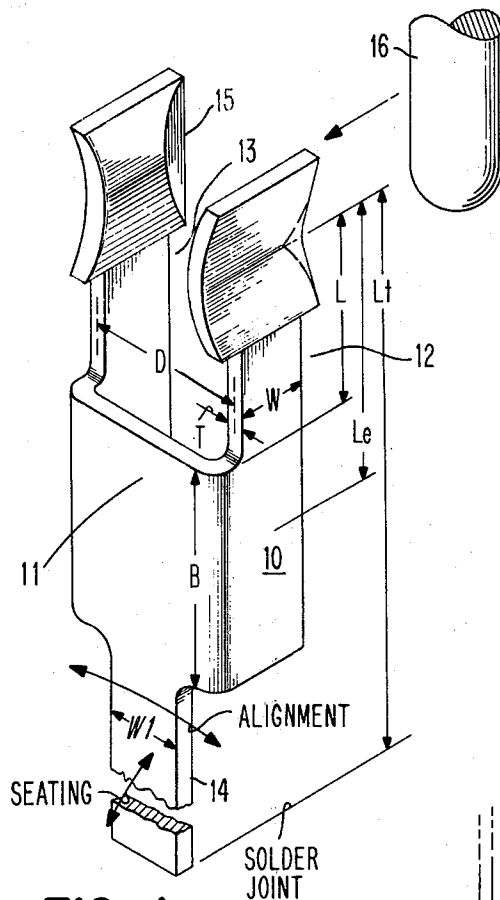


FIG. 1

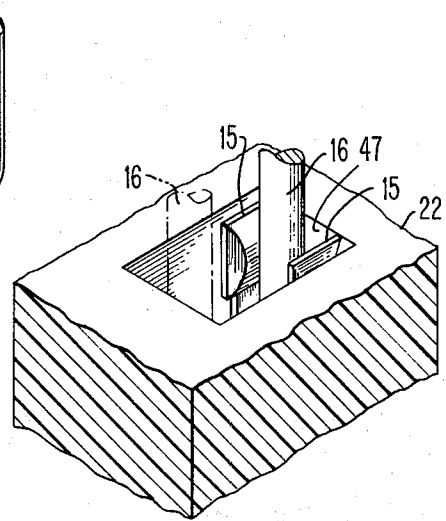


FIG. 3

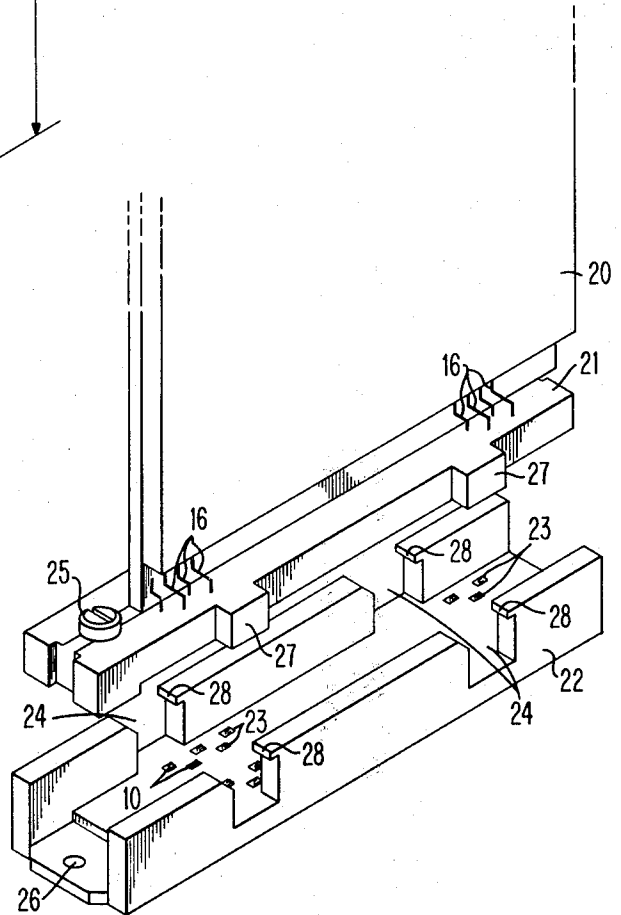
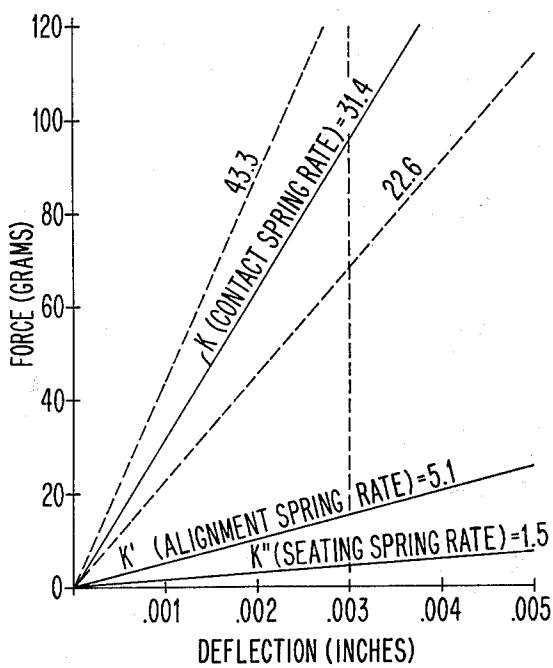


FIG. 2

FIG. 6

FIG. 4

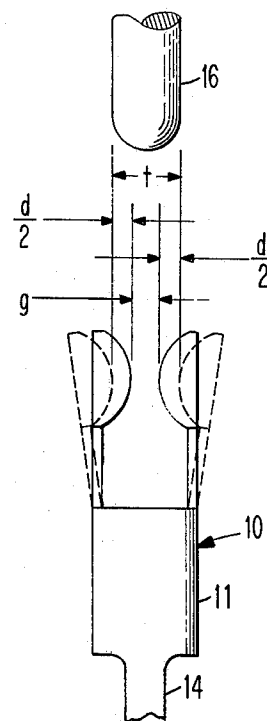
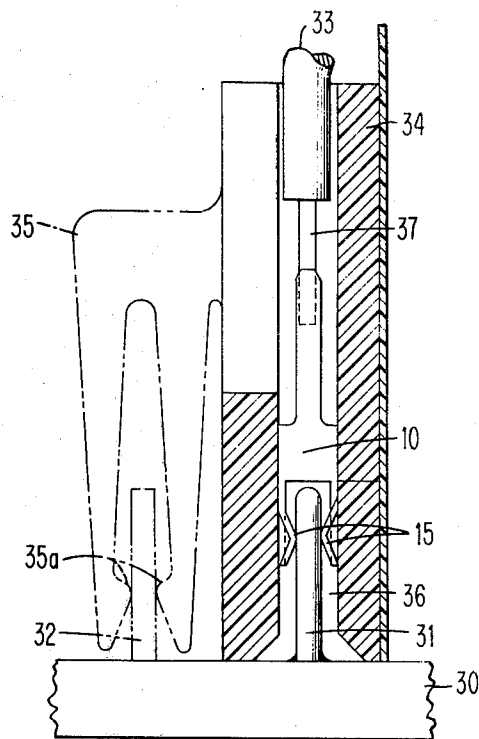


FIG. 7

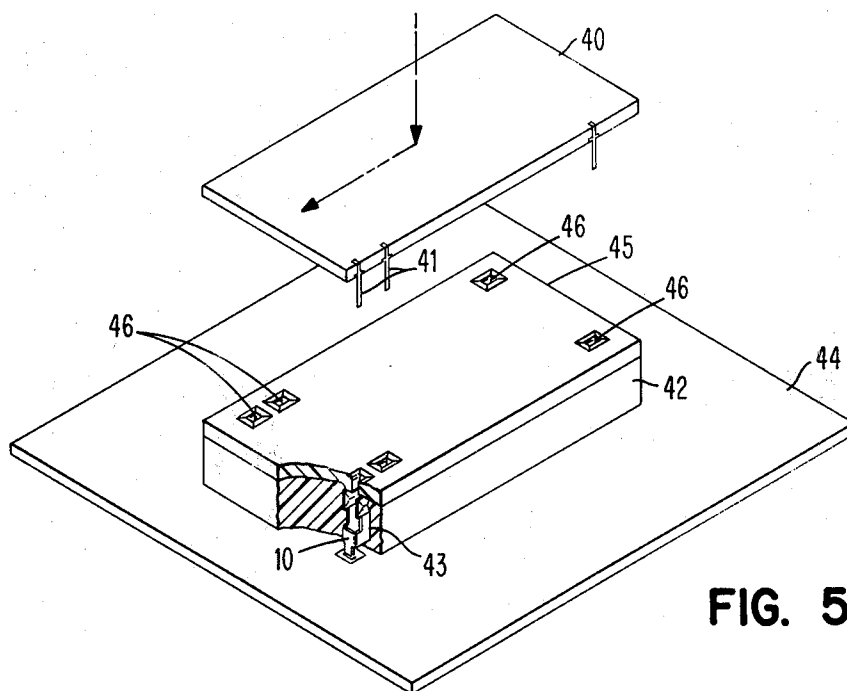


FIG. 5

UNIVERSAL ELECTRICAL CONNECTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 313,885, filed Dec. 11, 1972 which is now abandoned, and which application was a continuation-in-part of application Ser. No. 268,335, filed July 3, 1972 which is now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to electrical connectors and, more particularly, to universal type connectors adapted to receive either the pin or tab portion of a male electrical connector with no or low longitudinal stresses on the male or receiving connectors dependent upon the manner of insertion of the male connector.

2. Description of the Prior Art

In integrated circuit packaging, it is common practice to bond the connectors of the integrated circuit chip to a printed circuit pattern on a substrate material, such as a ceramic material. Connection to the printed circuit pattern is made by pins which pass through the substrate and are conductively connected to the pattern on one side of the substrate and project perpendicular to the plane of the substrate on its opposite side. As the number of devices per integrated circuit chip increases and as the number of connections necessarily increases, it is obvious that the number of external connections, e.g. pins on the substrate, must also increase. Insertion of the pins of the substrate into a socket on a printed circuit board is a problem because of the additional force required to insert a plurality of pins into friction-type female connectors. Also, as the size of the circuit modules is reduced and the quantity of modules employed is increased, the density of the input/output (I/O) connections per unit device becomes extremely critical. The problem of size reduction is recognized in many fields. The smallness of the I/O pin conductors which are in close proximity place exacting requirements on the connectors which are to be acceptable for use. Additionally because of problems inherent with bent pins, misaligned female connectors and/or pins, and the possibility of bending pins during insertion, the use of sockets with friction fit female connectors is undesirable in high reliability electronic equipment such as utilized in the present day data processing equipment.

Similarly, multiple circuit pin connectors are used on printed circuit cards to provide the I/O connections with printed circuit boards. In connectors of this type, the printed circuit card contact pins are small but must establish a positive and reliable electrical contact with the mating connectors of a printed circuit board. High insertion forces cause bent pins and misalignment.

In the February 1971 issue of the IBM Technical Disclosure Bulletin (at p. 2475), a connector is disclosed having opposed, laterally extending contact spring arms. Connected to the arms is a stem that passes through a plated through hole in a printed circuit board but has no facility to yield when a misaligned pin is introduced between the contact spring arms. U.S. Pat. No. 3,231,848 discloses a contact structuring to accommodate the direct reception of a printed circuit board. In such instances, the insertion forces depending on the number of pins in the board are usually very

high. U.S. Pat. No. 3,526,869 relates to a cam actuated printed circuit board connector wherein a cam is provided for driving a housing actuating member in a horizontal direction along its longitudinal axis forcing the connector contacts into intimate contact with the printed circuit board pads. Further, U.S. Pat. No. 3,605,062 pertains to an arrangement of connectors particularly adapted for the handling of a multilead electronic component, such as a dual inline package device.

SUMMARY OF THE INVENTION

The electrical connector device of the present invention overcomes disadvantages of prior known constructions. It includes the features and advantages of providing a good disengageable electrical connector device having high density capabilities enabling the connecting pin elements of integrated circuit packages with printed circuit boards of a data processing system.

Briefly, the electrical connector comprises a zero insertion force and low actuation force electrical connector which is adapted for incorporation into a printed circuit board or similar arrangement. The connector comprises a bifurcated spring yoke having flat longitudinally and upwardly extending arms, each with cylindrical or barrel-shaped contact surfaces in opposing and spaced apart relationship and chamfered at their respective entry ends to facilitate entry of the pin into the gap between said surfaces. The connector includes a longitudinally and downwardly extending mounting post or stem adapted to connect the connector device with a printed circuit board.

The elimination of insertion forces is accomplished by first locating the connecting pins in an area at a position adjacent the chamfered ends of the contact surfaces and then moving the pins slideably and transversely in guided relation between the opposing contact surfaces.

Alternatively, the shaping of the contact surfaces and the resiliency of the upwardly extending arms provides an electrical connector having a low insertion force when the pin is longitudinally introduced between the contact surfaces; the opposing cylindrical or barrel-shaped surfaces serving the function of the chamfers during insertion of the pin. But in either the transverse or in-line insertion, the opposing contact surfaces will assure line contact of each contact arm with the pin.

It is a primary object of the present invention to provide an improved universal type high-density electrical connector device for connecting the pin elements of an integrated circuit package with the conductive elements of a printed circuit board despite slight misalignment of the pins.

It is an object of the present invention to provide a connector device for use in conjunction with a pin-type male connector and wherein the connector permits insertion of the pin with zero longitudinal force on the pin and connector.

Another object of the present invention is to provide a connector which will automatically, within predetermined limits, align itself with a misaligned male connector without imposing longitudinal stresses on either connector while providing good electrical engagement therebetween by a relative shift in a lateral direction between the connectors.

It is a further object of the invention to provide a connector having a multispring rate and which has contact arms with a floating action that permits them to yield to

accommodate slight misalignments of a male connector.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of the preferred embodiments of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric drawing of the connector device per se embodying the invention shown associated with a pin-type male connector element.

FIG. 2 is an isometric drawing of plurality of such connector devices in a connector base adapted to function as a card-edge I/O electrical connector.

FIG. 3 is an enlarged fragmentary showing of one of the connector devices in the connector base illustration of FIG. 2.

FIG. 4 is a pin and ground rail application utilizing the connectors of the instant invention.

FIG. 5 is a dual in-line package (DIP) application utilizing the connector device of the present invention.

FIG. 6 is a plot of force vs. deflection, depicting the relationship between the contact spring rate, alignment spring rate and insertion/extraction spring rate that imparts a floating action to the connector.

FIG. 7 is a schematic drawing of the connector device and male connector element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and particularly to FIG. 1, a connector 10 of stamped and formed construction in accordance with the invention comprises a U-shaped yoke 11 having a pair of spring arms 12 and 13 normal to the yoke 11 and extending longitudinally upward from the parallel facing arms of the yoke. A mounting post or stem 14 extends downwardly from the lower edge of the central portion or base of yoke 11. The upper extremity of each arm 12, 13 is machine fabricated to provide preferably an elongated and cylindrically curved or barrel-shaped contact surface 15 to make line contact with a male connector element 16. Alternatively, a compound surface could be developed and then attached to the upper extremities of the arms 12 and 13 by brazing, soldering or the like; or a wire element could be shaped to provide a contoured surface and affixed to the upper extremities of the arms 12 and 13. In fabrication, after a stamping operation, the arms 12 and 13 are bent normal to the yoke 11 so that the contact surfaces 15 are in a spaced apart and opposing relationship. The dimension of the space between the opposing contact surfaces 15 is application oriented and less than the dimension of the male connector element 16 to be inserted therebetween. The male connector element 16 is illustrated as a round pin; however, it may be of other configurations, such as a flat tab or equivalent thereof.

According to the invention, the connector device 10 is characterized by its multispring rate characteristic. As will become more apparent presently the connector device 10 has an alignment spring rate (in the direction of the "Alignment" arrow in FIG. 1) at the stem 14 which is about one-sixth the spring rate of each contact arm 12, 13; and it also has a seating spring rate in the direction of the arrow) at the stem that is very small (e.g., about one-twentieth) that of each contact spring and hence essentially negligible.

The low spring rate (especially the low alignment spring rate) of the stem enables the stem to yield in response to slight misalignment forces resultant from slight relative misalignment of the pin 16 or other male element as it is introduced either laterally or longitudinally into the space between the opposing contact surfaces 15. This yielding of the stem assures that the facing cylindrical or barrel-like contact surfaces 15 will each make line contact with the pin 16. Thus, the yielding of the stem and identical spring rates of the opposing contact arms imparts a "floating action" or behavior to the connector device in the alignment direction. This floating action feature absorbs some of the tolerance accumulations and hence, in actual test, has been found to make it possible to install these connector devices on 0.050 inch centers in very high density applications.

More specifically, since the contact arms are complementarily identical, the contact spring rates for each arm 12, 13 will be identical. The contact spring rate, k , for each arm 12, 13 is determined generally by the following formula:

$$K = \frac{2E}{\frac{8Le^3}{WT^3} + \frac{12Le^2D}{B^3T} + \frac{D}{BT}}$$

where (see FIG. 1):

E = modulus of elasticity of the connector material

W = width of each contact arm

T = thickness of contact arm

Le = effective length of each contact arm, calculated empirically after the connector was measured, and found to be 1.375L, to take into account irregularities in the contact arm configuration (as it cannot properly be presumed to be a true cantilever beam of length L)

D = width of yoke 11 (measured from center of arm 12 to center of arm 13)

B = height of yoke 11

In the above formula, all distances are in inches; the first term in the denominator represents the bending force on each contact arm in the contact-spreading direction; and the second and third terms represent the bending and elongation forces, respectively, on the yoke 11. The third term, introduced to make the formula more precise, is essentially negligible. Also, the formula assumes that there is no misalignment of the pin 16, however, the magnitude of any such misalignment and the effect thereof is minimal and hence does not adversely affect the utility of the formula.

In the preferred configuration, the nominal value of the spring rate for each contact arm is 31.4 grams/mil; however, as shown in FIG. 6, this spring rate may vary between 22.6 and 43.3 grams/mil without significantly impairing the ability of the contact arms to accommodate slight misalignments of pin 16.

Referring now to FIG. 7, assume that the center lines of the pin 16 and connector device 10 lie in the same plane. Under this condition, the contact deflection, d , is defined as the total distance the contact arms 12, 13 spread when pin 16 is inserted. This distance, which is measured from the points where the arms 12, 13 contact pin 16, constitutes the difference between the original gap g between the contact arms and the thickness t of pin 16. Since the pin 16 is centrally aligned relative to contact spring arms 12, 13, the contact deflec-

tion, d , is shared equally between the two contact arms, i.e., each arm deflects $\frac{1}{2}d$ or one-half of the total.

If, as is preferable, t is 0.013 inch and g is 0.007 inch, then total contact deflection, d , will be 0.006 inch. Thus, the deflection of each contact arm, y , will be $(\frac{1}{2})d$ or 0.003 inch. Hence, the force, F , that each contact arm 12, 13 applies to pin 16 when the pin is perfectly aligned with the contact arms is:

$$F = ky = (31.4) (3) = 94.2 \text{ grams}$$

However, if these parts are initially out of alignment, then a slight additional force is added to that particular one of the arms that must yield a further degree in order to accommodate the misaligned pin.

The alignment tolerances for the contact arms 12, 13 and for the pin 16 are each preferably ± 0.002 inch. Therefore, the maximum or worst case alignment, y' , between the two parts is 0.004 inch, y' being the deflection in the direction of the Alignment arrows of FIG. 1.

Referring again to FIG. 1, the alignment spring rate, k' , is determined generally by the following formula:

$$k' = \frac{3E}{\frac{Le^3}{I_c} + \frac{L_t^3}{I_s}}$$

where:

E = modulus of elasticity of the connector material

Le = effective length, as previously defined

T = thickness of each contact arm

$I_c = WT^3/12$ = moment of inertia for the contact arm cross-section at W

$I_s = T(W) 3/12$ = moment of inertia for the stem cross-section at W

L_t = total cantilever length of the connector from the solder joint or anchor point to the center of the contact surfaces 15.

In the preferred configuration, this alignment spring rate is 5.1 grams/mil; however, it may vary about ± 25 percent (i.e., between about 3.8 and 6.5 grams/mil) without significantly impairing the ability of the contact arms to accommodate relative misalignments with the pin because such a change in rate would produce only a small change in alignment force under most conditions. The effect of torsion is assumed to be negligible because the connectors will be centered by an alignment fixture.

Assuming now that alignment spring rate is 5.1 grams/mil, the maximum amount of force, F' , required for alignment is:

$$F' = k'y' = (5.1) (4) = 20.4 \text{ grams}$$

Hence, the contact force that one of the contact arms 12 or 13 would exert on a pin 16 that is out of alignment by the maximum amount of 0.004 inch would be:

$$F_w = \text{force with worst alignment} = F + F' = (94.2) + (20.4) = 114.6 \text{ grams}$$

However, it is to be noted that the other contact arm would still exert the normal force of 94.2 grams.

It will now be apparent that for a 0.001 inch alignment deflection, the force will be only one-sixth the amount required for a 0.001 inch contact arm deflection. This is because the spring rate for each contact arm 12, 13 is 31.4 grams/mil as compared to 5.1 grams/mil for alignment. This very slight force required for alignment gives the spring the aforementioned "free floating" behavior in the alignment direction. This very important and unobvious feature in the connector configuration makes it possible to use the connector device 10 on a dense grid pattern; i.e., due to this floating ac-

tion tolerance accumulations are absorbed that would otherwise make a 0.050×0.050 inches connector system impossible.

There is also a seating spring rate in the direction indicated by the arrows of FIG. 1. This is a compensating function for variations in the assembly tolerances which allows the spring yoke (11) to seat against the back cavity wall 47 (FIG. 3) just prior to inserting the pin into the spring. The seating spring rate, k'' , is determined in accordance with the following formula:

$$k'' = \frac{3E}{\frac{Le^3}{I_c'} + \frac{L_s^3}{I_s'}}$$

where:

$I_c' = W^3 T/12$ = moment of inertia for each contact arm at cross-section W in the seating direction.

$I_s' = (W) T^3/12$ = moment of inertia for the stem at cross-section W in the seating direction.

In the preferred configuration, the seating spring rate, k'' , is 1.5 grams/mil; however, it may vary about ± 25 percent (i.e., between about 1.1 and 1.9 grams/mil) without adverse affect.

Assuming now that the seating spring rate is 1.5 grams/mil, the maximum amount of force required to seat the spring yoke against the cavity wall is $(1.5) (4) = 6$ grams.

In view of the above-described configuration and spring rate interrelationships in the connector device 10, it is uniquely suitable for a wide variety of applications, such as those now to be described, wherein simultaneous multiple connections are desirable without subjecting the connector to longitudinal stresses or forces.

For example, FIGS. 2 and 3 show the improved connector device 10 embodied in a card edge-type connector arrangement. A printed circuit card 20 having a plurality of terminal pins 16, to enable input and output electrical signal connections, is shown with the terminal edge of the printed circuit card 20 attached to a pin carrier member 21. The terminal pins 16 pass through the pin carrier member 21 and project from the bottom of the pin carrier member 21.

A connector base 22 is adapted to receive, support, and make electrical connection with the pin carrier 21 and printed circuit card 20 assembly. The connector base 22 has a plurality of recesses 23, each adapted to embrace and support one of the connector devices 10. The apertures 24 in the connector base 22 are arranged to guide the pin carrier 21 and printed circuit card 20 assembly during insertion wherein the terminal pins 16 projecting from the bottom of the pin carrier member 21 enter the recesses 23 and are positioned adjacent the contact surfaces 15 of the connector device 10. During this operation, no insertion forces are present on the terminal pins 16 or the connector devices 10. An actuation screw 25 which is integral with the pin carrier 21 has an end portion (not shown) that enters the hole 26 in the connector base 22. When the actuation screw 25 is turned, a camming portion of the screw (not shown) conventionally causes the pin carrier 21 to move laterally thereby forceably urging the pins 16 into frictional and electrical engagement with their respective connector devices 10. This lateral movement causes the projections 27 which are part of the pin carrier 21 to move under the ears 28 of the connector base

22 thereby retaining the pin carrier 21 and pins 16 in an electrically engaged position.

FIG. 4 is a showing of a pin and ground rail application utilizing the connector devices of the instant invention. There is shown a portion of a panel board 30 having a plurality of terminal pins 31 mounted in a row thereon. The ground conductor rail 32 is located at a predetermined distance from the row of pins 31 as shown. This connector assembly functions as an electrical connecting means for connecting the electrical conductor elements of cables 33 to the pin connectors 31 and ground conductor 32 on a panel board 30. The connector assembly is adapted to be disengageably mounted on a pin 31 and ground conductor rail 32, and comprises a molded plastic housing 34 for supporting a connector device 10 and a tuning fork connector 35. The lower end of housing 34 has a rectangular terminal pin entrance portion 36. The housing 34 is adapted to support a fork-type spring connector 35 which has been attached to the end of the ground wire of an electrical cable 33 and also a connector device 10 which has been connected with the signal conductor 37 of an electrical cable 33. The inner sides of the fork tines 35a are adapted to engage in straddling relationship and make electrical contact with the ground rail 32. A terminal pin 31 enters the rectangular hole 36 in a position adjacent the contact surfaces 15 of the connector device 10. The housing can then be mechanically and slideably moved so that the terminal pin will enter electrical connecting position between the contact surfaces 15 of the connector device 10.

Alternatively, the connector assembly of FIG. 4 is adapted to be disengageably mounted on a pin 31 and ground conductor rail 32 by insertion longitudinally and directly onto the pin 31 and ground conductor rail 32. With this manner of attachment there will be low insertion forces applied to the connector device 10 and pin 31. However, in this type of application usually only two electrical connections are simultaneously established and the insertion forces are low. The connector device 10 is compatible to this type of application.

FIG. 5 is a showing of a dual in-line package (DIP) application utilizing the connector device 10 of the instant invention. The standard DIP integrated circuit comprises a housing 40 which contains miniature internal circuitry. Electrical contact to the internal circuitry is made through a plurality of leads or prongs 41 extending laterally from the sides of the housing 40. The leads extend from the housing 40 a short distance and are formed to approximately a 90° angle to provide the contact areas. The leads 41 will provide two substantially parallel rows. A connector housing 42, having parallel rows of recesses 43 therein adapted to embrace the connector devices 10 of the instant invention, is attached to a printed circuit board 44. Each of the connector devices 10 in the housing are electrically connected to circuitry on the printed circuit board 44. A pin guide cover 45 having parallel rows of rectangular shaped apertures 46 therein overlies the connector housing 42 and functions as a protective element for the connector devices 10. Obviously the DIP module 40 can be attached to the printed circuit board 44 by introducing the module leads 41 into their respective apertures 46 in the pin guide cover 45 and then slideably moving the module 40 to effect electrical engagement of the pin leads 41 into electrical contact with the contact surfaces 15 of the connector devices 10 within the housing 42.

It should be noted that, as illustrated in FIG. 1, the male connector element 16 when laterally inserted preferably is inserted from the side opposite yoke 11; however, if desired, entry may be from the yoke side. The contact arms 12, 13 are not restricted along that opposite side and therefore have more freedom to yield with the pin 16; whereas during entry from the yoke side, the yoke tends to restrict the freedom of the contact arms during pin entry. Hence, the insertion force required for pin entry will be lower on the side opposite the yoke.

It should also be noted that the convexly curved contact surfaces 15 are preferably cylindrical or barrel-shaped, as illustrated, with the axial direction of the cylinders extending perpendicular to the length of the pin. These contact surfaces will thus provide and maintain reliable electrical contact whether the male connector element be in the form of a round pin or a flat pin or blade.

While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

We claim:

1. An electrical connector for connecting a male member to an electric circuit comprising:
 - a channel-shaped yoke having a base and two side portions, said base and said side portions being of equal thickness,
 - a pair of resilient complementarily configured contact arms, each arm extending parallel to the axis of said channel and connected to the end of one of said side portions, said contact arms together with the side portion of said base having a contact spring rate in an arm-spreading direction that is within the range from 22.6 to 43.3 grams/mil,
 - two convexly shaped contact surfaces mounted on said contact arms,
 - a chamfered edge on one side of each of said contact surfaces to facilitate lateral entry of said male member,
 - a planar stem, said stem being the same thickness as said base and of narrower width than said base, the plane of said stem being parallel to said base, said stem being in line with the axis of said channel and connected to the central portion of said base,
 - said stem having an alignment spring rate in said arm-spreading direction that is within the range of about 3.8 to 6.5 grams/mil,
 - said stem having a seating spring rate in a direction transverse to said arm-spreading direction that is within the range of 1.1 to 1.9 grams/mil,
 - whereby said alignment spring rate is lower than said contact spring rate and said seating spring rate is lower than said alignment spring rate so that said connector has a free floating action with greater flexibility in said alignment direction than in said arm-spreading direction, and greater flexibility in said seating direction than in said alignment direction.
2. An electrical connector for connecting a male member to an electric circuit comprising:
 - a channel-shaped yoke having a base and two side portions, said base and said side portions being of equal thickness,

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a pair of resilient complementarily configured contact arms, each extending parallel to the axis of said channel and connected to one of said side portions, said contact arms together with said side portions of said base having a particular contact spring rate in an arm-spreading direction, 5
two convexly shaped contact surfaces mounted on said contact arms,
a chamfered edge on one side of each of said contact surfaces to facilitate lateral entry of said male member, 10
a planar stem, said stem being the same thickness as said base and of narrower width than said base, the plane of said stem being parallel to said base, said 15

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stem being in line with and connected to the central portion of said base,
said stem having an alignment spring rate in said arm-spreading direction that is substantially lower than said contact spring rate,
said stem having a seating spring rate in a direction transverse to said arm-spreading direction that is substantially lower than said alignment spring rate, whereby said connector has free floating action with greater flexibility in said alignment direction than in said arm-spreading direction, and greater flexibility in said seating direction than in said alignment direction.

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