

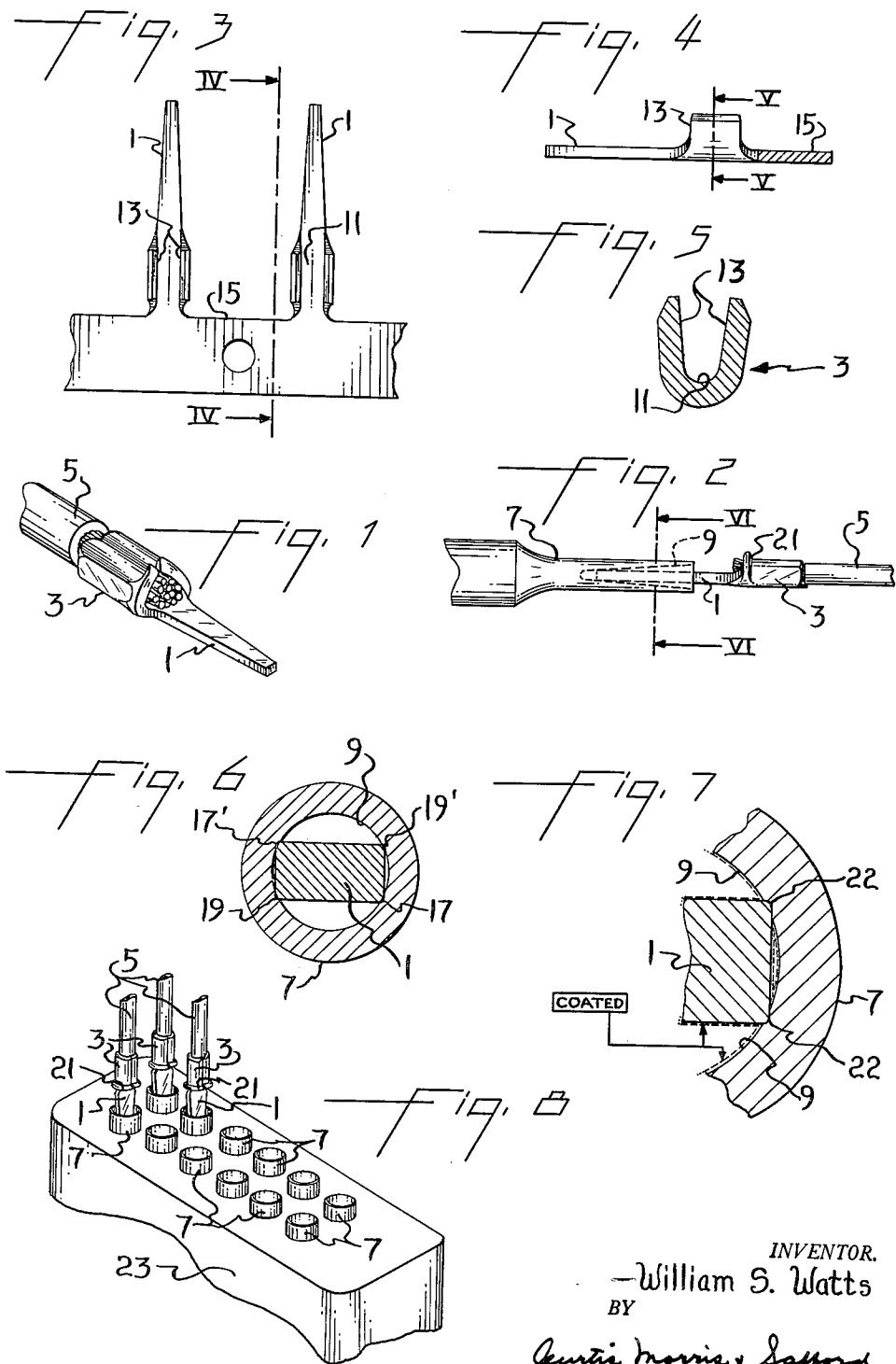
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MINIATURE TAPER PIN

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MINIATURE TAPER PIN

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This invention relates, in general, to electrical connectors and, in particular, to connectors of the taper pin type for use in miniature and sub-miniature applications.

As an electrical connector, the taper pin has become generally accepted because of well established advantages over prior connection methods, especially when used in combination with the solderless technique of affixing connector elements to the ends of wire conductors. In the most common form, the taper pins presently employed are formed by conventional blanking techniques from sheet metal strip stock and rolled to a tapered configuration circular in cross-section whereby to provide series of pins in reel or strip form. As such, the pins are suitable for rapid application to wire ends by automatic or semi-automatic applicator machines in the vast quantities necessary to fill the demand of mass production of electrical devices for a connection of predictable high quality which can be uniformly and easily made. In general, the taper pin connector advantageously can be made in vast quantities uniformly by simple and inexpensive means and can be applied to wires at rapid rates while achieving both a mechanical and electrical connection of uniform high quality. The variety of applications for the taper pin as heretofore designed has been limited, however, to uses where the space allotted to the connection made thereby is at least of a given volume since, as a practical matter, the minimum size of such pins cannot be less, for example, than the minimum dimension to which sheet metal stock can accurately be rolled by the fabricating dies. Although these pins are relatively small in comparison with other types of connectors, nevertheless, there are many applications wherein the connector size must be further reduced in order to satisfy present day emphasis on the fullest degree of miniaturization possible.

Other forms of taper pins, such as a pin of solid circular cross-section and made, for example, by a cold-heading operation or as a screw machine part, have been employed in special application, but these pins lack the attributes desired in a connector designed for mass production and use. For example, by virtue of the method of manufacture, such pins are made as separate parts which renders more difficult the mass handling of the connectors and installation thereof as the means for terminating electrical conductors.

It is, therefore, an object of the present invention to provide a solderless electrical connection of miniature size.

Another object is to provide a miniature solderless connector which is simple to fabricate and convenient to use either on an individual or a production line basis in the production of electrical devices.

A further object is to provide a taper pin connector having a configuration which can be reproduced by blanking or stamping sheet metal whereby the minimum size for the part is limited primarily only to the degree to which stamping or blanking operations may be accurately

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and uniformly performed to the tolerances required of a particular use.

A still further object is to provide a taper pin generally of rectangular cross-section and of miniature dimensions which approximates the characteristics of a taper pin having continuous, generally circular bearing surfaces.

Still another object is to provide a taper pin connector of miniature size which is capable of cooperation with taper pin receptacles of general design.

Other objects and attainments of the present invention will become apparent to those skilled in the art upon a reading of the following detailed description when taken in conjunction with the drawings in which there is shown and described an illustrative embodiment of the invention; it is to be understood, however, that this embodiment is not intended to be exhaustive nor limiting of the invention but is given for purposes of illustration in order that others skilled in the art may fully understand the invention and the principles thereof and the manner of applying it in practical use so that they may modify it in various forms, each as may be best suited to the conditions of a particular use.

In the drawings:

Figure 1 is a perspective view of a taper pin connector embodying the present invention affixed to the end of an electrical conductor;

Figure 2 is a side view in elevation of the taper pin connector of Figure 1 in operative connected relation with a mating tapered receptacle;

Figure 3 is a fragmentary plan view of a strip of connectors prior to attachment to the end of a wire;

Figure 4 is a view taken along lines 4-4 of Figure 3;

Figure 5 is an enlarged sectional view taken at lines 5-5 of Figure 4;

Figure 6 is an enlarged sectional view taken at lines 6-6 of Figure 2;

Figure 7 is a fragmentary sectional view similar to Figure 6 for the purpose of illustrating the details of the surfaces of the connector and the receptacle which are in contact; and

Figure 8 is a perspective view illustrating a plurality of receptacles mounted in a supporting block together with several taper pins in connected position.

With reference to Figures 1 and 2, the connector of the illustrated embodiment of the present invention in general includes a taper pin portion 1 and a ferrule portion 3 integrally formed from a unitary section of a suitable metal, such as brass, ferrule 3 being permanently attached on the bared end of conductor 5 to serve as the means whereby conductor 5 is coupled through pin 1 to contact member 7. An elongated opening or socket 9 in member 7 serves to receive pin portion 1 in electrical and mechanically locked engagement in a manner to be described in detail.

To secure the maximum advantages in use of the connector, ferrule portion 3 preferably is of a configuration capable of utilizing the solderless technique of cold-forging or crimping electrical connectors to a wire and thus, prior to installation on conductor 5, Figures 3 to 5, typically comprises a trough 11 into which conductor 5 is laid and a pair of ears 13 laterally extending from opposed side edges of trough 11. Ears 13, in the illustrated embodiment, are adapted to be curled around the conductor and pressed in conjunction with trough 11 into a predetermined volume substantially as described, for example, in the copending application to Kemper M. Hammell, Serial No. 311,265, filed September 24, 1952, now Patent No. 2,818,632, issued January 7, 1958. As thus defined, the ferrule configuration permits the connector of the present invention advantageously to be formed in continuous strips by blanking and forming methods well known in the art and wound on reels so

as to be applied to wire ends by automatic or semi-automatic connector applicator machines as disclosed, for example, in the copending application to Quentin Berg, Serial No. 151,795, filed March 24, 1950, now Patent No. 2,778,097, issued January 22, 1957. Thus, a plurality of such connectors may be formed, as indicated in Figure 3, so as to be joined in strip form by a linking strip 15 in a ladder-like arrangement, the linking strip 15 being severed from the individual connectors as they are being applied by the applicator machine to the associated wire end.

Socket 9, Figure 2, preferably is tapered and at an angle corresponding to the taper of pin portion 1. In accordance with the preferred embodiment pin portion 1 is an elongated strip of metal generally rectangular in cross-section, the side edges of the strip tapering toward the end remote from ferrule 3 so that at substantially all the points along the length of the connection made with contact member 7, the corners of the pin, defined by the rectangular cross-section, will be in contact with the side walls of socket 9, as illustrated in Figures 6 and 7. Upon the pin being driven into connective relationship with contact member 7, engagement therebetween will comprise the lines of contact established by the diagonally opposite pairs of side edges 17-17' and 19-19', Figure 6, of the pin with the side walls of socket 9. In this connection, where the taper angle of the socket is chosen to match the taper of the pin, it should be noted that the relative convergence of the diagonally opposite edges, for example, the pair of side edges 17-17' control the action of the pin and which therefore should be matched rather than the convergence of adjacent side edges such as edges 17 and 19.

In general, the taper angle, i.e., the angle of convergence of the side edge pair 17-17', should be within the range of angles such that the pin may be regarded as self-locking upon proper insertion. That is, force is required to extract the pin when fully inserted, which force is comparable and proportional, within proper limits, to the force of insertion. The degree to which the pin will stick or be locked within the receptacle will, of course, depend both upon the taper angle and the coefficient of friction between the surface of the pin and receptacle side walls. For wider angles within the self-locking range, however, the less will be the force effective to withdraw the pins as a consequence of imparting a given driving force to the elements, and the greater will be the axial component of force tending to loosen the pin, thereby resulting in less secure locking of the parts. Conversely, the smaller the angle of convergence the farther the pin will have to be inserted in order to produce the desired stress relationship at the contact surfaces, and the effect of any manufacturing irregularities will be emphasized. As a practical matter, to obtain the optimum locking force upon application of that amount of force which, in view of the size and strength contemplated of the parts, realistically is available to insert the pins, the upper limit of taper angle is about 7°. To hold the insertion distance to a reasonable value, especially in view of acceptable variations within fabrication tolerances in the size of the parts, the lower limit of the taper angle is about 3°. In addition, the metal used in fabricating the pin and receptacle, the treatment, such as plating, given to the engaging surfaces, the physical character of the surfaces, the amount of force for effecting optimum pin insertion, etc., all become more important and critical and, upon variation, subject the character of the connection to greater variation where the taper angle is increased above 4° or decreased below 3°. Thus, for taper angles which depart from between 3° to 4°, there is an increased tendency to obtain disadvantageous variations in the mechanical and electrical characteristics of the connections produced. A taper angle of 3.5° has been found to achieve the most consistent and predictable results: and a connection of high quality both with re-

spect to electrical contact resistance and the degree of resistance to mechanical disconnection, when made in accordance with the present invention.

As alluded to above, this invention contemplates achieving a taper pin having approximate the characteristics afforded by the conventional type of taper pin, i.e., those that are circular and solid or effectively solid in cross-section such as may be formed by rolling up a strip of sheet metal, but in a range of sizes below the minimum size to which the common type of pin can practically be made. With reference to the rolled form of taper pin, for example, such qualities of the of the sheet metal as width, thickness, rigidity, etc., obviously are factors which are limiting on minimum size from the mechanical aspects of the forming operation involved. In addition, however, in order to achieve at the ferrule end of the connector an electrical and mechanical connection of high quality utilizing cold-forging or crimping techniques, and at the pin portion of the connector a structure which can withstand the high external and internal stresses applied respectively during insertion and seating, the aforesaid limiting factors must be substantially enlarged from the minimum established solely from a consideration of the mechanical forming operation. Primarily, therefore, the lower practical limit for the circular taper pin depends upon the characteristics desired in the ferrule portion used in combination with the pin, the diameter of the wire to be coupled by the pin, the force applied to the pin on insertion, and the capability of mass production methods to form sheet metal stock with uniform and accurately predictable results. A realistic appraisal of all the involved factors dictates a minimum diameter of about 50 thousandths of an inch at the insertion end of the rolled type of pin which is well above the maximum size desired in many applications where space requirements are at a premium and miniaturization is to be emphasized.

It has been found, however, that both the mechanical and electrical action of the circular taper pin may be closely approximated by a taper pin having a rectangular cross-section and that such a pin may be uniformly and accurately made in miniature sizes utilizing mass production methods, preferably from sheet metal by stamping and blanking techniques well known in the art. In the illustrative embodiment of the invention pin portion 1 specifically comprises a strip of metal substantially constant in thickness and of uniformly decreasing width along the pin length so that the minor side faces of the strip converge at the desired taper angle, for example, 3½°, which configuration is advantageously susceptible of fabrication simply by a blanking or shearing operation on sheet metal.

As thus constructed, it is contemplated that the taper pin will be driven into socket 9 by means of an insertion tool which delivers to the pin a measured amount of energy, such tools being exemplified by the copending application of Gilbert C. Sitz, Serial No. 408,632, filed February 8, 1954, now Patent No. 2,774,133, issued December 18, 1956. For receiving the driving impulse of the insertion tool the pin is provided with a laterally extending element 21 in the form of a rib or shoulder which conveniently may be formed as a part of the ferrule portion 3 during the crimping or cold-forging of the pin to conductor 5. In the crimping operation, preferably in accordance with the aforesaid application, Serial No. 311,265, now Patent No. 2,818,632, the opposed ears 13 of ferrule portion 3 are initially curled inwardly and around a wire; thereafter the entire periphery of the ferrule is tightly compressed into intimate contact with the wire, resulting in a crimped connection which is generally rectangular in shape as shown in Figures 1 and 2. To form shoulder 21 the curling dies which effect the crimping action are relieved at their forward ends so that, as a consequence of the curling and compression action, there is left at the forward end

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of the ferrule, adjacent the base of the pin portion, a lateral extension having a rearwardly facing surface engageable by the driving surface of the insertion tool.

To maintain the least possible lateral dimensions for the pin, the significant dimension of shoulder 21 preferably is raised from the top of ferrule 3, as seen in Figures 1 and 2, and therefore adds lateral width only of the minor dimension of the rectangle formed by the ferrule.

Upon insertion of the pin, lines of electrical contact will be established, as discussed in connection with Figure 6, and stresses will be set up at the contact surfaces which gives rise to the friction securing the pin in connected position. A square configuration obviously provides maximum rigidity and stability in a pin of rectangular shape, and advantageously distributes as evenly as possible the stresses imposed by the pin on the receptacle. Conversely, as the thickness of the pin decreases relative to its width, the rigidity and stability decrease while the stresses involved become more localized rendering the connector less efficacious. For example, for a pin of relatively low rigidity more care and lower driving or inserting forces are required in order to seat the pin and to avoid bending of the pin shank during the driving operation. Hence, a pin below a minimum thickness relative to width is ineffective as a taper pin connector. Between the limits of relative thickness it has been found that adequate mechanical characteristics are had where the thickness of the pin is at least one-third the diameter of the socket. The acceptable range thus defined advantageously admits of a pin of rectangular cross-section and of uniform thickness along its length, which therefore permits fabrication of the connector by the convenient method, from a mass production standpoint, of blanking or stamping a continuous strip of sheet metal.

In blanking the pin portion from sheet metal, due to the miniature size involved the thickness of the sheet metal stock should also be selected in view of the limitations imposed by the formation and application of the ferrule portion of the connector. For example, to impart sufficient mechanical strength to the ferrule, both to withstand the high crimping pressures during application and external stresses encountered in use, a relatively thick metal stock is preferred; but in formation of the U-shape of the ferrule (Figure 5) around appropriate forming dies, a thinner metal stock is preferred to obtain accurate and consistent "U-ing" operation. Accordingly, a consideration of all the factors which bear upon the relative dimensions of the connector, both in view of the mechanical problems involved and the preferred electrical and mechanical characteristics of the connection to be formed, demonstrates that an optimum configuration of the pin in cross-section is had where the cross-sectional diagonal at the maximum width within the active length of the pin is approximately $2\frac{1}{2}$ times the pin thickness. Assuming a circular receptacle, or socket, the pin thickness should thus be approximately $\frac{1}{2}$ the diameter of the socket mouth. In this connection for maximum effectiveness the active length of the tapered portion of the connector should be at least $2\frac{1}{2}$ times the greatest width of the pin.

By way of specific example, good results were obtained utilizing a pin formed from sheet stock 20 thousandths of an inch in thickness, the active tapered portion of the pin having a length of approximately 200 thousandths of an inch and a maximum width of 46 thousandths of an inch. The side faces of the pin converge relative to the longitudinal axis at a taper angle of $3\frac{1}{2}$ degrees, the associated receptacle being provided with a matching tapered socket of inside dimensions generally conforming to those of the pin. For insertion purposes a laterally greater dimension of approximately 15 thousandths of an inch at shoulder 21 as compared to the remainder of ferrule portion 3 sufficed to provide an area for engagement by the driving face of the insertion tool.

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For a pin constructed in accordance with the specific example given above, a driving impulse of sufficient magnitude to result in a connection having a tensile strength in excess of the contemplated minimum of 10 pounds is easily obtained in insertion tools of the type referred to above. The magnitude of the force of application, compared to the size of the parts as indicated above, is relatively great which produces high localized stresses at the lines of contact. As a result, scoring of the inside walls of the receptacle and burnishing of the relatively sharp side edges or corners of the pin will occur on driving the pin, as best shown in exaggeration at 22 in Figure 7, which significantly increases the width of the longitudinal line of contact. Intermediate the contact areas along the side corners there will, of course, be major surface portions of the rectangular pin which remain spaced from and free of engagement with the socket sidewalls as shown in Figure 7. The degree to which the parts are deformed during insertion depends, of course, upon the character of the metal comprising the parts. In order to achieve maximum tensile strength the metal chosen should be relatively hard and resilient, for example, hard brass, which would tend to reduce deformation and hence the width of the line of contact. For increasing corrosion resistance and electrical conductivity of the connection, however, it is preferred that the surfaces of the receptacle and pin be plated with a metal such as tin, silver or gold. Since these plating metals generally are of a significantly greater plastic character than the base metal, the high localized stresses set up during insertion advantageously tend plastically to flow the plating material laterally from the line of contact in a manner substantially to increase the area of contact.

The receptacle illustrated in connection with the preferred form of the invention has been described to be circular in cross-section and tapered at an angle corresponding to the taper angle of the pin; it is to be understood, however, that the taper pin may advantageously be used with a variety of receptacle configurations. For example, the socket may be a rigid cylindrical structure or may have a taper differing from the angle of taper of the pin, according to the characteristics desired of the specific connection to be made. Further, the metal comprising the receptacle may be more or less soft or thin so that on driving the relatively rigid pin, the receptacle side walls will yield more or less as desired into conformance with the taper of the pin.

Figure 8 illustrates one of the common methods of utilizing the taper pin as a connector. As shown, a block 23 of a suitable insulating material supports in closely spaced relation a plurality of receptacles 7 in mutual parallelism, each receptacle providing the terminus of an electrical circuit, not shown. On insertion, the taper pins assume rigid, axially parallel positions, and, when formed in accordance with the present invention, admit of a concentration of connections per unit area limited substantially only by the space requirements of the receptacles associated therewith.

I claim:

1. In an electrical connection, a connector in the form of a flat pin substantially rectangular in cross-section, at least the diametric side corners of said pin uniformly converging toward one end thereof, a circumferentially continuous socket circular in cross-section receiving the pin, said side corners being in forceful engagement with the side walls of said socket substantially over the length of said pin and the thickness of said pin being at least one-third the cross-sectional diagonal at the maximum pin width along the pin length within said socket, the metal of said sidewalls being deformed around said side corners to provide surface conformance and engagement therebetween extending a significant distance across both the plane surfaces defining each side corner of the pin, major surface portions on the four sides of the rectangular

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pin intermediate said side corners being spaced from and free of engagement with the socket sidewalls.

2. In an electrical connection, a connector in the form of a flat pin substantially rectangular in cross-section, the diametric side edges of said pin uniformly converging toward one end thereof, a socket receiving the pin and being approximately circular in cross-section and originally tapering away from the mouth thereof at an angle substantially corresponding to the convergence of said side edges, the contact surface of said socket being at least coextensive with the length of said pin, and the thickness of said pin being approximately one-half the original diameter of the mouth of said socket, and the maximum width of the pin being approximately 0.046 inch.

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