April 6, 1965 P. J. GRAY 3,177,405

MODULAR ELECTRICAL ASSEMBLY

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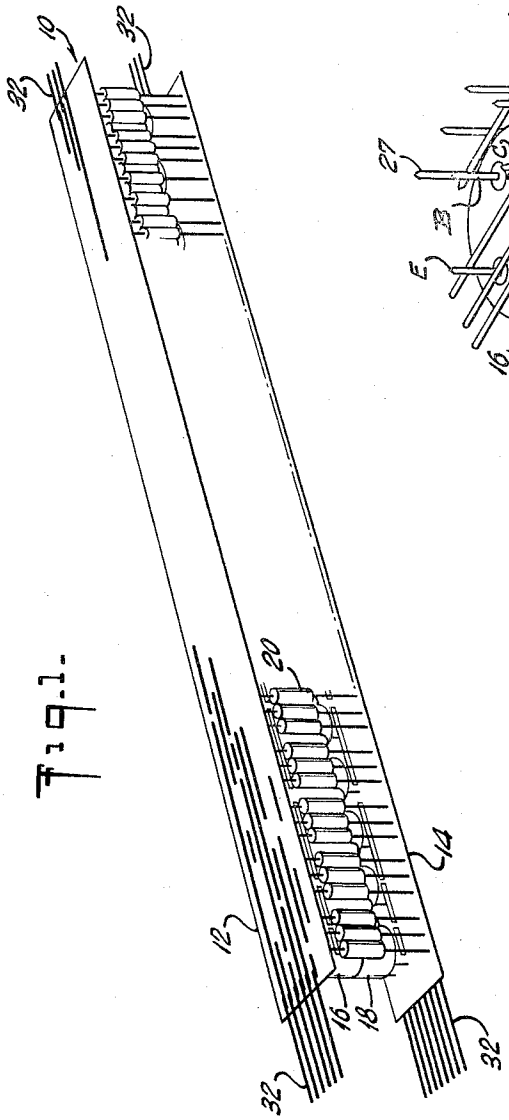


Fig. 1.

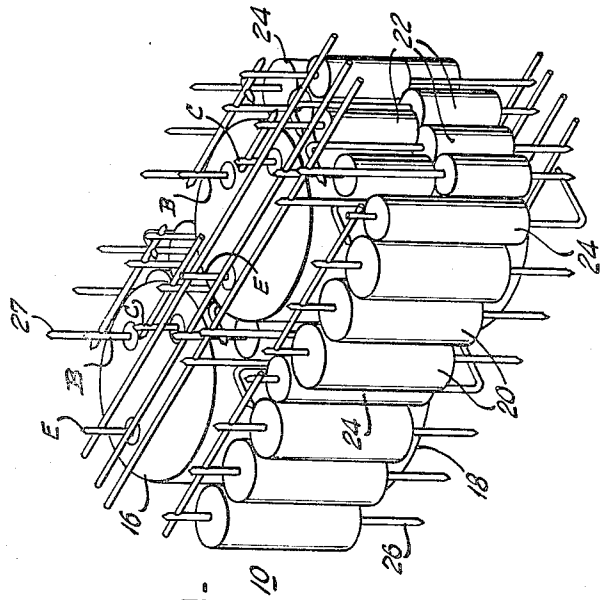


Fig. 10.

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Fig. 2.

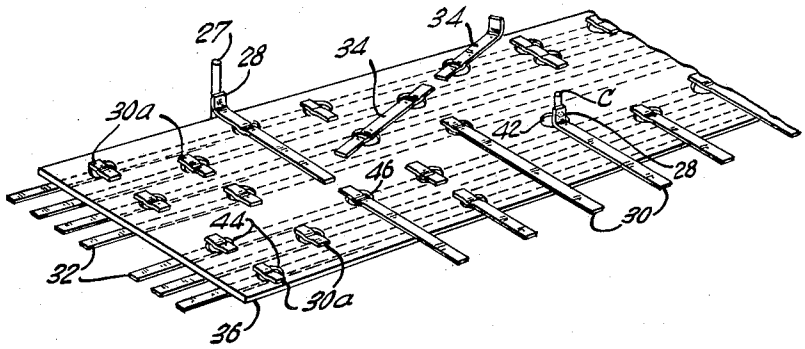


Fig. 3.

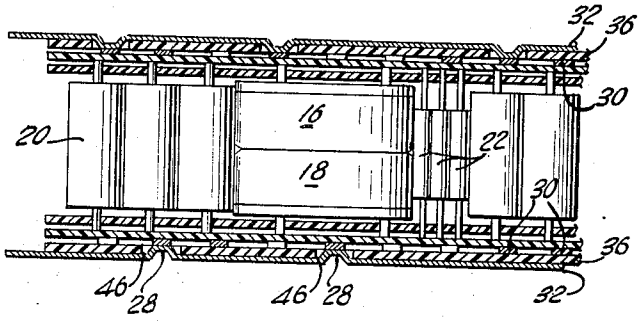
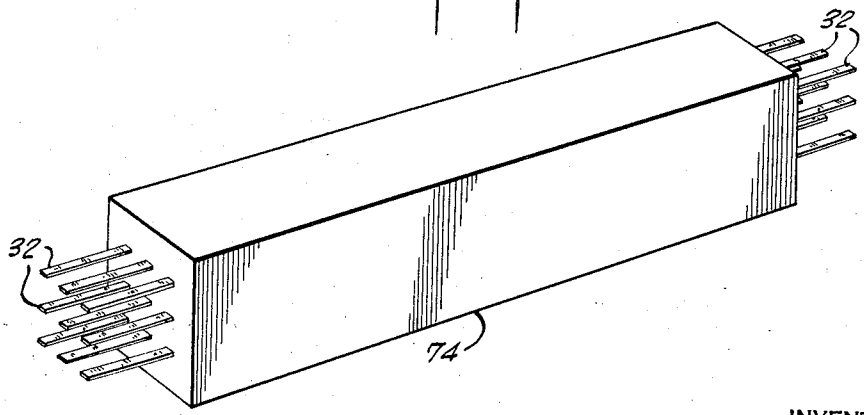


Fig. 8A.



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Fig. 4.

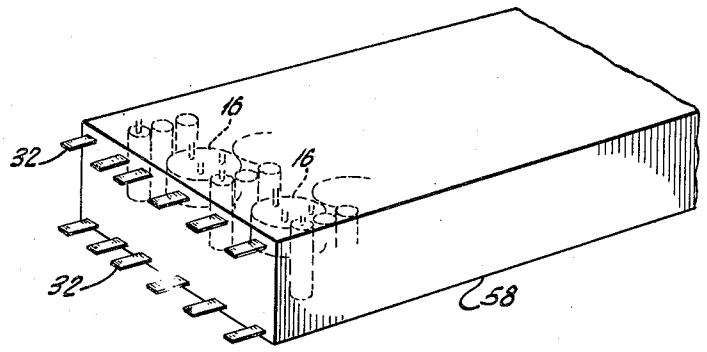


Fig. 5.

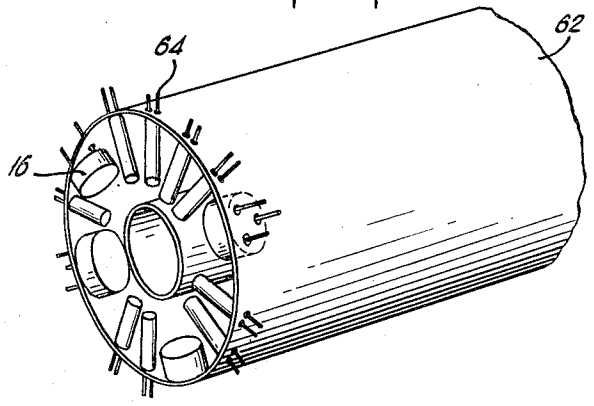
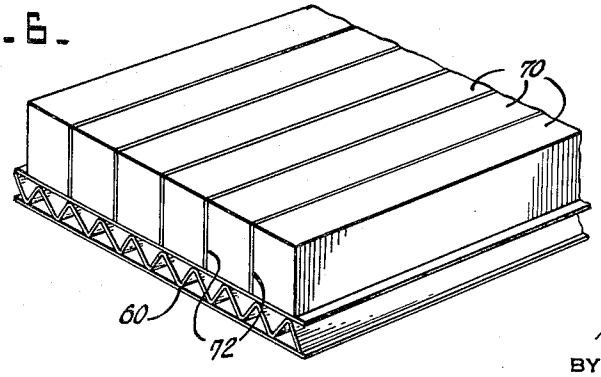


Fig. 6.



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FIG. 7.

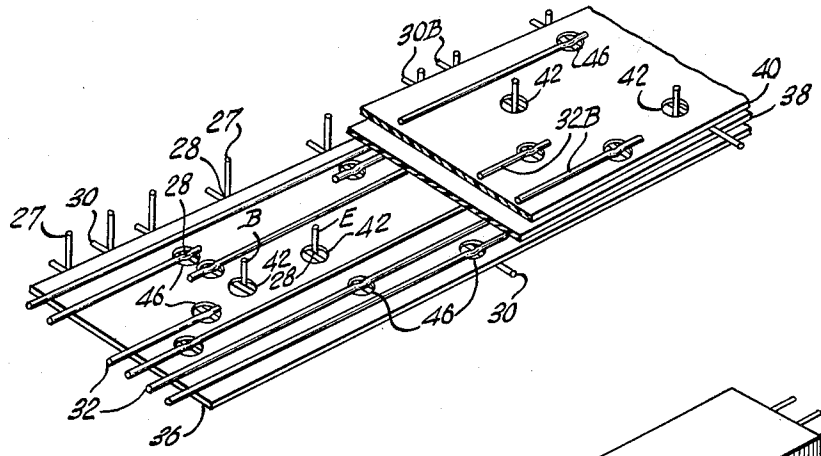


FIG. 8.

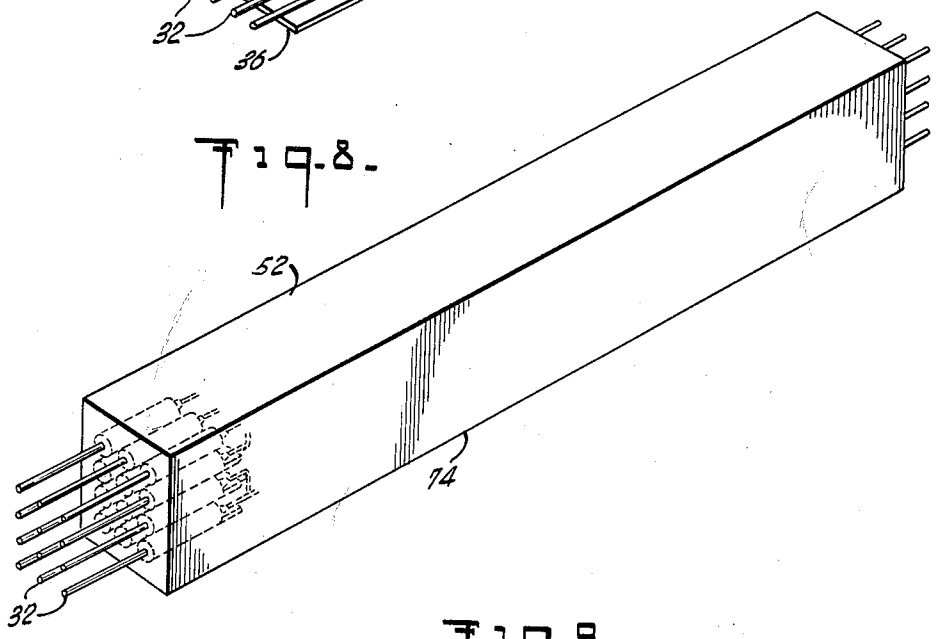
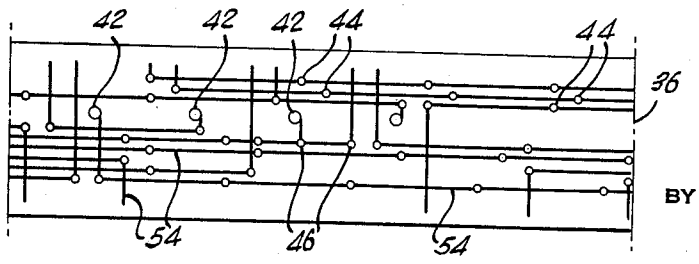


FIG. 9.



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United States Patent Office 3,177,405 Patented Apr. 6, 1965

3,177,405

MODULAR ELECTRICAL ASSEMBLY

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Filed Dec. 23, 1959, Ser. No. 861,619
11 Claims. (Cl. 317—101)

The present invention relates in general to electrical interconnection of complex and compact assemblies of electrical components, and particularly to an improved conductor structure and fabrication method.

The present application is a continuation-in-part of applicant's prior co-pending application serial No. 771,042, filed October 31, 1958, now abandoned.

In a number of branches of electronics there is a necessity for building a great number of interconnected circuits in to a very small space. In some instances these circuits must be formed into very compact assemblies having a high immunity to vibration and shock. It is desirable also that large numbers of such assemblies be capable of being packed close together. Under these severe requirements the provision of interconnecting wiring and external wiring, without a great increase in the size of the miniaturized assembly, is a very difficult problem. While a great deal of emphasis has been placed upon electrical component size reduction in recent years to accomplish miniaturization, an equivalent emphasis has not been placed upon the size reduction of the interconnecting wiring thereof. Accordingly, the result has been an increase in the ratio of interconnection weight to component weight, inconsistent with the size and weight reductions made by the miniaturization of the components. It is one of the objects of the present invention to solve this problem.

It is another object of the invention to provide wiring arrangements for a complex assembly of electrical circuits without excessively increasing the size and weight of the assembly.

Another object of the invention is to provide interconnecting conductor arrangement for assemblies of large numbers of electrical components which structurally conform to the assemblies but do not excessively increase their size and which actually increase the rigidity of the assemblies.

A still further object of the invention is to provide an improved welded conductor wafer or matrix employing a novel conductor attachment technique.

Yet another object of the invention is to provide an improved method of attachment of conductors to opposite sides of an insulating sheet.

The present application will be illustrated with respect to electrical assemblies of the type disclosed in application Serial No. 736,529, filed May 20, 1958, and now U.S. Patent No. 2,911,572, although it should be understood that the invention is in no way limited to this specific application. The assemblies may be in the form of a rod of more or less rectangular cross section. The components may be transistors, rectifiers, resistors, thermistors, capacitors, etc. packed together closely so that there is substantially no room between them for interconnecting conductors. My prior application disclosed the manner in which the connections can be made for placing each transistor and its neighboring components in a desired circuit. According to the present invention interconnections between the different circuits and connections from these circuits to external input, output and voltage sources are provided by means of wiring assemblies in the form of sandwich-like conductor panels which may be connected to a side or end of the electrical assembly.

Each of the wiring panels may consist of a layer of

substantially longitudinal conductors, another layer of substantially transverse conductors and an insulating film or sheet lying between said layers of criss crossing conductors. The insulating layer is provided with a multiplicity of spaced apertures at selected crossover points to permit electrical connection between opposite side conductors. The film may be very thin and the conductors may be either in the form of wires or very thin strips or ribbons. Although most of the conductors extend beyond one or more longitudinal edges of the insulating layer for connection to component leads, some component lead connections are made directly to the conductors by welding at the location of enlarged apertures in the insulation film. The panels are prefabricated before being placed on the electrical assembly so that the connections between intersecting conductors on the panel may be made under the most convenient conditions and the panel, which is stiffened by these connections, can be easily placed in position on the assembly to permit the remainder of the required connections to be made. After the component lead welding is completed the assembly input and output conductors are suitably grouped on exterior surface of the electrical assembly and the resulting structure may be encapsulated in a suitable insulating compound.

The criss-cross conductor matrix of the invention is readily adaptable to other shaped electrical packages and may easily be conformed to the exterior contour of, for instance, a cylindrical package. If, when necessary, the desired electrical interconnection of components cannot be made upon a single conductor panel, a second similar conductor panel may be placed thereover using suitable insulation therebetween. Again, welded connection is made between selected leads about the periphery of the panel and also to leads projecting through the first and second panels.

Other objects and advantages of the invention will become apparent and the invention itself will be fully understood from the following description.

In the drawings:

FIG. 1 is a picture of a semi-complete electrical component assembly including conductor panels before encapsulation;

FIG. 2 is a partial isometric view of a conductor panel employing ribbon-like conductors;

FIG. 3 is a side elevation view of an electrical module showing upper and lower conductor panels in connected relation;

FIG. 4 is a partial perspective view of another form of the invention as applied to a slab-like module;

FIG. 5 is a perspective view of a cylindrical package employing single ended components prior to securing of a conductor panel thereto;

FIG. 6 is a perspective view of the invention showing an array of adjacent component assemblies separated by aluminum sheets and mounted upon a heat conductive plate;

FIG. 7 is an isometric view of two panels employing round conductors and separated from one another by a third insulating sheet;

FIG. 8 is a perspective view of an encapsulating assembly showing the routing of the longitudinal panel conductors into a spaced terminal arrangement at opposite ends thereof;

FIG. 8*a* is a perspective view similar to FIG. 8 wherein ribbon-like conductors are employed for module interconnection;

FIG. 9 is a top plan view of an insulating sheet having printed thereon conductor placement guide lines and aperture locations; and

FIG. 10 is an isometric view of two units of the elec-

trical assembly before the conductor panels are added.

Referring to the drawings there is shown a semi-completed component assembly or module 10 provided with upper and lower conductor panels, respectively 12 and 14. The panels or matrices 12 and 14 may be located on one side of the assembly if desired by employing components having lead terminations on a single side. The assembly may consist of a large number of units arranged in a row so as to form a rectangular and rod-like cross section. Each unit may include a pair of transistors 16 and 18 connected back to back and having emitter, space and collector electrodes, respectively E, B and C, extending from the top and bottom thereof (FIG. 10). Module 10 also includes diodes 20, resistors 22 and capacitors 24. The components are partially electrically interconnected prior to applying the matrices 12 and 14 by wiring which is shown in FIG. 10 into circuits which may be of a general form shown in FIG. 1 of the above-mentioned patent. Component leads 26 and 27 extend from diodes 20 in substantially parallel arrangement and perpendicularly intersect the plane of the subsequently applied conductor panels 12 and 14. The assembly 10 illustrated in FIG. 1 and partially in FIG. 10 is formed in the manner fully described in Patent No. 2,911,572.

The conductor panels 12 and 14 are formed separately prior to connection to the component assembly. The two conductor panels in this particular embodiment of the invention are similar mechanically, but differ electrically. Refering to FIGS. 2 and 7, each conductor panel consists of a plurality of spaced conductors 30 and 32 of substantially parallel wires extending respectively transversely and longitudinally and having an insulating film 36 therebetween. More than a single conductor wafer may be required and accordingly, a second layer is shown composed of conductors 30*b* and 32*b* separated by a similar insulating film 40. A separate insulating sheet 38, suitably punched with apertures, is provided to electrically insulate the conductors on adjacent panels from one another. The conductors may be in an oblique direction as at 34 and extend beyond the longitudinal edges of the insulating films 36 and 40 and may be connected to the upstanding component leads 27 by welding at 28. Electrical connections between the conductors on opposite sides of the insulating sheet is accomplished by welding through a plurality of spaced apertures 46. As best seen in FIGS. 2 and 9, the insulating sheet 36 is provided with a multiplicity of spaced apertures, numbered 42, 44 and 46. Apertures 44 are provided to permit securing tab welds to be made. The transverse conductor tabs 30*a* function to secure and prevent shorting between adjacent longitudinal conductors 32, particularly at the ends of the conductor panels. In like manner similar securing tabs may be employed to align transverse conductors. The apertures 42 are of a slightly increased size and allow the weldable connection between a selected component lead and a portion of a transverse or longitudinal conductor. Apertures 46 locate the welds which electrically connect a transverse conductor to a longitudinal conductor on opposite sides of the matrix.

In FIG. 9 a typical insulating sheet 36 is shown having printed thereon a wiring layout pattern of conductor guide lines 54. This conductor layout can be conveniently reproduced directly to the insulating sheet in one of any well known photo transfer processes or printing methods. The desired location of each of the apertures 42, 44 and 46 is also indicated.

It will be understood that all vertically projecting leads may extend through one or more layers of cross conductors and insulation sheets to the particular layer at which a connection is required. It is desirable to arrange the terminating connections on the one hand, and the through connections or buss connections on the other hand, in groups, in different areas of the conductor panel. Thus, in FIG. 7 the through connections are generally at the bottom or right in what may be called a traffic area, and above or to the left of the traffic area there is a termination area.

The conductor matrix may be conveniently constructed by arranging the criss-crossing grid pattern of the transverse and longitudinal conductors on opposite sides of the insulating sheet in any well known jigging arrangement. The required welds would then be made at the aperture 44 and 46. Upon removal from the jig (not shown), severing of any unwanted transverse or longitudinal conductor portions can be made. This principle of removing unwanted conductors, is illustrated and easily seen by reference to the securing tab portions 30*a* in FIG. 2 which have been formed by the severance of the interconnecting linear portions of a previously attached transverse conductor 30. The conductor matrices 12 and 14 thus formed, are placed on the top and bottom of the assembly 10 and welded to the leads 27, B, E, etc. The longitudinally extending conductors 32 and 32*b* are then suitably spaced and grouped in a predetermined connector pattern on a surface of the assembly and the entire structure is encapsulated with an insulating compound 52 into an elongated module 74 (FIG. 8).

Referring to FIGS. 4, 5, 8, and 8*a*, various shaped electrical module assemblies are shown. A slab-like encapsulated module 58 employs a side by side transistor placement arrangement with abutting placement of the associated resistors and condensers, etc. In this form the upper and lower surfaces of the slab could contain the conductor matrices of the present invention. In this way a larger surface area is made available for the electrical interconnection of all the component leads on a single side of the module. Alternatively, this form of the invention could employ components having their electrical terminations at a single end thereof, and in this case all of the upstanding vertical component leads would project from the upper surface of the flat module. In another module form, single ended components having leads 64 may be inserted through apertures in a tubular insulating sleeve 62. The invention may be formed about the outer periphery of this cylindrical tube to similarly interconnect and provide the desired electrical circuitry between the various components.

Yet another module arrangement is shown in FIG. 6 wherein a plurality of electrical packages 70 are arranged side by side upon a corrugated heat transfer plate 68. To enhance package to plate heat transfer, separators 72 are employed between the heat generating units. These upstanding separators may be conveniently made of aluminum and attached to the heat transfer plate 68 by welding along their lower edges.

Thus it can be seen that the invention provides an improved method for constructing miniaturized interconnecting electrical panels which are readily welded to modules of various shapes. The desired circuits are provided in an extremely compact manner by employing welded connection through apertures in an insulating layer between transverse, oblique and longitudinal conductors. The conductors so placed upon the insulating sheet are held thereto by virtue of the interconnecting welds themselves and no separate bonding of the conductor to the insulating sheet is required. The invention is equally adaptable to conductors having round or rectangular cross sections and is not intended to be limited specifically thereto.

It will be understood that the embodiments herein disclosed are intended to be illustrative of the techniques and structures, which in accordance with the invention, can be applied advantageously to many types of electrical equipment. It will be evident that many more conductors and connections may be used than have been illustrated. Many variations and modifications of the particular embodiments herein disclosed will be apparent to those skilled in the art and therefore this invention is not to be construed as limited except as defined in the following claims.

What is claimed is:

1. An electrical wiring arrangement for providing connections to a first assembly of closely packed electrical components having leads extending in opposite directions, comprising a pair of second assemblies on opposite sides of the first assembly, each second assembly including a plurality of layers each having substantially parallel conductors and a flexible sheet of insulating material interposed between adjacent layers of said conductors, some of said conductors having portions thereof removed, the conductors of one layer extending transversely to the conductors of an adjacent layer, said insulating sheet having holes at the intersections of certain of the conductors on opposite sides of the sheet, and electrical connections between said certain conductors within said holes, means including said electrical connections for holding said layers of conductors and said insulating sheet in a rigid assembled condition, certain of said electrical component leads extending through said holes and intersecting said conductors, and electrical connections between said conductors and leads at their intersections.

2. An electrical wiring arrangement according to claim 1, wherein a plurality of electrical component leads extend into said holes in said flexible insulating sheet and have electrical connection to the conductors at said holes.

3. An electrical wiring arrangement according to claim 1, wherein the leads of the electrical components intersect the conductors and are electrically connected thereto beyond the boundary of the insulating sheet.

4. An electrical wiring arrangement according to claim 1, including a multiplicity of layers of first substantially parallel conductors extending in one direction and a multiplicity of layers of second substantially parallel conductors extending transverse to the first conductors and a plurality of insulating sheets separating adjacent layers of said conductors.

5. An electrical wiring arrangement according to claim 1, including an insulating compound encapsulating said first and second assemblies.

6. An electrical interconnection arrangement for a compact assembly of electrical components arranged side by side in contacting relation and having leads extending along a first pair of opposite sides in opposite directions, comprising a pair of conductor panels, each panel including a plurality of layers of substantially parallel conductors and a flexible film of insulating material interposed between adjacent layers of said conductors, some of said conductors having portions thereof removed and others of said conductors extending continuously from one end to the opposite end of the layers, the conductors of one layer extending transversely to the conductors of an adjacent layer, said insulating film having holes at the intersections of certain of the conductors on opposite sides of the film, and welded electrical connections between said certain conductors within said holes, means including said welded electrical connections for holding said layers of conductors and said insulating film in a rigid assembled condition, said conductor panels being mounted on said opposite sides of said electrical component assembly with the leads extending into the holes of said panels, and electrical connection between said conductors and leads at their intersections.

7. An arrangement according to claim 6, wherein each panel includes a multiplicity of layers of first conductors extending in one direction and a multiplicity of layers of second substantially parallel conductors extending substantially perpendicular to the first conductors and a plurality of insulating films separating adjacent layers of said conductors.

8. An electrical interconnection arrangement comprising, a flexible film of smooth surfaced insulating material having a plurality of apertures, a plurality of first conductors extending longitudinally upon said film having portions extending over selected apertures in said film and end portions extending beyond the edges of said film, a plurality of second conductors on the opposite side of said film extending transverse to said first conductors and intersecting said first conductors at predetermined apertures in said film, said second conductors having end portions extending beyond the edges of said film, first welds at selected aperture locations to electrically interconnect predetermined first conductors with predetermined second conductors, a plurality of third conductors of short length overlying predetermined apertures in said film, and a plurality of second welds connecting each of said third conductors to an associated conductor on the opposite side of said film, said third conductors acting to mechanically secure said associated conductors to said film and to prevent shorting thereof.

9. Apparatus according to claim 8 including, in combination, a compact assembly of electrical components arranged side by side in contacting relation and having connection leads extending therefrom, said leads being weldably connected to selected end portions of said second conductors which extend beyond the edges of said film.

10. A flexible electrical interconnection arrangement according to claim 10 wherein said film is formed into a cylindrical tube and includes a plurality of tightly packed electrical components arranged radially side by side in contacting relation having connection leads extending radially therefrom, said connection leads being welded in predetermined fashion to said conductors upon said film.

11. Means for separating layers of crossing wires of a wiring panel for a miniature electronic assembly having junctions between certain crossing wires, said means comprising an insulating film, said film having designations of closely spaced small holes located at points where junctions are required between crossing wires, said hole designations being located in correspondence with a reduced size photograph of the hole layout of a large scale model of said miniature electronic assembly.

References Cited by the Examiner

UNITED STATES PATENTS

1,892,146	12/32	Harshberger	317—101
2,019,625	11/35	O'Brien	317—101
2,857,558	10/58	Fiske	317—101
2,892,131	6/59	MacDonald	317—101
2,911,572	11/59	Francis et al.	317—101
2,934,814	5/60	Williams et al.	317—101

OTHER REFERENCES

Tape Cable Corporation, Engineering Bulletin No. 9, pages 1–6 (790 Linden Ave., Rochester, N.Y.).

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,177,405 April 6, 1965

Philip J. Gray

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 33, for the claim reference numeral "10" read -- 8 --.

Signed and sealed this 24th day of August 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

UNITED STATES PATENT OFFICE

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