United States Patent

Cardell et al.

[15] **3,649,801**

[45] **Mar. 14, 1972**

[54] FILM RESISTOR TRIMMER

[72] Inventors: **Robert J. Cardell; Walter S. Harubin,** both of Pittsfield, Mass.

[73] Assignee: **General Electric Company**

[22] Filed: **Apr. 29, 1970**

[21] Appl. No.: **33,004**

[52] **U.S. Cl.** **219/68,** 338/195

[51] **Int. Cl.** **B23p 1/00**

[58] **Field of Search** ..... 219/69 M, 85, 68; 338/195

[56] **References Cited**

UNITED STATES PATENTS

3,165,818	1/1965	Soffa et al.	219/85 X
2,710,325	6/1955	Johnson	201/63
3,119,919	1/1964	Pratt	219/19
3,375,342	3/1968	Robinson	219/69 M
3,486,221	12/1969	Robinson	29/620

OTHER PUBLICATIONS

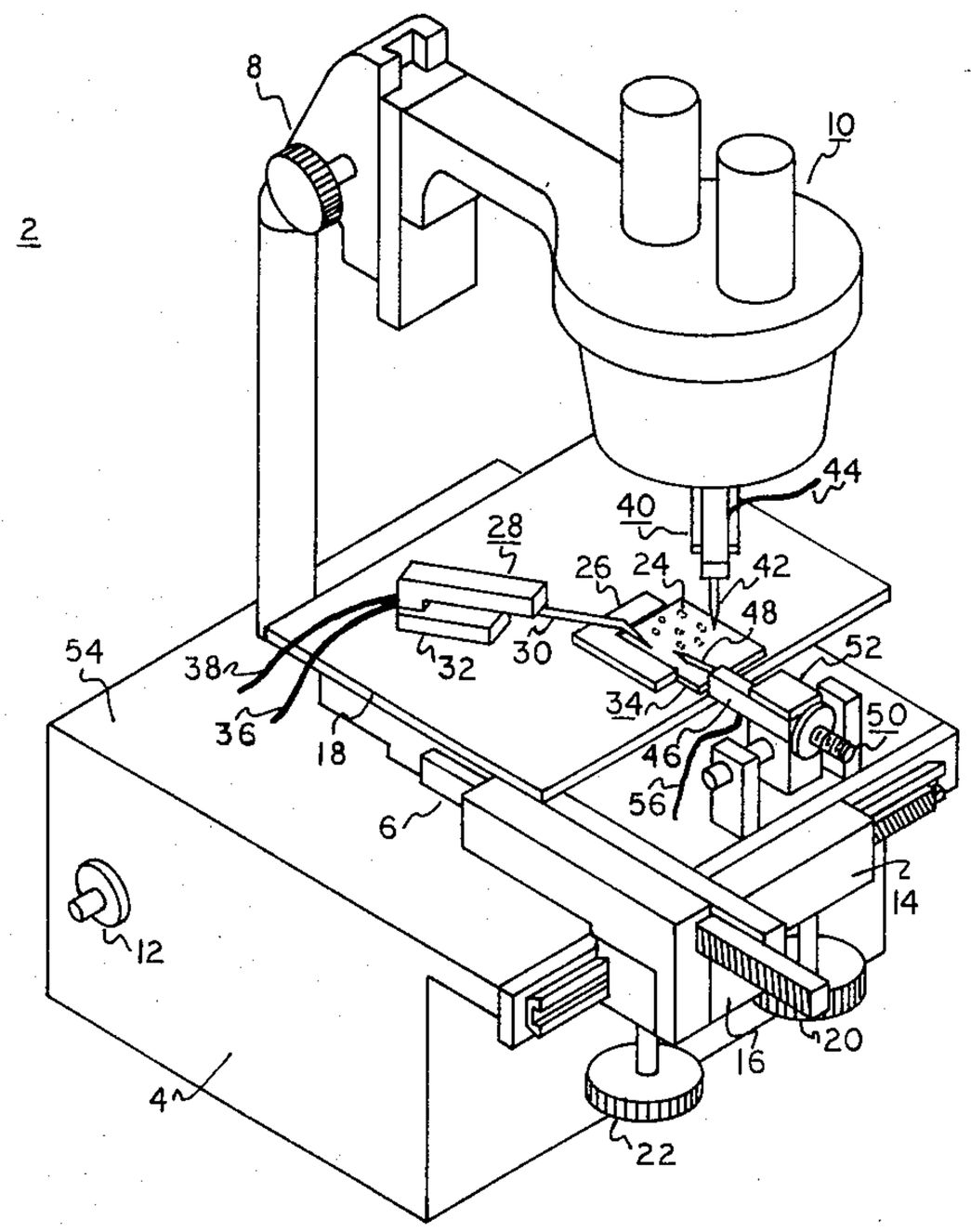
Western Electric Technical Digest No. 9 January 1968 " Apparatus and Method for Loading...Nests"

Primary Examiner—J. V. Truhe
Assistant Examiner—Gale R. Peterson
Attorney—Francis K. Richwine, Carl W. Baker, Frank L. Neuhauser, Oscar B. Waddell and Joseph B. Forman

[57] **ABSTRACT**

A method and apparatus for adjusting the resistance value of film resistors by arc probe means which removes the resistor material until readout means in the apparatus indicates that a desired resistance value has been obtained. A work table in the apparatus holds the resistor being trimmed so that it can be moved in a given plane with respect to the stationary arc probe means while the resistor material is being removed. The adjustment of resistance values by his technique carefully removes the resistive material thereby increasing the resistance of the film resistor until the desired value is obtained and permits trimming a resistor in a microelectronic circuit while power is being applied to the circuit.

4 Claims, 2 Drawing Figures



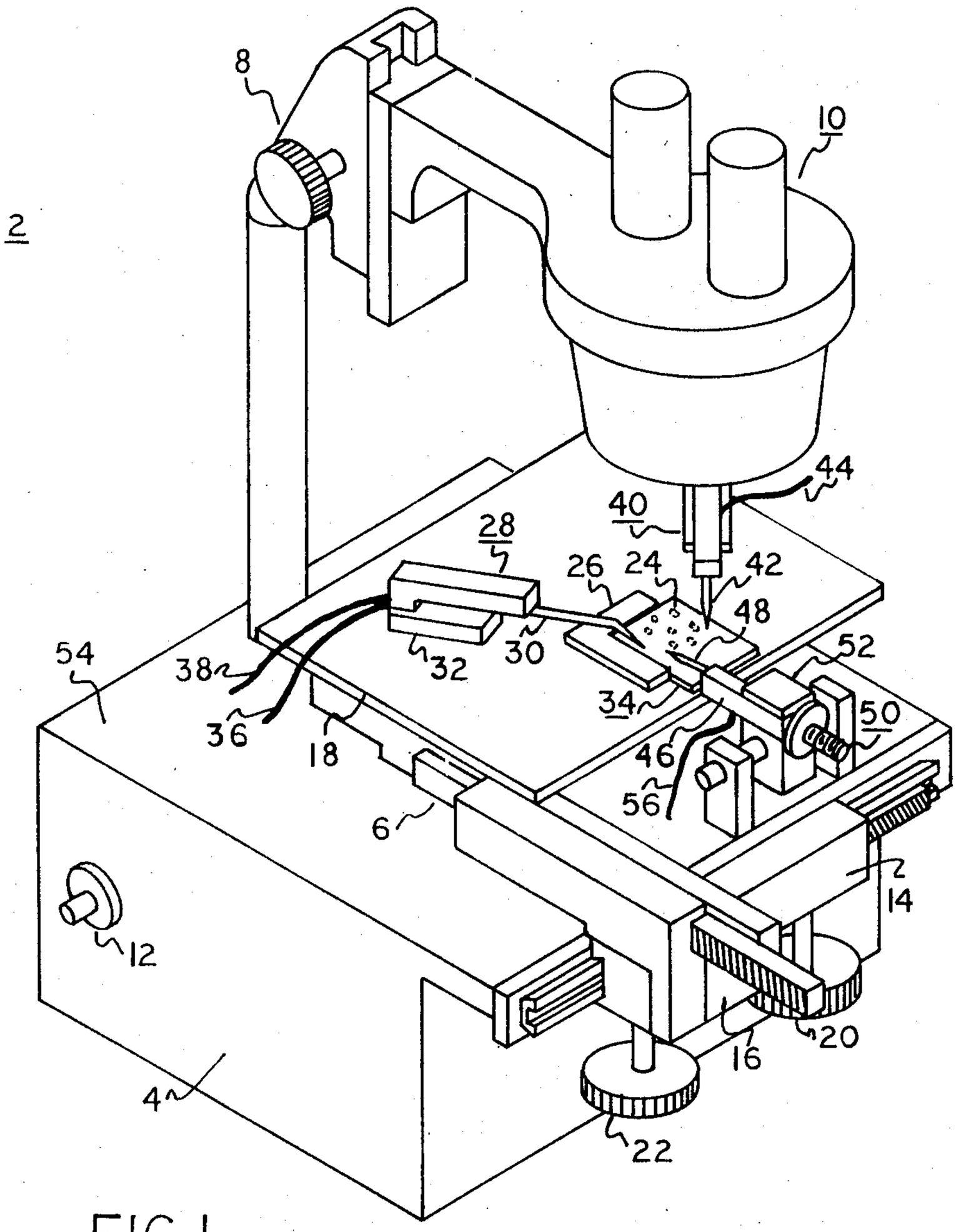


FIG. 1

INVENTORS
ROBERT J. CARDELL
WALTER S. HARUBIN

BY J. F. McDermott

THEIR ATTORNEY

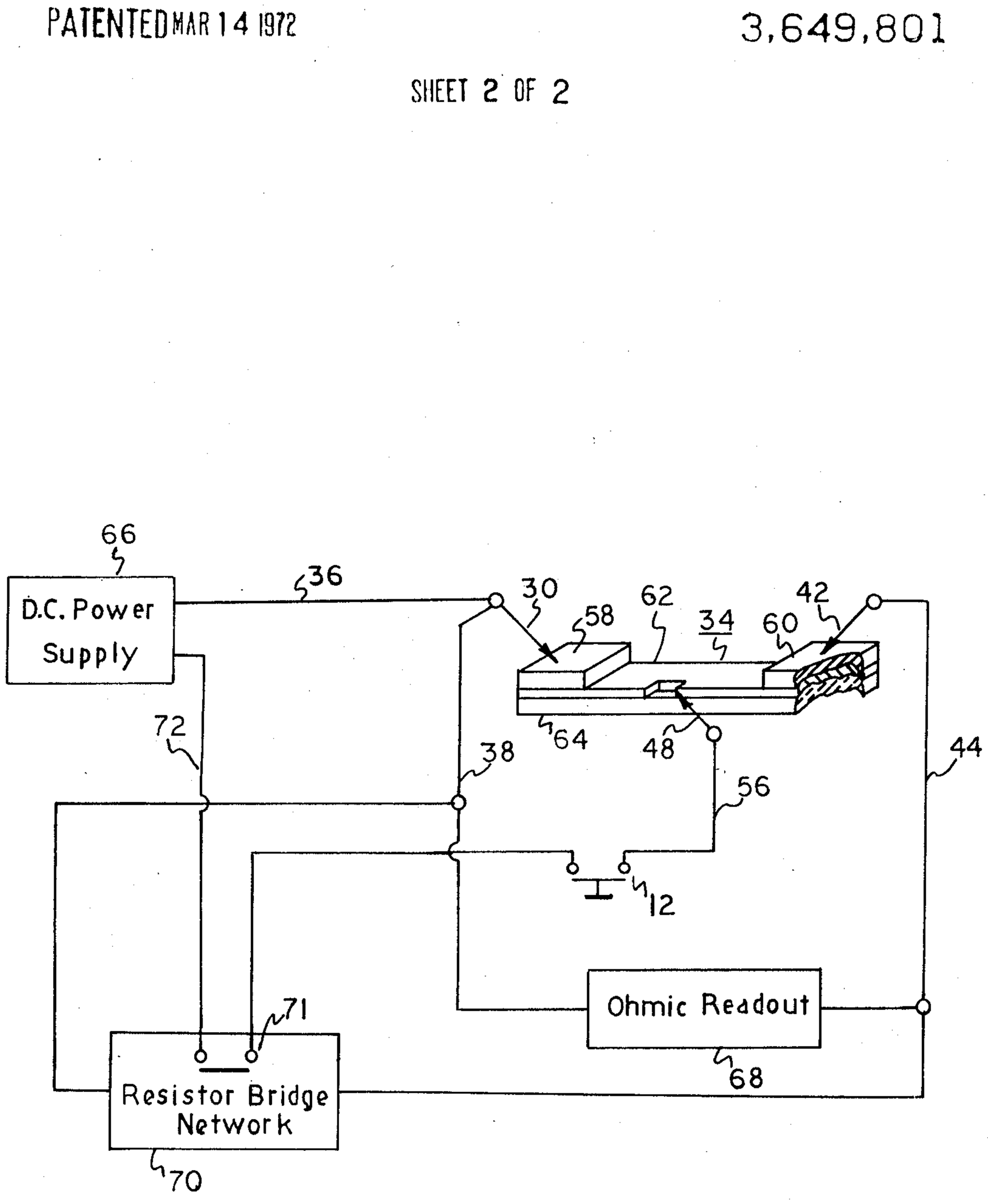


FIG. 2

INVENTORS
ROBERT J. CARDELL
WALTER S. HARUBIN

BY J.F. MacDevitt
THEIR ATTORNEY

FILM RESISTOR TRIMMER

DESCRIPTION OF THE INVENTION

The production of microcircuits involves the coating of insulated materials to form resistor elements in the microcircuit. Such resistor elements can be applied by metal evaporation called thin film coating or by silk screening which is called thick film coating and neither overall process is sufficiently precise to achieve the required resistance values in such circuits. Consequently, an adjusting operation is normally required which is called film resistor trimming whereby the resistive material is carefully removed until the desired resistance values are obtained.

Abrasive trimming is a known technique for adjusting film resistors but said technique has a relatively slow material removal rate and requires removal of the abrasive residue in order to avoid undesired effects upon circuit operation. A small area resistor cannot be trimmed effectively by the aforementioned technique due to the lack of precise control which can cause harm to other portions of the circuit being so treated. Laser trimming equipment is also known but the initial cost of the equipment is high as is the operational cost and an operator is generally required to run this equipment which can require shielding protection or other equivalent safeguards while the equipment is in use.

In view of the above-summarized shortcomings with existing film resistor trimming it would be advantageous to provide a relatively simple trimming technique capable of comparatively low cost and precise operation. It would be further advantageous if such novel trimming technique provided further operational advantages not found with existing techniques.

Accordingly, an object of this invention is to provide a novel, general-purpose technique for trimming both thin film and thick film resistors.

It is another object of the invention to provide a highly accurate film resistor trimmer which can be built at low cost compared with the existing equipment.

Still another object of the invention is to provide a film resistor trimmer which permits functional trimming of a resistor in a microelectronic circuit while said circuit is being operated with electrical power.

A still further object of the invention is to provide a film resistor trimmer capable of trimming plurality of film resistors in a microelectronic circuit by numerically controlled positioning means wherein one or more of the arc probe means is programmed to remove resistive material from the individual resistors until the desired resistance values are obtained.

In accordance with a preferred embodiment of the present invention a film resistor trimmer is provided which includes contact means to measure the surface resistance value of the film resistor in operative association with arc probe means to remove a portion of the resistive material while said film resistor is moved in a given plane with respect to the arc probe means until a desired resistance value is obtained from cooperating resistance readout means. The electrical contact means are disposed at opposing ends of the film resistor with the arc probe means being disposed intermediate therebetween so that an electrical circuit is formed with a common power supply which is connected to one of the contact means and the arc probe means. A movable X-Y-type stage supporting the film resistor is mounted upon a base containing the remaining components of the trimmer. Ohmic readout means are electrically connected to the above-defined contact means and a resistor bridge network is provided in the trimmer to interrupt electrical power to the arc probe means when the desired resistance value has been obtained for the film resistor.

These and other objects, features, and advantages of the present invention will become apparent upon consideration of the following detailed description when considered in connection with the accompanying drawings which illustrate a preferred embodiment of the present invention.

In The Drawings

FIG. 1 is a three-dimensional view depicting a film resistor trimmer of the invention; and

FIG. 2 constitutes an electrical schematic diagram for a film resistor trimmer of the invention including a partial cross section view for a typical thin film resistor.

In FIG. 1, a film resistor trimmer **2** is shown in three-dimension which includes a base support **4** having mounted thereon a movable stage frame **6** which supports the workpiece and certain electrical components of the apparatus and which further includes an upright arm **8** which supports an optical microscope assembly **10**. The base support provides housing means for the electrical power supply (not shown) and a resistor bridge network (also not shown) which are included in the electrical circuit of the apparatus. External ohmic readout means (not shown) are electrically connected in said electrical circuit in a manner to be described in detail with respect to FIG. **2**.

Returning now to the mechanical configuration of the trimmer embodiment shown in FIG. **1** an on-off switch **12** is mounted upon the base support of the apparatus. The X-Y-type stage frame **6** located on the base support includes slide mechanisms **14** and **16** which move the workpiece in a horizontal plane during the trimming operation. Each of said slide mechanisms is of conventional construction and provides support for the metal carriage member **18** upon which the workpiece is mounted. Slide mechanism **14** is movably mounted on the base support and is operated by a knob **20** in the horizontal plane along a direction parallel to the front edge of the base support. Slide mechanism **16** is movably mounted upon the slide member of slide mechanism **14** for movement of the carriage member **18** in a horizontal direction perpendicular to the front edge of the base support. Knob **22** drives slide mechanism **16** by conventional hand-operation in the embodiment shown although it is within contemplation of the invention to automatically drive the carriage member **18** in a programmed sequence using already known numerical control techniques if a plurality of film resistors is to be trimmed on the workpiece. Thus, an automatic trimming system is contemplated including numerically controlled positioning of one or more trimmer means which further includes programmable switching of said trimmer means when the film resistors being trimmed correspond with predetermined resistance values measured automatically by known resistance bridge techniques.

Carriage member **18** in the embodiment is made of steel in order to fix components thereto by magnetic contact and further contains drilled holes **24** fitted with connection means (not shown) to a vacuum supply for holding the workpiece in place while the trimming operation is being conducted. The work surface of said carriage member further contains a lateral holding fixture **26** for the workpiece which cooperates with the vacuum being applied to maintain physical location between the workpiece and members of the probe means in the apparatus. Electrical contact means **28** is secured to the work surface of the carriage member **18** by magnetization and includes a probe element **30** fixed to the magnetized base portion **32** of said contact means with said probe element being in electrical contact at its opposite end with one end of the film resistor workpiece **34** being trimmed. Electrical conductors **36** and **38** provide electrical connection from the power supply to the probe element and from said element to the ohmic readout means in the apparatus.

Similarly, electrical contact means **40** is magnetically affixed to the work surface of carriage member **18** so that its probe element **42** maintains electrical contact with the opposite end of the film resistor being trimmed. An electrical conductor **44** completes the electrical circuit from the film resistor to the ohmic readout means in the apparatus. Arc probe means **46** in the embodiment includes a probe element **48** affixed to one end of a cantilever-type counterbalance assembly

50 in order to apply only sufficient mechanical pressure by the probe element upon the contacting surface of the film resistor to prevent losing the arc discharge while the resistor is being moved during the trimming operation. The opposite end of the cantilever element in the counterbalance assembly **50** is affixed to a weight **52** pivotally mounted between supports attached to the top surface **54** of the base support. An electrical conductor **56** furnishes electrical power to probe element **48** and is connected to switch **12** in the apparatus.

In FIG. **2** there is shown a schematic block diagram of the electrical circuit for the film resistor trimmer **2**. In the following description of said electrical circuit the same numerals are used to identify common elements described in the FIG. **1** embodiment. Accordingly, a film resistor **34** having surface electrical terminations **58** and **60** overlying a layer **62** of resistive material and a base dielectric layer **64** is shown forming part of the completed electrical circuit in the apparatus. Such resistors are well known and generally comprise a very thin film of resistive metal coated on a glass or ceramic substrate having surface terminations at each of the resistive films. Various metals can be used for the resistive film including chromium and various chromium alloys. A related type film resistor which can be trimmed by practice of the present invention comprises integral thin film networks in which the dielectric substrate carries both resistors and conductors. Consequently, only a relatively simple form of film resistor is being shown for purposes of clarity and illustration but it will be apparent that a highly precise removal of other metal films used in microelectronic circuits, such as gold, can also be achieved by practice of this invention.

Contact probe **30** is electrically connected to a DC power supply **66** by electrical conductor **36**. Electrical conductor **38** leads directly from said contact probe to the ohmic readout means **68** and the resistance bridge network **70** of the apparatus. Contact probe **42** at the opposite end of the film resistor completes the electrical circuit to the ohmic readout means and the resistance bridge network **70** via electrical conductor **44**. Arc probe **48** which contacts the resistive film to remove a portion of the resistive material is connected by electrical conductor **56** to switch **12** and switch **71** in the resistance bridge network. A conventional resistor bridge network **70** is connected between contact probes **30** and **42** with switch **71** serving the function of turning the power off when the desired resistance value is reached. Generally, the bridge arrangement comprises a Wheatstone bridge having four arms, two adjacent arms of which comprise variable resistors with the other arms in the bridge having a resistor being adjusted in the remaining arm. Detector means in said bridge arrangement functions to open switch **71** when the bridge is balanced. An electrical conductor **72** provides electrical power from the DC power supply to said resistor bridge network.

In operation, the above-described film resistor trimmer apparatus is capable of trimming very fine line resistors in the order of only **.002** inch in width accurately even while a microelectronic circuit containing said type resistors is under power. When electrical power is turned on to the trimmer after the probe element of the arc probe means has been placed in contact with the resistive film an arc discharge is generated between said probe element and the underlying surface of said resistive film. An operator observing the film removal through the microscope means **10** provided in the apparatus manually guides the probe element along the film by adjustment of the slide mechanisms supporting carriage member **18**. Visual guidance is used to maintain the probe element in contact with the resistive film as distinct from other areas of the microelectronic circuit being trimmed. Approximately one-quarter to one-half gram weight is adequate to maintain contact between the probe element and the resistive film while not exerting enough pressure to scratch softer metal surfaces such as gold contacts in the microelectronic circuit. Automatic shutoff of the equipment takes place when the desired resistance value is reached by operation of the resistor bridge network in the apparatus. In accordance with the above-described method of adjusting the resistance value for a film resistor it should be noted that electrical power is applied to the resistive film of the film resistor between one of the electrical contact means disposed at both ends of said film and the arc probe means disposed intermediate therebetween. The cooperative association of said means generates the arc discharge between the probe element of the arc probe means and the resistive film when physical contact is established therebetween which arc discharge is maintained to remove portions of the resistive material along the path of the arc probe element. Continuous monitoring of the resistance value in said film resistor while the resistive material is being removed permits an operator visually observing the path being taken by the arc probe element to select locations for additional removal of resistive film material in the event that the desired resistance value cannot be obtained along a single selected path.

It will be apparent from the foregoing description that variations can be made in the equipment and technique for adjusting the resistance value of a film resistor as hereinbefore described without departing from the true spirit and scope of this invention. It is not intended to limit the invention, therefore, to the scope of the preferred embodiments above described since it will be apparent that various modifications are possible within the scope of the appended claims. For example, it is possible to conduct removal of resistive material in a vertical plane rather than in a horizontal plane as well as to utilize and AC power supply for the trimming. Simultaneous trimming upon a plurality of film resistors can also be conducted by duplicating the trimming means for removal of resistive material. Likewise, it will be apparent that numerical control techniques may be practiced to automatically trim film resistors without having an operator regulate the operation.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. Apparatus for adjusting the resistance of a planar film resistor by trimming comprising

a. an apparatus base,

b. movable planar platform means mounted on said base for supporting the planar film resistor to be trimmed, said platform means including means for moving said resistor relative to said base in directions parallel to the planar dimensions of said resistor,

c. electrical contact means supported by said platform for movement with said resistor and having contact portions arranged to electrically contact opposite ends of said film resistor,

d. measurement circuit means including DC potential means and resistance detecting means interconnecting said contact means for monitoring the resistance of said resistor during use of the apparatus,

e. pivotal arc probe means attached to said base and including adjustable counterbalance means and terminating in an electrically conducting probe element the end of which is supported over said platform means for contacting said resistor with adjustable pressure at a fixed point with respect to said base whereby movement of said platform means with said resistor will cause relative movement between said probe element and resistor while maintaining controlled pressure contact between them, and

f. arc probe circuit means including an electrical power supply, said probe element and switch means for causing removal of that part of said resistor touched by said probe element.

2. The apparatus of claim **1** wherein said resistance detecting means includes both meter means for measuring the resistance of said resistor and resistance bridge network for comparing the resistance of said resistor with another resistance and wherein said switch means is responsive to said bridge network for opening said arc probe circuit when the resistance of said resistor equals said other resistance.

3. The apparatus of claim 1 further comprising
g. vacuum retaining means for holding said resistor on said platform means.
4. The apparatus of claim 1 further comprising
h. optical viewing means supported by said base to permit to operator to have a view of the point of contact between said probe element and said resistor while operating said apparatus.

* * * * *