Feb. 27, 1951 J. GYURIS 2,543,527

PUNCH MACHINE FOR PUNCHING ELECTRICAL HEATER ELEMENTS

Filed Nov. 1, 1946 3 Sheets-Sheet 1

Fig. 13

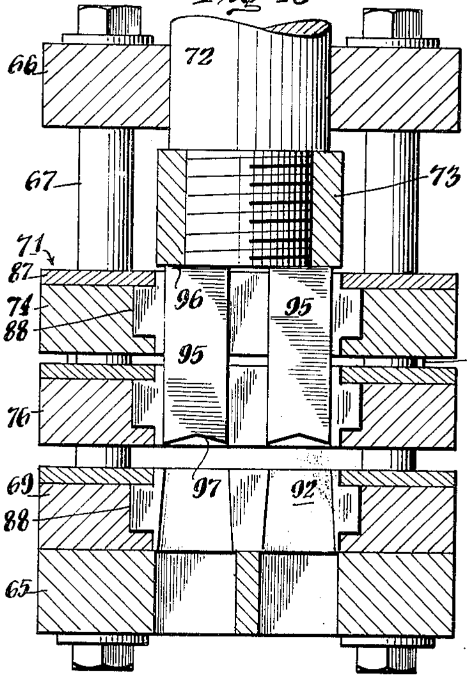


Fig. 12

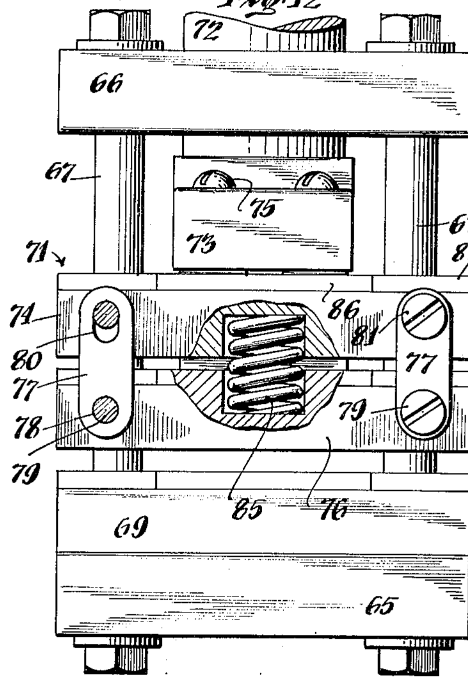


Fig. 17

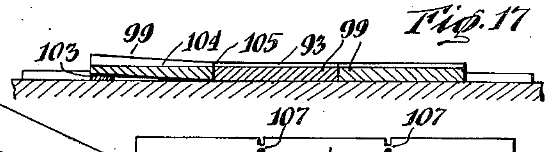


Fig. 18

Fig. 16

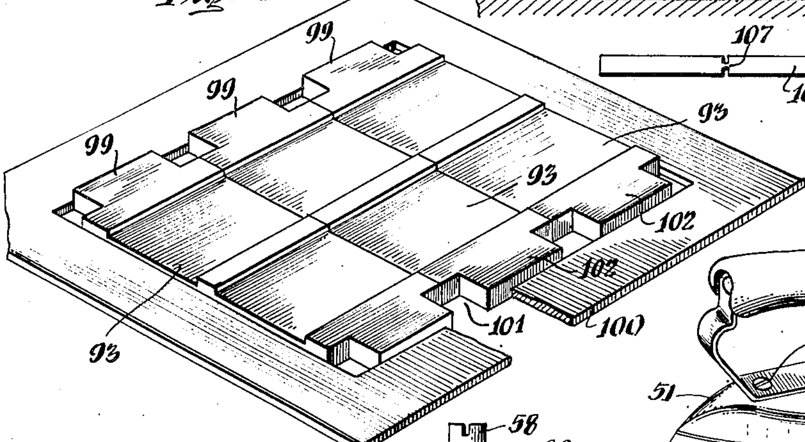


Fig. 1

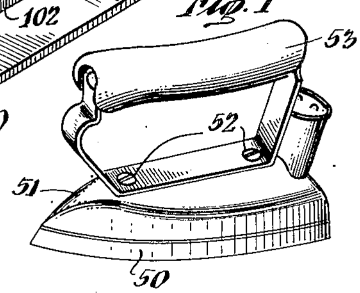
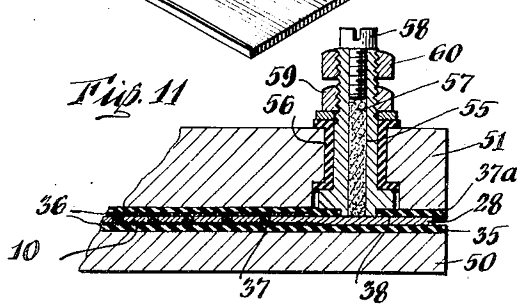


Fig. 11



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PUNCH MACHINE FOR PUNCHING ELECTRICAL HEATER ELEMENTS

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Fig. 2

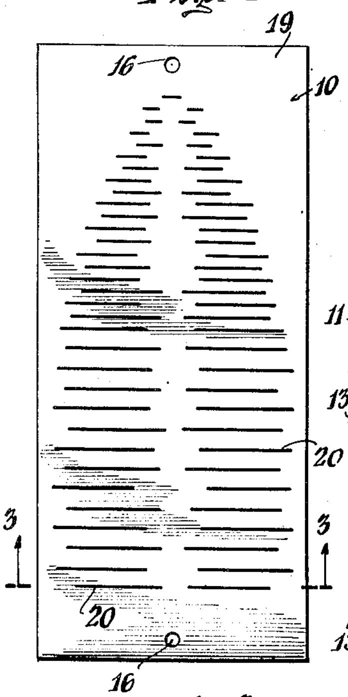

Fig. 4

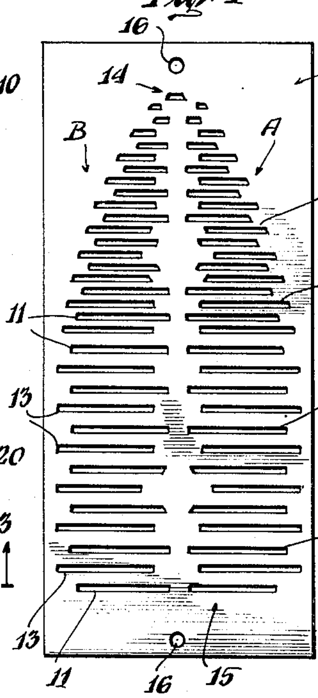

Fig. 5

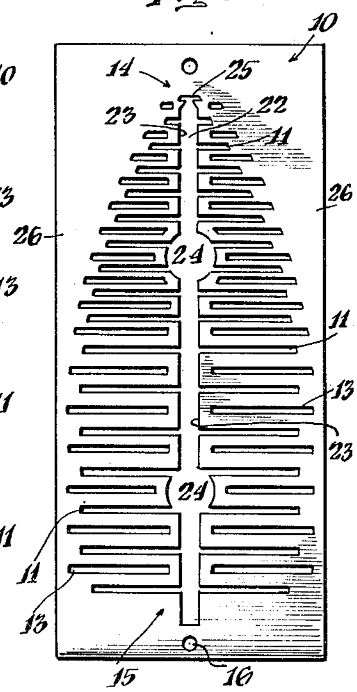

Fig. 3

Fig. 9

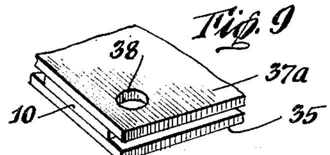

Fig. 6

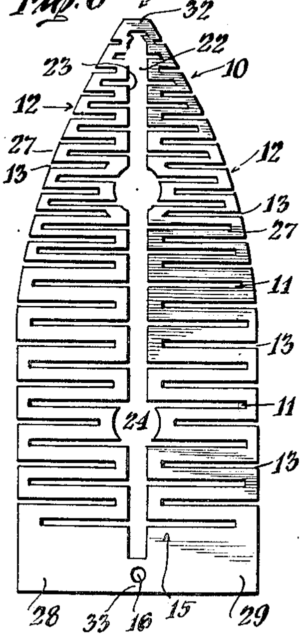

Fig. 7

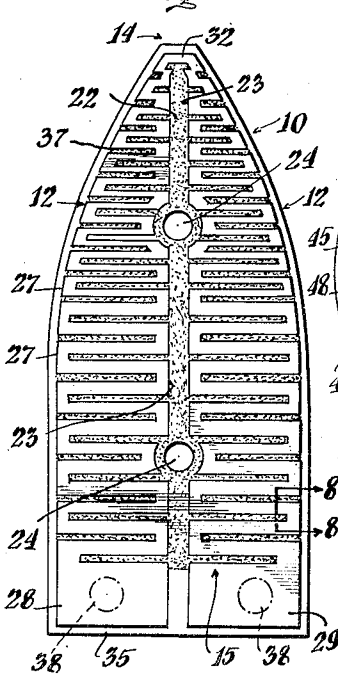

Fig. 10

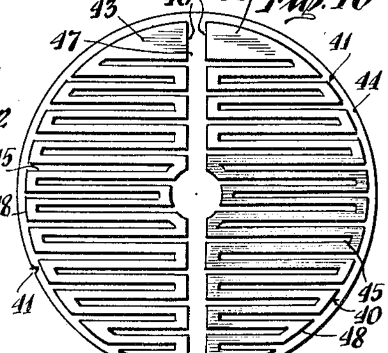

Fig. 8

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PUNCH MACHINE FOR PUNCHING ELECTRICAL HEATER ELEMENTS

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Fig. 15

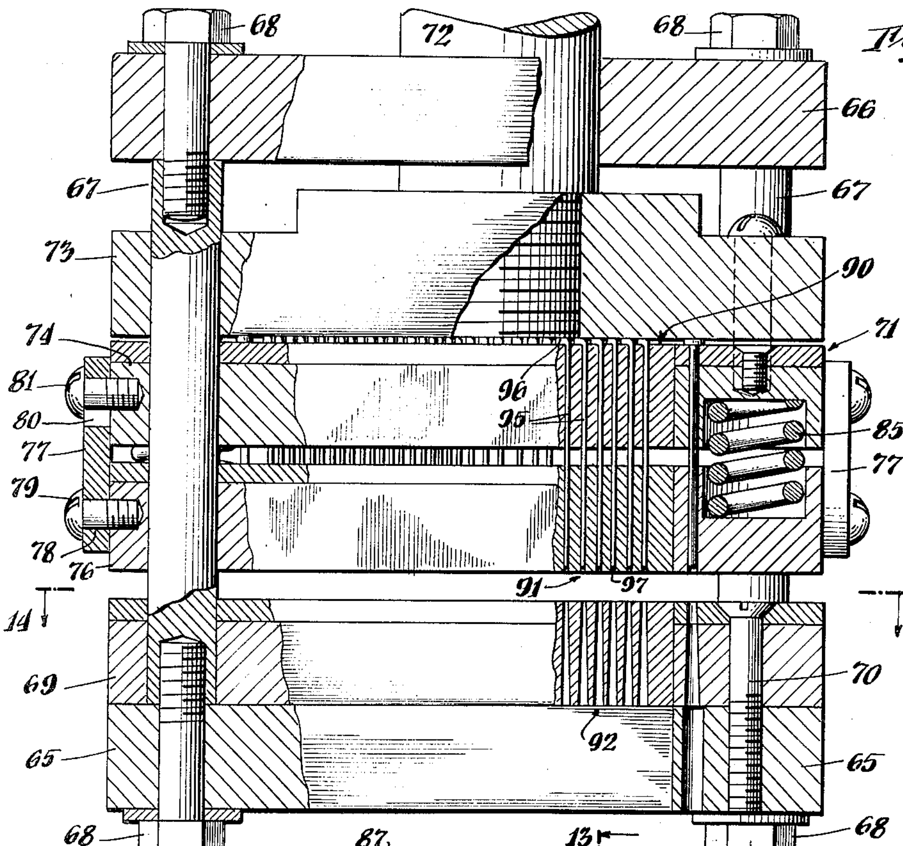
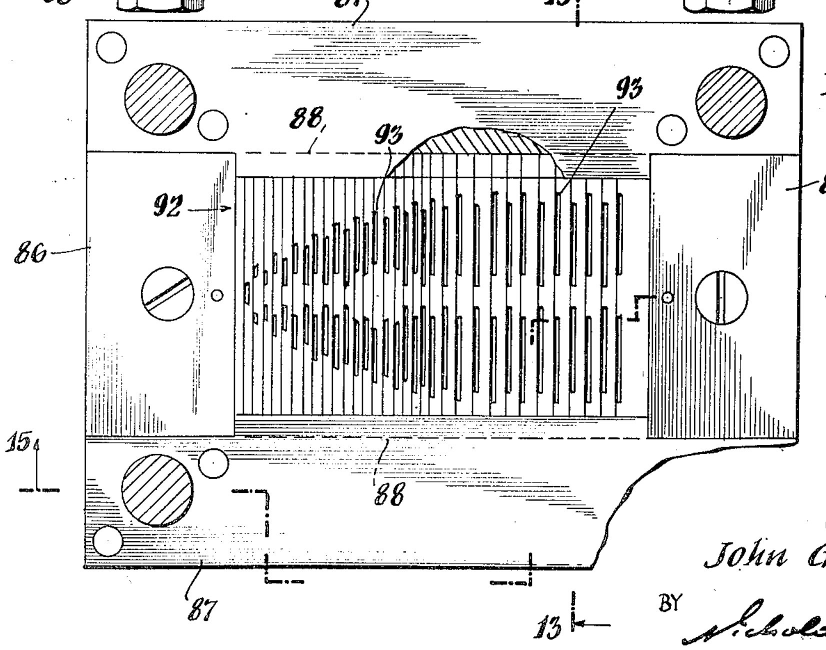


Fig. 14



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UNITED STATES PATENT OFFICE

2,543,527

PUNCH MACHINE FOR PUNCHING ELECTRICAL HEATER ELEMENTS

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Application November 1, 1946, Serial No. 707,106

16 Claims. (Cl. 164—58)

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This invention relates to a heating element adapted for use in an electric iron or other electrical appliance and to a method for making such a heating element.

This invention further relates to a terminal construction which is particularly adapted to make contact with a flat, conductive portion of a heating element.

This invention has further reference to a die constructed and arranged to form a heating element in a single operation and to a method for making the same.

This invention also embraces the construction of an electric iron or appliance embodying the novel heating element or terminal structure, alone or in combination.

Heretofore, heating elements for electric irons and other electrical appliances have ordinarily consisted of a ribbon or spiral of resistive material embedded in a mass of insulating material, this element being secured between two metal plates constituting the body of the iron. Aside from the inherent difficulties of constructing and assembling such a structure, the prime disadvantage of this type of heating element resides in the poor heat conduction between the heating element and the body of the iron. This arises from the thickness of the insulating material which is necessary to enclose a spiral or ribbon of resistance material and adequately insulate it from the body of the iron, such insulating materials normally being poor conductors of heat. As a result, the heating element is ordinarily operated at a temperature of several hundred degrees above the operating temperature of the iron, resulting in rapid deterioration of the heating element and formation of an oxide film thereon which is in itself a poor heat conductor, thus causing a further increase in the temperature differential between the heating element and the body of the iron.

It has been proposed to substantially minimize this temperature differential by utilizing a substantially flat heating element in which a number of slots are punched to define the respective segments of a heating element. However, difficulties have been encountered with such structures in that it is extremely difficult to provide an element with sufficient rigidity and mechanical strength to prevent buckling and the contacting of adjacent resistance segments. In addition, difficulty is also experienced in the manufacture of such elements in that a large number of closely-spaced slots must be formed in the heating element, usually by cutting one slot at a time, with the result that the process is quite expensive and difficult to perform.

In accordance with my invention, a heating element is provided in which both the resistance portions and the terminal portions lie in a single plane and in which the resistance portions are bonded to a sheet of heat resistant insulating material to provide the requisite mechanical strength and rigidity. In manufacturing my novel heating element, grid like resistance elements are formed by suitable cutting or etching operations from a thin plate of resistance metal. The resistance elements are interconnected, during the initial stages of the process, by portions of the plate of sufficient size to provide enough mechanical strength and rigidity to prevent buckling. While in this stage, the resistance elements are bonded to a thin sheet of heat resistant insulating material, such as, for example, mica, to positively retain the respective segments of the resistance element in their proper relation. Thereafter, the interconnecting portions are severed to provide a resistance element bonded to the sheet of insulating material with flat plate-like terminal members extending from the respective ends thereof. I may then complete the resistance unit by bonding a second insulating sheet to the exposed surface of the plate.

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In this manner, I eliminate the difficulties arising from an excessive temperature differential between the heating element and the metal plates associated therewith. This is explicable on the basis that my heating element is entirely flat throughout and free from buckling so that it may be placed in intimate contact with the adjacent metal plates, separated therefrom only by extremely thin sheets of heat resistant insulating material. The advantages resulting from the use of such thin sheets of insulating material may be better understood by reference to the following tabulation which compares the temperature differential with the thickness of the interposed insulating material where the operating temperature is maintained constant at 250° C.

Thickness of Insulating Material (Mica) in Inches	Temperature of Heating Element	Temperature Differential between Heating Element and Body of Iron
	° C.	° C.
0.001	251	1
0.002	253	3
0.003	256	6
0.004	263	13
0.005	275	25
0.006	296	46
0.007	328	78
0.008	375	125
0.009	436	186
0.010	494	244
0.011	547	297
0.012	598	348
0.013	648	398
0.014	696	446
0.015	742	492
0.016	787	537

Conventional heating elements utilize insulating plates ranging from about 0.013 inch to about 0.016 inch in thicknes and the temperature differential, which is an index of the heat transfer efficiency between the heating element and the iron, varies from about 400° C. to about 550° C. It will be observed that the heating elements of such irons are operated at temperatures on the order of 650° C. to 787° C. which approaches red heat for Nichrome wire. This results in rapid deterioration and oxidation of the heater structure. When the novel heating elements of this invention are utilized, the thickness of the insulating material may be reduced to a thickness in the range from 0.001 inch to 0.010 inch with a temperature differential of as little as 1° to 244° C. Preferably, I utilize insulating material having a thickness of 0.004 inch to 0.005 inch with a temperature differential of 13° C. to 25° C. It will be noted that the element may be operated, in accordance with the invention, at temperatures of about 250° C. to 300° C. which is insufficient to cause deterioration or excessive oxidation of the heater element even when it is used for extended periods. I have verified these facts by extensive life tests and found that the novel heating elements of this invention, after prolonged operation, show no signs of deterioration and preserve a bright untarnished surface. These results may be attributed to the fact that the heater element is under the protection of the heated body as a result of the intimate heat exchange relation therebetween.

Another factor contributing to the low temperature differential and increased efficiency of my heating units is the novel terminal construction therefor. By the use of this structure, the terminal portions of the heating element may consist of plate-like members integrally formed with and lying in the same plane as the grid-like resistance structure. I have found that the use of such terminal portions contributes substantially to the low temperature differential of the heating element and I have devised a terminal structure for making efficient contact with such flat plate-like terminal members.

Another aspect of the invention relates to an improved die for forming, at a single operation, one or more rows of slots in a metal plate defining grid-like resistance portions and terminals. With this die, a large number of extremely thin, accurately positioned slots may be formed in a single operation and, in order to accomplish this result, I provide a plurality of die members each comprising a row of stacked metal plates with corresponding plates in each row being of identical thickness and having accurately aligned slots therein for receiving and guiding a cutting tool.

I prefer to make the respective sets of corresponding plates by placing the plate portions of each set in side by side position, machining the plates to uniform thickness and forming aligned transverse slots in the plates while they are in such side by side position. Thereafter, I assemble the plates in rows to form a plurality of die members with the plates of each set occupying corresponding positions in the respective rows.

In view of the foregoing discussion, it will be seen that I have provided an efficacious solution to many of the problems confronting the manufacturer of electrical appliances, such as electric irons and heating units.

It is an object of this invention to improve the construction and operation of heating elements.

It is a further object of the invention to set forth a novel method of making a heating element.

It is a still further object of the invention to provide an improved terminal structure for a heating element.

The invention further aims to provide an electrical appliance, such as an iron, embodying the novel heating element from a plate of resistance metal in a single punching operation.

It is another object of the invention to describe an improved method for making such a die.

Other objects of the invention will be apparent from the following description and accompanying drawings taken in connection with the appended claims.

The invention accordingly comprises the features of construction, combination of elements, arrangement of parts, and method of manufacture referred to above or which will be brought out and exemplified in the disclosure hereinafter set forth, including the illustrations in the drawings, the scope of the invention being indicated in the appended claims.

For a fuller understanding of the nature and objects of the invention as well as for specific fulfillment thereof, reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Figure 1 is a perspective view of an electric iron embodying the novel heater element and terminal structure;

Figure 2 is plan view showing a metal plate prepared for an etching operation;

Figure 3 is an end view of the plate shown in Figure 2;

Figure 4 is a plan view of a metal plate having a series of slots formed therein by a punching or etching operation;

Figures 5 and 6 are plan views of a partially completed heating element;

Figure 7 is a plan view illustrating the resistance unit bonded to a sheet of heat resistant insulating material;

Figure 8 is a sectional view taken along the line 8—8 of Figure 7;

Figure 9 is a fragmentary perspective view of the completed resistance unit;

Figure 10 is a plan view of a completed heating element of modified structure;

Figure 11 is a vertical sectional view of the novel terminal construction;

Figure 12 is a front elevational view, partially in section, of a die constructed in accordance with this invention;

Figure 13 is a side elevational view of the die shown in Figure 12;

Figure 14 is a plan view of the stationary die assembly;

Figure 15 is a sectional view taken along the line 15—15 of Figure 14;

Figure 16 is a perspective view showing a step in making the die of Figure 12;

Figure 17 is a sectional view which is descriptive of another step in making the die of Figure 12; and

Figure 18 is a front elevational view showing a modification of the step illustrated by Figure 17.

In each figure, the size of the slots shown therein is greatly exaggerated for clarity.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention. In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

Referring now to the drawings in detail, Figures 2 to 9 illustrate successive steps in the method of making my novel heating element. In Figure 4, a thin plate 10 of resistance metal, such as Nichrome, is shown having two rows of slots A, B formed therein in the manner to be hereinafter explained. Each row comprises a series of parallel, closely spaced slots which are arranged in staggered formation so that each slot is laterally offset from the two slots adjacent thereto. Accordingly, each row may be said to consist of a group of slots 11, the inner ends of which define the inner edge of a grid-like resistance element 12, Figure 6, together with a group of slots 13, laterally offset from slots 11, the outer ends of which define the outer edge of grid-like resistance element 12.

It will be observed that the outer ends of the respective groups of slots 13 define substantially the outline of an electric iron, the slots being shorter and more closely spaced adjacent the tip portion 14 than the slots adjacent the other end portion 15. Closer spacing of the slots will increase the electrical resistance of the grid portions defined thereby and thus will increase the temperature of the electric iron in such regions. If it is desired to manufacture a heating element adapted for use in an appliance other than an electric iron, the slots may be formed to define any desired shape of heating element, as will become clearly apparent from the following description. For the purpose of supporting and aligning the element with the die during successive stages of the manufacturing operations, I may provide holes or openings 16 at the respective opposite ends of the plate 10 for cooperating with suitable guide pins to accurately locate the plate during subsequent stamping operations. Where the slots are formed by a stamping operation, the holes 16 may be formed in the same step as the slots.

In acordance with the invention, the slotted plate depicted in Figure 4 may be formed either by a stamping operation or by an etching process. In a preferred embodiment of the invention, the slots are stamped in the plate by a single operation of my novel die which is described in detail hereinafter. However, the method of making a heating element in accordance with the invention contemplates the formation of the slots in any suitable manner such as, for example, by punching out the slots one at a time or in groups, or by utilizing the etching process now to be described in connection with Figures 2 and 3.

In forming the slots by etching, the plate 10 is coated on one or both sides thereof by a layer of masking material 19. A plurality of slits 20 corresponding, respectively, to the slots 11, 13 are formed in the masking layer in any suitable manner, as by scratching the masking layer with a sharp instrument. The plate is then immersed in a bath of a suitable acid reagent which corrodes the unmasked portions of the plate forming the slots 11 and 13. In order to carry out the etching in a quick and efficient manner, it is preferred to make the resistance plate the anode in an etching solution which may be a strong mineral acid, such as sulphuric, nitric or hydrochloric acid of the desired concentration and to apply a voltage of 50–60 volts to the anode and cathode. I have found that in this manner a Nichrome plate having a thickness of 0.003 may be etched through in about 5 to 6 seconds. Instead of providing a continuous coating of the masking material on the resistance plate, it is also possible to apply the masking material in the form of a waxy film having the desired configuration by means of a printing or lithographic process which eliminates the necessity of scratching in the slots by a separate operation. The masking material is then removed leaving the plate in the condition shown by Figure 4.

The slotted plate of Figure 4, whether produced by etching or stamping, is then placed in a suitable die and a central channel 22, Figure 5, is formed therein, the longitudinal edges 23 of which define the respective inner edges of the grid-like resistance elements 12, Figure 6. Preferably, the edges 23 are formed along the extreme inner ends of the slots 11 but some tolerance is permissible in the width of channel 22, the essential feature being that each slot 11 communicates with the channel 22 to prevent a short circuit being formed between adjacent segments of the resistance grids. It will be observed that the slots and the channel are shaped to form circular passages 24 constituting openings for receiving supporting bolts to secure the heating element in proper position with respect to the structure associated therewith. The end of channel 22 may terminate at a short slot 25 at the tip portion 14 to provide uniform thickness of the heating element in this region.

The structure of the grid-like resistance units 12 is then completed by cutting away portions 26 of the plate, thus defining the outer edges 27, Figure 6, of grid-like resistance structures 12. The edges 27 are preferably formed along the extreme outer ends of slots 13 but may extend inwardly a short distance beyond such outer ends, the essential feature being that the slots 13 separate and prevent a short circuit between adjoining outer ends of the segments of grid-like resistance elements 12. It will be observed that the ends 15 of resistance elements 12 terminate in integral flat plate-like portions 28, 29 constituting terminals for the heater element, such terminals lying in the same plane as resistance elements 12.

The structure shown in Figure 6 has sufficient mechanical strength and rigidity to prevent buckling and bending of the resistance segments into short circuiting contact with each other. This is due to the fact that the grid-like resistance element is interconnected at the end 14 thereof by a plate portion 32 which serves to connect elements 12 in series. The mechanical strength and rigidity is also due to the interconnection of terminal members 28 and 29 by plate portion 33. It will be undersood, however, that plate portion 33 forms a short circuit between portions of the grid-like structure at this time and, accordingly, must be subsequently removed.

In accordance with the invention, while the grid-like structure is still interconnected in this manner, I bond it to a sheet of heat resistant insulating material, such as mica. Referring to Figure 7, the element is shown with the grid-like resistance elements 12 secured to a mica sheet 35 by bonding material 36, Figure 8. More specifically, the grid-like elements 12 may be bonded or heatsealed to the surface of mica sheet 35 by means of a layer **36**, Figures 8 and 11, of thermoplastic resin, such as a suitable vinyl resin. This may be accomplished by coating the mica surface with a suitable thermoplastic resin, such as vinylseal, placing the resistance grid thereon and then applying heat and pressure to the said plate by means of a metal surface, such as steel, which is heated to a temperature of 180°–220° C. Preferably, the application of heat and pressure stops short of the terminal regions of the plate, which are initially integrally connected so that such regions are not bonded to the insulating surface. This permits the terminal regions to be slightly lifted up so that the short portion **33** of the metal plate bridging the terminal portions may be cut out. Thereupon heat and pressure may be applied to the entire surface of the resistance plate so that the terminal regions are also firmly bonded to the mica plate by the layer **36**. The bonding material serves to afford sufficient strength and rigidity to preserve the flatness and configuration of the heater element, at least until it is rigidly mounted in an iron or other electrical appliance. Once the element is mounted in this fashion, it is immaterial whether the bond between the heating element and insulating sheet **35** persists or whether the bonding material is decomposed during operation of the iron.

After the bonding has been completed, I fill the slots **11**, **13** with a semi-refractory insulating compound or mass **37**, Figures 8 and 11, which remains in position after assembly and at all times, positively insulates adjoining segments of the resistance elements from each other. A suitable compound for this purpose is an oxide paste prepared from a refractory metal oxide, such as aluminum, calcium, or magnesium oxide, a filler such as water glass or uncalcined borax and water.

After the slots are filled, a second sheet **37*a***, Figure 9, of heat resistant insulating material, such as mica, is bonded or otherwise suitably secured to the exposed surface of plate **10**, this second sheet having openings **38** therein permitting access to the respective terminal portions **28** and **29**.

Alternatively, the bonding operation may be performed at any stage of the process so long as the grid-like resistance elements are interconnected before the bonding in such fashion that the structure has sufficient mechanical strength and rigidity to prevent buckling and contact of adjacent resistance elements. After bonding, the interconnecting portions are severed to define the heater element. Thus, for example, the plate **10** of Figure 2 may be coated, on one side only, with masking material after which the other side thereof may be bonded to insulating sheet **35**, Figure 7. The masking material is then removed from the coated face to define the finished heater element of Figure 7 after which the assembly is etched electrolytically, a potential being applied to a number of points at the same time. In this manner, the interconnecting portions are severed or removed by the etching and the complete resistance element is formed in a single etching operation. Thereupon the interspaces between the slots may be filled, as described, with an oxide paste and a second insulating sheet bonded to the exposed surface of the metal plate to form a completed heater element.

Accordingly, the completed resistance element comprises a metal plate of resistance material **10** having grid-like resistance elements **12**, **12** defined therein by the slots **11** and **13**, inner edges **23** and outer edges **27**. The elongated grid-like resistance elements **12** are connected in series by plate portion **32** and terminate, respectively, in flat integral plate-like terminal portions **28**, **29** which lie in the same plane as grid-like resistance elements **12**. The grid-like portions of the element are bonded to heat resistant insulating sheet **35** to secure the desirable mechanical strength and rigidity, and the insulating compound **37** fills the slots **11**, **13** to effectively insulate the respective resistance segments from each other. A second sheet of insulating material, such as mica, is applied or bonded to the exposed surface of the plate, this second sheet having openings **38** therein for effecting connection to the terminals **28** and **29**. In its completed form, the heater element is of uniform thickness throughout and free from bonds, folds, soldered or welded joints. The insulating layers are likewise completely plane and of uniform thickness throughout so that they can be pressed against the plane heater element substantially in the complete absence of any interposed or entrapped air spaces or films. This is of critical importance as even an air film or gap of 0.0001″ may very appreciably reduce the efficiency of heat transfer. In this manner, the concentration of heat in definite regions, which is characteristic of conventional wire or ribbon-wound heater elements, and the resulting presence of "hot spots" is completely avoided.

Suitable dimensions for the component parts of the novel heating element are a thickness of about 0.001 to 0.004 inch for the plate **10** and a thickness of about 0.004 to 0.005 inch for the insulating sheets **35** and **37*a***. I prefer to utilize about 80 to 150 slots on each side of the channel **22**, the width of the slots varying from about 0.002 to 0.01 inch and the length thereof being determined by the particular zigzag pattern desired for the heater element. The width of the grid-like portions defined by the slots may vary from about $\frac{1}{32}$ to $\frac{3}{16}$ inch, this dimension being adjusted in accordance with the heating effect desired in particular regions.

A modified form of resistance element, which is suitable for use in a hot plate, is shown by Figure 10. This element is formed in accordance with the principles of the present invention and comprises a plate **40** of resistance metal having generally semicircular grid-like resistance elements **41** connected, at one end, by a plate portion **42** and terminating, at the other end, in integral, flat terminal members **43**. The grid-like portions are bonded to a sheet **44** of heat resistant insulating material and, prior to the bonding operation, the terminals were interconnected by a metal plate portion giving sufficient mechanical strength to prevent buckling, this interconnecting portion being severed after the bonding step. The resistance elements are defined, as in the case of the element shown in Figure 7, by slots **45**, the inner edges **46** of a channel **47**, and outer edges **48**. The slots **45** are filled by a suitable insulating compound or paste thus insulating adjacent segments of the grid-like resistance elements.

Referring now to Figures 1 and 7, an electric iron is shown embodying the heating element of the present invention. The heating element is mounted between a pair of metal plates or bodies **50**, **51** which are held together by bolts **52** extending through the respective openings **24** in the heating element and also carrying a handle **53**.

In accordance with the invention, I provide terminals of novel construction for making connection to the respective plate-like terminal portions **28** and **29**, these terminals making an efficient electrical connection to the plate portions **28** and **29** while permitting them to remain in the plane of the heater element.

Each terminal, as shown in detail in Figure 11, may comprise a metal sleeve or container member **55** having a lower flanged portion resting on insulating sheet **37***a* and disposed in a cavity formed in the upper iron member **51**. Sleeve member **55** may be insulated from metal plate **51** by a bushing or grommet **56** which is lapped over the top of plate **51**. A solid body or rod **57** of compressed, conductive, powdered material, such as graphite, is disposed within the container member **55** and a portion of this material extends through the opening **38** into contact with the flat terminal portion **28**. In preparing the terminal rod, pure graphite powder of high electrical conductivity is glowed while in powder form and compressed into desired cylindrical shape generally without any binder. The resulting pressed graphite body is characterized by high mechanical strength, is unaffected by elevated temperatures, and has some elasticity to apply resilient pressure to the resistance plate. The compressed body of powdered material or rod is forced into contact with the terminal portion in any suitable manner, such for example, as by a set screw **58** which is disposed on interior threads located at the top of sleeve member **55**. The set screw **58** should be formed of material which is non-oxidizing at moderately high temperatures, such as nickel, monel metal, or silver plated brass.

The member **55** also carries external means for making electrical connection through the sleeve and compressed conductive material **57** to the flat terminal portion **28**. This external means may comprise a pair of nuts **59**, **60** threaded to the exterior of the sleeve. The nut **59** may be forced into engagement with grommet **56** and the top of plate member **51** to hold the terminal firmly in assembled position thereon. The nut **60** may be utilized to hold a lead or conductor in contact with sleeve **55** and nut **59** to afford an electrical connection to the terminal portion **28**. It is also possible, of course, to clamp or otherwise attach a conventional contactor pin to the terminal which is adapted to cooperate with a conventional connector at the end of a flexible cord.

It will be apparent that the entire heating element, including the grid-like resistance elements **12** and the terminal portions **28**, **29** is held in a perfectly flat position between the metal plates **50**, **51** and the insulating sheets **35**, **37***a*. Accordingly, the insulating sheets may be greatly reduced in thickness, as compared with prior art structures, thus reducing the operating temperature of the heater element and decreasing the temperature differential between the heater element and the body of the iron. As a result, the heater element is placed under the protection of the body of the iron due to the intimate heat exchange relation therebetween. Furthermore, the heating element is absolutely plane, of uniform thickness throughout and free from bonds, folds, soldered or welded joints. The terminals, one of which is provided for each terminal portion **28** and **29**, cooperate with the associated structure to maintain a perfectly flat position for the entire heating element and to afford an efficient electrical connection thereto.

Another important aspect of this invention relates to a die for forming the slotted plate shown in Figure 4 by a single punching operation and to a method for making such a die. The die is shown by Figures 12 to 15 in which upper and lower rectangular frame members **65** and **66**, respectively, are mounted on four posts or rods **67** disposed at the respective corners thereof, as by bolts **68**. A stationary die assembly **69** is fixedly secured to the frame **66** in any suitable manner, for example, by bolts **70**.

A movable unit generally indicated at **71** is mounted for reciprocatory vertical motion on the rods **67** and this movable unit is actuated by a reciprocatory shaft **72** connected to any suitable power source, not shown. The movable unit comprises a support or frame **73** to which is secured a tool carrying assembly **74**, as by bolts **75**. A guide or header assembly **76** is carried by the movable unit **71** but is adapted for limited relative movement with respect to the tool carrying assembly **74**. To this end, the guide assembly and tool carrying assembly are interconnected by members **77**, Figure 12, each having a circular opening **78** for receiving a bolt **79** which is attached to guide assembly **76** and a slot **80** for receiving a bolt **81** attached to tool-carrying assembly **74**. Accordingly, it will be apparent that the guide member may slide along the posts **67**, moving relatively to the tool-carrying assembly a distance determined by the length of slots **80**.

The guide assembly is urged to a spaced position with respect to the tool-carrying assembly by a pair of compression springs **85** which are mounted in suitable recesses provided in the aforesaid guide and tool-carrying assemblies.

The tool-carrying assembly, guide assembly, and stationary die assembly are each adapted to receive a row of stacked metal plates and hold said plates in their stacked position. To this end, each assembly comprises a pair of end frame members **86** and lateral frame members **87**, Figure 14. The inner surfaces of frame members **87** are shaped to form longitudinal slots **88**, respectively, which are adapted to receive complementary end portions of the aforesaid metal plates.

The tool-carrying assembly carries a row **90** of metal plates, the guide assembly carries a row **91** of metal plates and the stationary die assembly carries a row **92** of metal plates, each row being supported, as stated, by the longitudinal slots **88** in frame members **87**. In accordance with the invention, corresponding plates in each row are of identical thickness and have accurately machined parallel sides. Aligned slots **93** are formed in each set of corresponding plates, these slots conforming, in size and location, to the slots to be formed in metal plate **10**, Figure 4. That is to say, the slots in each assembly are divided into two rows, the slots in each row being in parallel staggered arrangement with their ends defining the edges of the heating element to be formed, which, in the example shown, is an element adapted for use in an electric iron. It will be noted that the plates are of progressively decreasing thickness progressing toward the tip of the heating element defined thereby.

The edges of each slot in the stationary die assembly may diverge somewhat progressing away from the top of the plates to define cutting edges at the top of the plate and permit severed material to be readily ejected from the die.

Each of the slots in the tool-carrying assembly carries a cutting tool or knife **95**, Figures 13 and 15, having a flanged end portion **96** and an angular cutting edge 97. The flanged portion is held between the frame member 73, Figure 15, and tool-carrying assembly 74 and the body of the knife extends through the adjacent slot in tool-carrying assembly 74 and into the corresponding slot in guide assembly 76, the cutting edge being closely spaced from the lower end of such corresponding slot.

From the foregoing description, the operation of my novel die may be readily understood by those skilled in the art. A thin metal plate, such as the plate 10 of Figure 4, is placed on the upper surface of stationary die assembly 69. Thereupon, the movable unit 71 is lowered causing the guide assembly to press against and hold the plate in flattened position on the stationary die member. Upon continued movement of the unit 71, the tool-carrying member moves downwardly into engagement with the guide assembly, causing the respective cutting edges of the knives to penetrate the plate 10 and move into the slots in the stationary die assembly. In this manner, the slots 11 and 13, Figure 4, are formed in the plate by a single punching operation. When the movable unit is retracted, the parts return to the position shown by Figure 12 and the guide assembly is urged to a position spaced from the tool-carrying assembly by the springs 85.

In order to insure that corresponding plates in the three die assemblies shall be of exactly the same thickness and that the slots therein shall be in precise alignment, I form each set of corresponding plates, which I refer to as a die element, in a single machining operation. In Figure 16, I have shown a set of hardened plates 99, constituting a die element, in side-by-side position upon a hardened steel frame 100 which is secured to the table of a milling or grinding machine, as by a magnetic tool holder or clamp. It will be noted that portions 101 have been cut from the sides of the plates, thus defining tongues 102 which fit into the grooves 88, Figure 14, on the respective die assemblies.

In the machining operation, the plates are formed to identical thickness and transverse slots are formed across the set of plates while they are in the aforesaid side-by-side position. In this manner, I insure that the corresponding plates in each die assembly are of precisely uniform thickness and that the slots 93 therein are in exact alignment.

Preferably, and in accordance with the invention, one end of the plate utilized in the stationary die assembly is elevated while the slot 93 is being formed, Figure 17. This may be accomplished by placing a spacer 103, which may be about 0.003 inch in height, between one side of the plate and the table of the grinding machine. In this manner, the slot 104 in this plate is of progressively increasing depth and forms a shoulder or cutting edge at 105 against which the plate 10 is positioned after the die is assembled.

Instead of using three plates in side-by-side position, as illustrated in Figures 16 and 17, I may utilize a single piece of metal 106, Figure 18, having weakened portions 107 along which the metal piece is severed, after the machining operation, to form a set of plates 99. The weakened portions or grooves 107 are preferably formed before the plate 106 is hardened.

It will be understood that the sets of plates forming the respective die elements are made separately and that a number of such sets are utilized to form the completed die. In assembling the die, the plates are assembled into rows, with the plates of each die element occupying corresponding positions in the rows. Thereupon, the rows of plates are inserted into position in the slotted portions 88 of the respective die assemblies and secured in position therein to form the completed die.

In some cases, where the die is used for cutting relatively thick material, it may not be necessary to provide a guide assembly. In such a structure, each die element will consist of two plates, one for the stationary die assembly and the other for the tool carrying assembly.

While the present invention, as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but it is intended to cover the invention broadly within the spirit and scope of the appended claims. For example, instead of concentrating the heat at the tip of the iron by decreasing the width of the element adjacent the tip regions, it is also within the scope of the invention to slightly roll down the tip portion of the heater element blank, thereby increasing the specific resistance of the element in this region.

What is claimed is:

1. In a machine for forming a series of slots in a metal plate, a stationary die assembly and a movable die assembly, each of said assemblies comprising a row of stacked metal plates having parallel sides, corresponding plates in each row being of substantially identical thickness and having aligned slots therein which are adapted to receive a cutting tool, the slots in each assembly being arranged in two rows with staggered ends defining the outer and inner edges of a resistive heating element, and a plurality of cutting tools mounted on said movable die assembly, each tool extending through a slot in the movable die assembly and being adapted, during each stroke of the movable die assembly, to pierce a plate mounted on the stationary die assembly and enter the corresponding slot in said stationary die assembly.

2. In a machine for forming a series of slots in a thin metal plate, a stationary die assembly defining a plate supporting portion, a movable unit including a guide assembly and a tool carrying assembly adapted for relative motion with respect to said guide assembly, each of said assemblies comprising a row of stacked metal plates having accurately machined parallel sides, corresponding plates in each row being of substantially indentical thickness and having slots therein which are adapted to receive a cutting tool, the slots in the guide assembly and tool carrying assembly being of equal depth throughout, the slots in the stationary die assembly being of increasing depth progressing away from the plate supporting portion thereof to define a cutting edge and facilitate removal of severed pieces from the die, and means for urging the guide assembly to a spaced position with respect to the tool carrying assembly.

3. In a machine for forming a series of slots in a thin metal plate, a stationary die assembly, a movable unit including a guide assembly and a tool carrying assembly adapted for relative motion with respect to said guide assembly, each of said assemblies comprising a row of stacked metal plates having accurately machined parallel sides, corresponding plates in each row being of substantially identical thickness and having a set of aligned slots therein which are adapted to receive a cutting tool, the slots in each assembly

being arranged in two rows with staggered ends defining the outer and inner edges of a resistive heating element, and means for urging the guide assembly to a spaced position with respect to the tool carrying assembly.

4. In a machine for forming a series of slots in a thin metal plate, a stationary die assembly, a movable unit including a guide assembly and a tool carrying assembly adapted for relative motion with respect to said guide assembly, each of said assemblies comprising a row of stacked metal plates having accurately machined parallel sides, corresponding plates in each row being of substantially identical thickness and having a set of aligned slots therein which are adapted to receive a cutting tool, the slots in each assembly being arranged in two rows with staggered ends defining the outer and inner edges of a resistive heating element having a pointed tip, the thickness of the plates in each assembly progressively decreasing as the tip portion is approached, and means for urging the guide asembly to a spaced position with respect to the tool carrying assembly.

5. In a machine for forming a series of slots in a thin metal plate, a stationary die assembly, a movable unit including a guide assembly and a tool carrying assembly adapted for relative motion with respect to said guide assembly, each of said assemblies comprising a row of stacked metal plates having slots therein to receive and guide a cutting tool, corresponding plates in each row being of substantially identical size and shape with their slots in precise alignment, a plurality of cutting tools supported by said tool carrying assembly, each tool extending through a slot in the tool carrying assembly and into the corresponding slot in said guide assembly, and means for urging said guide assembly to a spaced position with respect to said tool carrying assembly whereby, during each stroke of the movable unit, the guide assembly is adapted to press against a metal plate supported on said stationary die assembly, further movement of said unit causing each cutting tool to pierce the plate and enter the slot aligned therewith in the stationary die assembly.

6. In a machine for forming a series of slots in a thin metal plate, a stationary die assembly, a movable unit including a guide assembly and a tool carrying assembly adapted for relative motion with respect to said guide assembly, each of said assemblies comprising a row of stacked metal plates having accurately machined parallel sides, corresponding plates in each row being of substantially identical thickness and having a set of aligned slots therein which are adapted to receive a cutting tool, the slots in each assembly being arranged in two rows with staggered ends defining the outer and inner edges of a resistive heating element having a pointed tip, the thickness of the plates in each assembly progressively decreasing as to the tip portion is approached, and means for urging the guide assembly to a spaced position with respect to the tool carrying assembly, and a set of cutting tools on the tool carrying assembly, each tool extending through a slot in said tool carrying assembly and into the corresponding slot in said guide assembly whereby, during each stroke of the movable unit, the guide assembly is adapted to press against a metal plate supported on said stationary die assembly, further movement of said unit causing each cutting tool to pierce the plate and enter the slot aligned therewith in the stationary die assembly.

7. In a machine for cutting a series of slots in a metal sheet or plate, the combination of a stationary die assembly having a plate supporting portion and a movable die assembly, each of the die assemblies including a row of stacked metal plates with the opposite sides thereof mutually facing each other and corresponding plates in each row being of substantially the same thickness and having substantially aligned slots therein for receiving a cutting tool, the slots in the stationary die assembly having widened clearance portions in the ends thereof remote from said plate supporting portion and the stacked plates in each die assembly having the slots arranged in two rows with staggered ends defining the outer and inner edges of a resistance heating element; and a plurality of cutting tools mounted on said movable die assembly with each cutting tool extending through a slot therein in effective position to pierce a metal sheet or plate supported on the plate supporting portion of said stationary die assembly and enter the corresponding slot in said stationary die assembly during each cutting stroke of said movable die assembly.

8. In a machine for cutting a series of slots in a thin metal sheet or plate, the combination of a stationary die assembly defining a plate supporting portion; a movable unit comprising a guide assembly and a tool carrying assembly mounted for relative movement with respect to said guide assembly, each of said assemblies comprising a row of stacked plates having accurately finished sides mutually facing each other, and corresponding plates in each row being of substantially the same thickness and having slots therein adapted to receive a cutting tool, the guide assembly and tool carrying assembly having the individual slots therein of equal depth throughout, and the stationary die assembly having each slot therein progressively increasing in depth away from the plate supporting section thereof to define a cutting edge and facilitate removal of severed pieces from said stationary die assembly; and means for biasing the guide assembly to a spaced apart position with respect to the tool carrying assembly.

9. In a machine for cutting a series of slots in a thin metal sheet or plate, the combination of a stationary die assembly defining a plate supporting portion; a movable unit comprising a guide assembly and a tool carrying assembly mounted for relative movement with respect to said guide assembly, each of said assemblies comprising a row of stacked plates having accurately finished sides mutually facing each other, and corresponding plates in each row being of substantially the same thickness and having a set of substantially aligned slots therein adapted to receive a cutting tool, each assembly having the slots therein arranged in two rows with staggered ends defining the outer and inner edges of a resistance heating element; and means for biasing the guide assembly to a spaced apart position with respect to the tool carrying assembly.

10. In a machine for cutting a series of slots in a thin metal sheet or plate, the combination of a stationary die assembly defining a plate supporting portion; a movable unit comprising a guide assembly and a tool carrying assembly mounted for relative movement with respect to said guide assembly, each of said assemblies comprising a row of stacked plates having accurately finished sides mutually facing each other, and

corresponding plates in each row being of substantially the same thickness and having a set of substantially aligned slots therein adapted to receive a cutting tool, each assembly having the slots therein arranged in two rows with staggered ends defining the outer and inner edges of a resistance heating element having a substantially pointed tip portion, the slots in the stationary die assembly being tapered toward the plate supporting portion and the thickness of the plates in each assembly progressively decreasing in the direction approaching said tip portion; and means for biasing the guide assembly to a spaced apart position with respect to the tool carrying assembly.

11. In a machine for cutting a series of slots in a thin metal sheet or plate, the combination of a stationary die assembly defining a plate supporting portion; a movable unit comprising a guide assembly and a tool carrying assembly mounted for relative movement with respect to said guide assembly, each of said assemblies comprising a row of stacked plates having accurately finished sides mutually facing each other and corresponding plates in each row being of substantially the same thickness and having slots therein for receiving and guiding a cutting tool, corresponding plates in each row being of substantially equal size and shape with their slots in precise alignment; a plurality of cutting tools supported on said tool carrying assembly, each cutting tool extending through a slot in the tool carrying assembly and into the corresponding slot in said die assembly; and means for biasing the die assembly to a spaced apart position with respect to the tool carrying assembly whereby, during each cutting stroke of the movable unit, the die assembly initially presses upon a metal sheet or plate to be cut when supported on said stationary die assembly, while further movement of said unit causes each cutting tool to pierce the latter metal plate and enter the slot aligned with the cutting tool in said stationary die assembly.

12. In a machine for cutting a series of slots in a metal sheet or plate, the combination of a stationary die assembly having a plate supporting portion and a movable die assembly, each of the die assemblies including a row of stacked metal plates with the opposite sides thereof mutually facing each other and corresponding plates in each row being of substantially the same thickness and having substantially aligned slots therein individually aligned slots therein individually cut in one side of each stacked plate for receiving a cutting tool, the stacked plates in each die assembly having the slots therein arranged in at least one row with staggered ends defining the opposite edges of a resistance heating element; and a plurality of cutting tools mounted on said movable die assembly with each cutting tool extending through a slot therein in effective position to pierce a metal sheet or plate supported on the plate supporting portion of said stationary die assembly and enter the corresponding slot in said stationary die assembly during each cutting stroke of said movable die assembly.

13. In a machine for cutting a series of slots in a metal sheet or plate, the combination of a stationary die assembly having a plate supporting portion and a movable die assembly, each of the die assemblies including a row of stacked metal plates with the opposite sides thereof mutually facing each other and corresponding plates in each row being of substantially the same thickness and having substantially aligned slots therein individually cut in one side of each stacked plate for receiving a cutting tool, the stacked plates in each die assembly having the slots therein arranged in two rows with staggered ends defining the outer and inner edges of a resistance heating element having a substantially pointed tip portion, the slots in the stationary die assembly being narrowed toward the plate supporting portion thereof and the thickness of the stacked plates in both die assemblies progressively decreasing in the direction approaching said tip portion; and a plurality of cutting tools mounted on said movable die assembly with each cutting tool extending through a slot therein in effective position to pierce a metal sheet or plate supported on the plate supporting portion of said stationary die assembly and enter the corresponding slot in said stationary die assembly during each cutting stroke of said movable die assembly.

14. In a machine for cutting a series of slots in a metal sheet or plate, the combination of a stationary die assembly having a plate supporting portion and a movable die assembly, each of the die assemblies including a row of stacked metal plates with the opposite sides thereof mutually facing each other and corresponding plates in each row being of substantially the same thickness and having substantially aligned shallow slots therein individually cut in one side of each stacked plate for receiving a thin cutting tool, the stacked plates in each die assembly having the slots arranged in at least one row with staggered ends defining the opposite edges of a resistance heating element; and a plurality of thin cutting tools mounted on said movable die assembly with each cutting tool extending through a slot therein in effective position to pierce a metal sheet or plate supported on the plate supporting portion of said stationary die assembly and enter the corresponding slot in said stationary die assembly during each cutting stroke of said movable die assembly.

15. In a machine for cutting a series of slots in a metal sheet or plate, the combination of a stationary die assembly having a plate supporting portion and a movable die assembly, each of the die assemblies including a row of stacked metal plates with the opposite sides thereof mutually facing each other and corresponding plates in each row being of substantially the same thickness and having substantially aligned shallow slots therein individually cut in one side of each stacked plate for receiving a thin cutting tool, the stacked plates in each die assembly having the slots arranged in two rows with staggered ends defining the outer and inner edges of a resistance heating element having a substantially pointed tip portion, the slots in the stationary assembly being tapered toward the plate supporting portion thereof and the thickness of the stacked plates in both die assemblies progressively decreasing in the direction toward said tip portion; and a plurality of thin cutting tools mounted on said movable die assembly with each cutting tool extending through a slot therein in effective position to pierce a metal sheet or plate supported on the plate supporting portion of said stationary die assembly and enter the corresponding slot in said stationary die assembly during each cutting stroke of said movable die assembly.

16. In a machine for cutting a series of slots in a metal sheet or plate, the combination of a stationary die assembly having a plate support-

ing portion and a movable die assembly, each of the die assemblies including a row of stacked metal plates with the opposite sides thereof mutually facing each other and corresponding plates in each row being of substantially the same thickness and having substantially aligned shallow slots therein cut from the sides thereof for receiving a cutting tool, the stacked plates in each die assembly having the slots therein arranged in at least one row with staggered ends defining the opposite edges of a resistance heating element; and a plurality of cutting tools mounted on said movable die assembly with each cutting tool extending through a slot therein in effective position to pierce a metal sheet or plate supported on the plate supporting portion of said stationary die assembly and enter the corresponding slot in said stationary die assembly during each cutting stroke of said movable die assembly.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
346,580	Cobb	Aug. 3, 1886
454,618	Gaiger	June 23, 1891
455,015	Gilliland	June 30, 1891
776,511	Hall	Dec. 6, 1904
1,272,747	Whitney	July 16, 1918
1,302,249	Vogetzer	Apr. 29, 1919
1,343,639	Murphy	June 14, 1920
1,344,435	Bottone	June 22, 1920
1,533,681	Witkus	Apr. 14, 1925
1,906,897	Ballentine	May 2, 1933
2,162,918	Marvin	June 20, 1939
2,389,466	Stoffel	Nov. 20, 1945