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3,764,276

MECHANOCHEMICAL SHEET METAL BLANKING SYSTEM

Original Filed Aug. 31, 1967

3 Sheets-Sheet 1

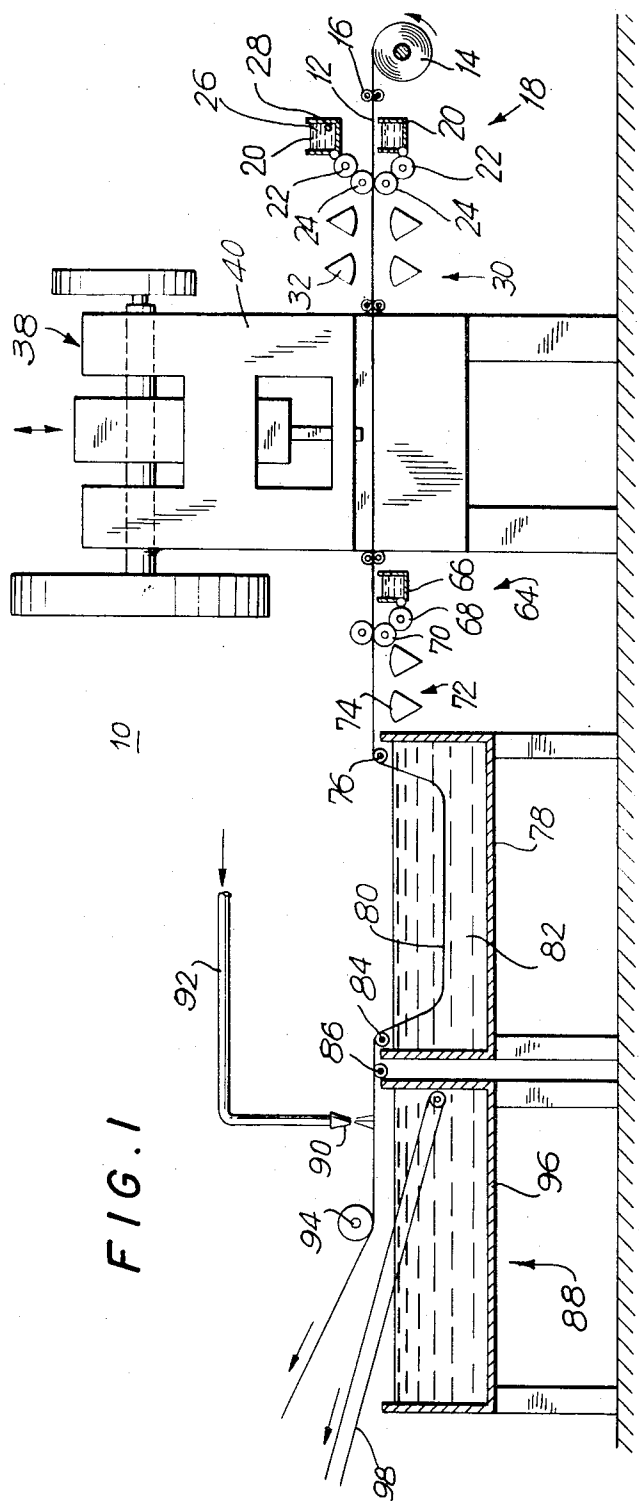


FIG. 1

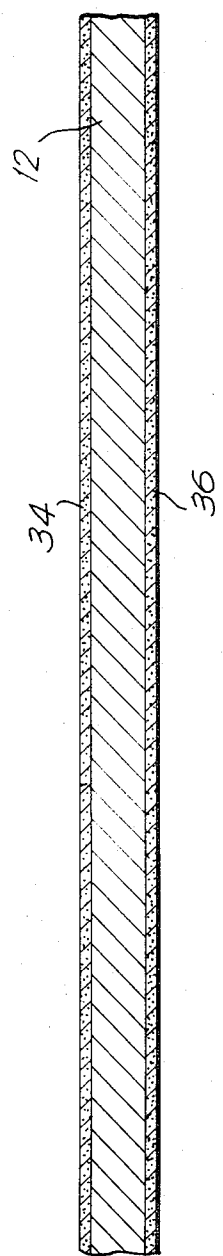


FIG. 2

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3 Sheets-Sheet 2

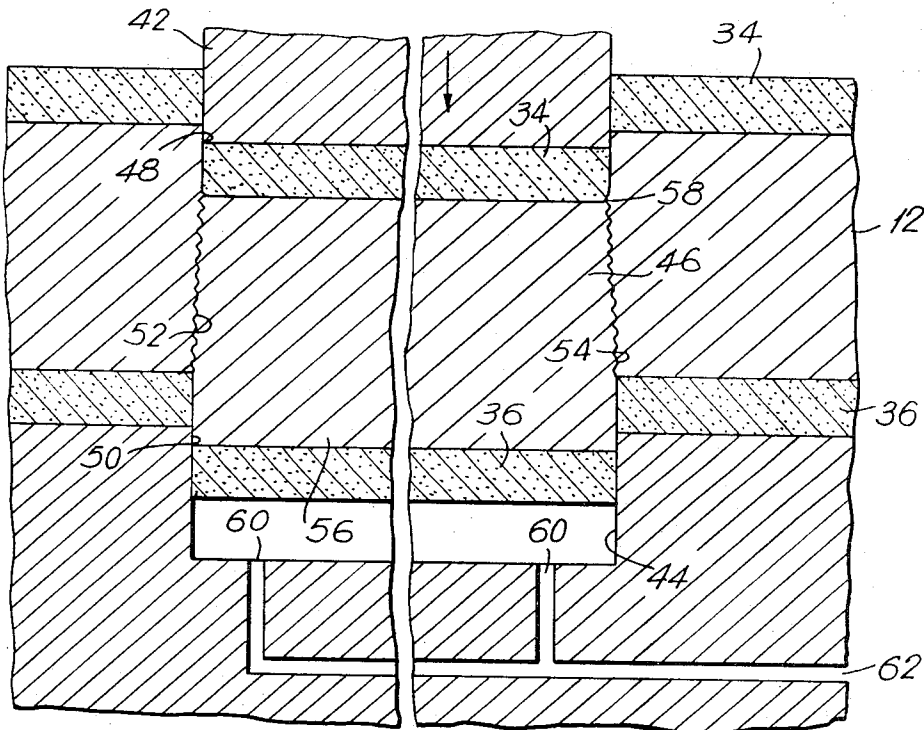


FIG. 3

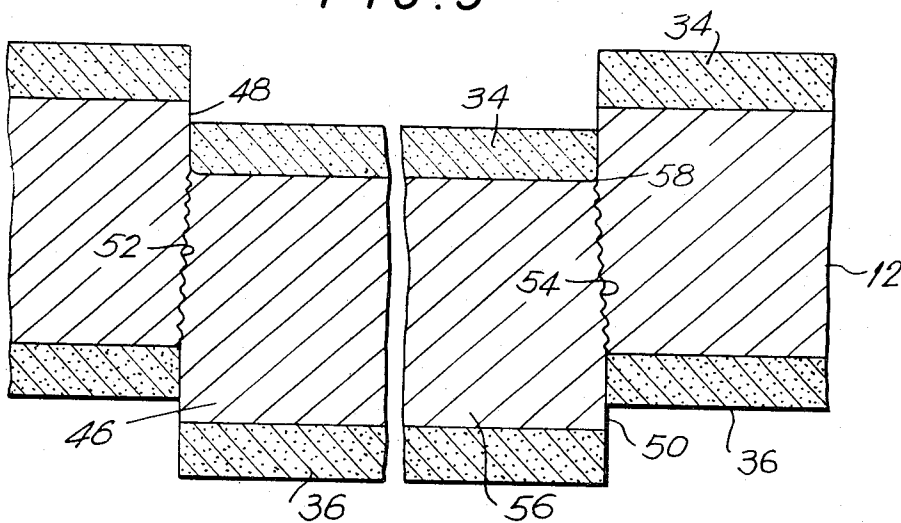


FIG. 4

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FIG. 5

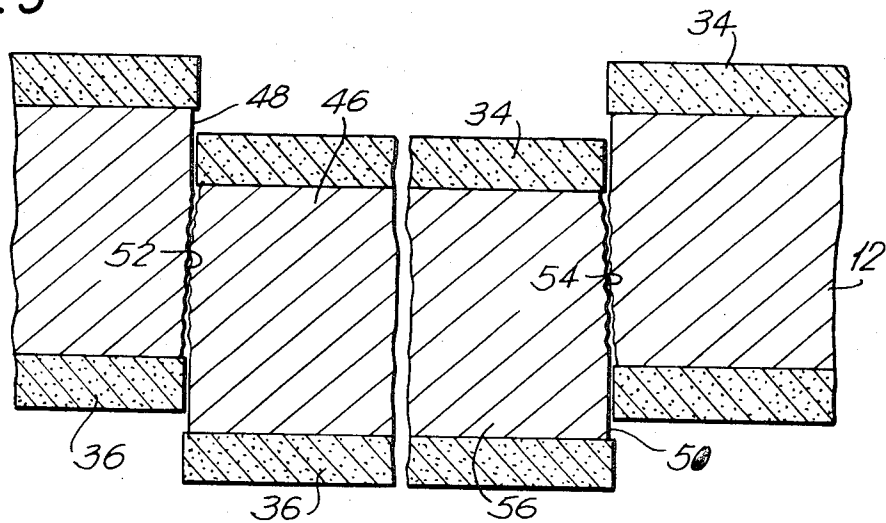


FIG. 6

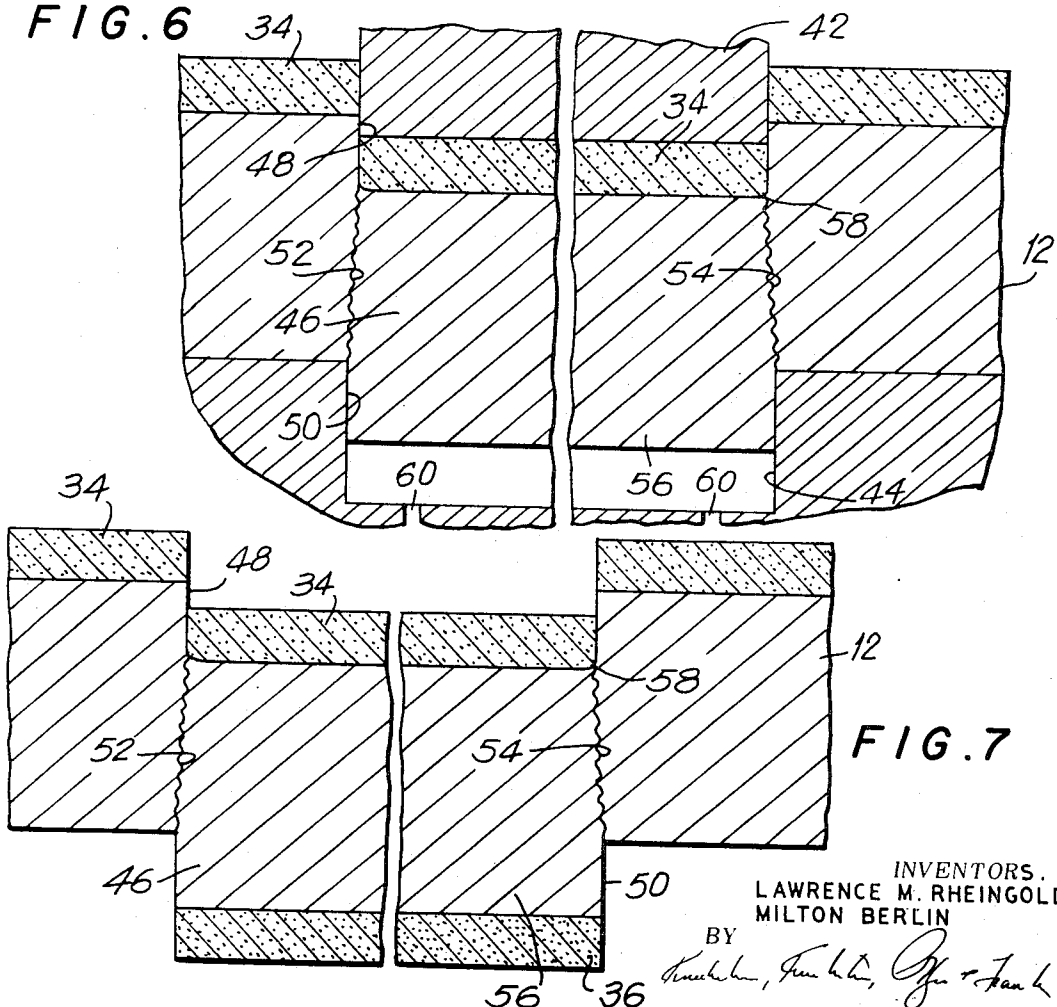


FIG. 7

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3,764,276

MECHANOCHEMICAL SHEET METAL BLANKING SYSTEM

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tion, Hicksville, N.Y.

Original application Aug. 31, 1967, Ser. No. 664,881.

Divided and this application Oct. 22, 1970, Ser.
No. 82,973

Int. Cl. B23p 17/00

U.S. Cl. 29—190

1 Claim

ABSTRACT OF THE DISCLOSURE

A system of blanking sheet metal by using a punch and die to stamp a part out of sheet metal stock for only a portion of its thickness so that the part is substantially surrounded by a peripheral fracture but is still retained by the stock and projects a fraction of its thickness therefrom, protecting the broad faces of the part with a resist, then chemically etching the stock and part so that the etch attacks the metal at the fracture and thereby loosens the part and finally removing the part from the stock.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of our application Ser. No. 664,881, filed Aug. 31, 1967, for Mechanochemical Sheet Metal Blanking System, now U.S. Pat. 3,563,819.

BACKGROUND OF THE INVENTION

(1) Field of the invention

A system of blanking sheet metal by partially stamping a part out of sheet metal part, chemically attacking the walls of the crack substantially surrounding the stock, and removing the part.

(2) Description of the prior art

There are presently two general categories of forming parts from sheet metal (this includes forming or blanking an opening in sheet metal). One of these is a mechanical system, and the other is a chemical system. Each system has advantages and disadvantages which markedly separate it from the other.

In the mechanical system it is conventional to provide a male punch and a female die. The punch matches the die, except that there is usually a slight clearance around the punch when the punch is nested within the die. The punch is made by metal removing operations which usually are quite precise, the precision depending upon, inter alia, permissive variations in the part to be blanked out, the number of parts to be made with the tool, the thickness of the stock from which the blank is to be formed, and the type of finish required of the part, e.g., degree of freedom from burrs. Similarly, precision metal removing operations are required in the formation of the female die. Customarily, the female die is in the form of an opening which extends completely through a metal member inasmuch as in a standard blank-stamping operation the part, after severance from the stock, is traversed completely through the female die and is discharged from the face thereof opposite to the face entered by the punch. It also is usual to provide strippers for disengagement of the blanked out part from the tip of the punch and for disengagement of the stock from the sides of the punch. The speed of the blanking operation is to some extent limited by the length of stroke of the punch which exceeds the thickness of the stock.

Due to the cost of labor and equipment involved in the production of a punch and die, such a system customarily is employed only where a run of a large number of pieces is contemplated. A commonly accepted point is

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about one hundred thousand pieces as a minimum, that is to say, if less than one hundred thousand pieces are to be made, the manufacturer usually will look to a system other than a mechanical system for forming the parts. Of course once a punch and die is made, it can be operated with relatively high speed and is relatively inexpensive to use. It is the considerable length of toolmaker's time (in weeks and sometimes months) and the initial high cost of the punch and die which restricts its use for anything but extended runs. In a typical shop the mechanical system enables from one hundred to three hundred parts per minute to be punched out and an average cost per part for punching is about one and one-half mills.

Aside from the disadvantage of requiring a lengthy run, the mechanical system is subject to the drawback that unless the punch and die are manufactured to precise tolerances and clearances, the parts that are made therewith often will have peripheral burrs which, depending upon the use of the part, may have to be removed, as by tumbling and scraping or filing. A further drawback of the mechanical system is that the punches and dies must be sharp or the parts blanked out thereby experience edge deformation and do not hold to required tolerances. This entails the necessity of frequent regrinding operations.

A basic punch and die operates by placing sheet metal stock on top of the die and then moving the punch toward the die. The punch stamps a blank of predetermined shape out of the stock by pushing the blank through the die. When the punch first engages the stock it embosses the stock, that is to say, it indents a depression on the punch side of the stock, and raises a boss on the die side of the stock. This boss-embossing step involves as to the stock a shearing operation for a fraction of the stock thickness adjacent the punch and as to the part a shearing operation for a fraction of the part thickness remote from the punch. The boss-embossing step further involves a relative displacement of metal for the remainder of the thickness of the part and the stock, the metal of the stock remaining substantially stationary and the metal in the part moving with the punch for such remainder of the thickness.

However, during this initial boss-embossing operation the part remains in one piece with the stock, being severed only at the stock and part shear zones and being integral for the remaining thickness. The part and stock, in other words, are not completely separated from one another. Further movement of the punch into the die causes the stock to fracture around the periphery of the part between the shear zones in the stock and part. Phrased differently, as the punch moves into the stock past the point where only shear is experienced at the zones mentioned, a peripheral crack (fracture) develops around the part, i.e., between the part and the stock, which crack extends from the shear zone in the stock to the shear zone in the part. Still further movement of the punch forces the shear-fractured part out of the stock. The difference between the peripheral shear zone, and the peripheral fracture zone is readily visible on a stamped out part. The shear zone conventionally is shiny and smooth; the fracture zone is finely jagged. The fracture zone of the part tapers inwardly at a slight angle, for example, about 2°, from the die facing surface of the part to the face of the part adjacent the punch. Roughly speaking, the shear zone occupies up to about one-third of the thickness of the part, while the fracture zone occupies the balance.

The chemical system forms a blank by partially coating at least one surface of sheet metal stock with a resist, i.e., a material that is not attacked by the particular chemical etchant employed. The resist coating is in the shape of the part to be made. For instance, assume that the part to be made is a washer. Then the coating is in the form of a flat annulus which will leave exposed on the inside of the

annulus a surface in the shape of the hole that ultimately is to be present in the washer and will leave uncoated on the outside of the annulus a periphery in the shape that the circumference of the washer ultimately is to assume. Thereafter, the surface of the stock bearing the resist is exposed to a chemical etchant which erodes the uncoated area and does not affect the protected area. The etch erodes through the thickness of the stock and finally leaves free the part to be blanked out.

As a practical matter, the chemical system is restricted to parts made from thin stock because of the time involved in etching through the unprotected part of the stock and because of the cost involved in replenishing chemical in the solution. Chemical blanking has one marked advantage. It does not require expensive and time-consuming fabrication of metal punches and dies. The chemical dies, if they may be so denominated, are far cheaper and simpler to make than mechanical dies. They usually are nothing but printing plates or rubber stamps which apply the resist coating in substantially the correct shape on the sheet stock. The printing plates can be made photographically, so that extremely complex shapes can be fabricated at a low cost. Also, the protective resist can be produced by direct photochemical methods in situ on the sheet metal stock which is used by way of example in the production of integrated circuit packs and is conducive to formation of highly involved shapes. Additionally, the shape of the part can be repeated in multiple, so that many parts can be chemically blanked out in one operation. But, as a practical matter, chemical erosion is expensive and time consuming. On an average of about one hundred fifty to three hundred operations per hour can be performed (although many parts can be blanked in one operation) in contrast to the one hundred to three hundred strokes per minute of a stamping press used in the mechanical system. The average cost of making a part with the chemical system is about five cents in comparison to the one and one-half mills for the mechanical blanking system. Of course, the higher per part cost of the chemical system is offset by the very low price of the so-called "dies" used in the chemical system. It has been found that the chemical system is best employed where the total number of parts made in a run is up to about one hundred thousand and that the mechanical system is best used when there are more than about one hundred thousand parts to a run. Thus, each of these two methods operates in its own field tending to be exclusive of the other. Each has many advantages and each has many disadvantages.

Among the drawbacks of the chemical system, aside from its slow speed, are corrosion and undercutting of the blanked out parts and the restriction of the system for efficient operation to very thin sheet metal stock. Also, with the chemical system it is difficult to maintain uniformity and close tolerances of the parts, particularly where a printing-type step is employed, as in the production of integrated circuit parts.

At the present time it is estimated that the chemical system is used for about 85% of the jobs in the United States which make up about 25% of the volume of parts blanked out from sheet metal. The remaining 15% of the jobs which constitute about 75% of the present volume of blanked out parts are made by the mechanical system, in the miniature circuit field.

SUMMARY OF THE INVENTION

The present invention provides a hybrid system including certain steps and equipment taken from the mechanical system and certain steps and equipment taken from the chemical system, the steps and equipment being so blended as to retain the advantages of both systems and to minimize the disadvantages of each in the metal stamping field.

More particularly, it is an object of the present invention to provide a mechanochemical sheet metal blanking system.

It is another object of the invention to provide a mechanochemical system of the character described which has a greater versatility than either the mechanical system or the chemical system and thereby can be economically used for a wider range in the number of parts run, such, for example, as from about ten thousand up rather than from about one hundred thousand up as with the mechanical system, and an unrestricted upper limit rather than having a commercial upper limit of about one hundred thousand as with the chemical system.

It is another object of the invention to provide a mechanochemical system of the character described which can be economically employed for a wider range of jobs and a larger volume of parts than either of the two previous systems, the new system having a projected capability of about 95% of the volume of parts blanked and about 75% of the jobs handled.

It is another object of the invention to provide a mechanochemical system of the character described employing female dies which are of a more rudimentary and, therefore, less expensive character than the female dies employed in the mechanical system and in which the parts may be run through the mechanical section of the mechanochemical system more rapidly than through a mechanical blanking system.

It is another object of the invention to provide a mechanochemical system of the character described employing an erosion step which is carried out far more quickly than the erosion step of the chemical blanking system.

It is another object of the invention to provide a mechanochemical system of the character described in which the erosion step is carried out so quickly that no appreciable undercutting of the blanked part occurs and that the outline of the blanked part is kept substantially even, i.e., at its intended predetermined contour.

It is another object of the invention to provide a mechanochemical system of the character described in which it is unnecessary in a separate step to remove any burrs that might have been formed during the mechanical portion of the operation.

It is another object of the invention to provide a mechanochemical system of the character described in which the clearance between the punch and die is not as critical as in the mechanical system, inasmuch as the burr factor is reduced by the subsequent chemical steps.

It is another object of the invention to provide a mechanochemical system of the character described in which the die work entailed in making the female die is considerably reduced as compared to the mechanical system.

It is another object of the invention to provide a mechanochemical system of the character described which generally does not require strippers to remove either the scrap or the blanked out part from the punch.

It is another object of the invention to provide a mechanochemical system of the character described which enables parts to be blanked with ease and minimal operational steps from thin ductile stock.

Other objects of the invention in part will be obvious and in part will be pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and series of steps which will be exemplified in the system hereinafter described and of which the scope of application will be indicated in the appended claim.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings in which are shown various possible embodiments of the invention,

FIG. 1 is a side elevational schematic view of the equipment employed for carrying out the present invention;

FIG. 2 is an enlarged sectional view through the sheet

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metal stock after the upper and lower surfaces of the stock have been coated with an etch resist;

FIG. 3 is a highly enlarged fragmentary sectional view through the stock at the punching station, the stock being illustrated at the termination of a punch stroke;

FIG. 4 is a highly enlarged sectional view through the stock subsequent to the punching operation, but before the erosion operation;

FIG. 5 is a highly enlarged sectional view through the stock after the erosion operation; and

FIGS. 6 and 7 are views similar, respectively, to FIGS. 3 and 4, but illustrating a modified form of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In general, the present invention is carried out by first performing a mechanical punching operation, which essentially only partly displaces the part from thin stock and leaves a boss-embossed part with a peripheral fracture between it and the stock, and then performing a chemical erosion operation on the walls of the fracture.

The mechanical punching operation is performed with a punch and die. The punch is conventional, constituting a hard metal, e.g., machine tool steel, punch, to which has been imparted a cross-section in the shape and plan dimensions of the part to be blanked out. However, the die differs from a conventional blanking (stamping) die. As noted previously, a conventional blanking die matches its punch, providing stamping clearance (sometime negative) between the two which is appropriate for the type of metal in the sheet metal stock, the thickness of the sheet metal stock, the precision required for the dimensions of the sheet metal stock, the acceptable burr factor, and the number of parts contemplated to be run before resharpening of the punch and die. Moreover, the opening in the die usually extends completely through the die, so that the part being blanked (stamped) out can be pushed through such opening to be discharged on the side opposite to that upon which the punch enters. The die of the instant mechanochemical system is different from the conventional die of the mechanical system in that it does not require a through opening. The die works satisfactorily if it is a bottomed hole, this being the preferred form. Moreover, the clearance, if any, between the punch and die need not be as precise as in the mechanical blanking system and can even be negative, if desired, because the punch need not enter the die. The die of the mechanochemical blanking system can, due to its shallowness, be fabricated quite speedily either by mechanical metal removing operations or by electric discharge or electro-etching methods. Hence, the new die is quicker, easier and more speedy to make than the more conventional stamping female die heretofore used.

As previously was observed, in the mechanical system there is an intermediate stage in the blanking of the part at which a boss-embossing step is completed prior to complete separation of the part from the stock. It will be recalled that at the termination of the boss-embossing step (which in the mechanical system is a transitory phase instantly followed by ejection of the part from the stock), the periphery of the part has two zones in its thickness, the zone adjacent the punch being a fracture zone and the zone remote from the punch being a shear zone. The fracture zone at the termination of the boss-embossing phase is still somewhat tightly, frictionally held in the embryo opening of the stock, and to disengage the part from the stock it is necessary to continue with the descent of the punch through the stock and into the female die.

Pursuant to the instant invention, the punch and die engage the stock far enough to complete the boss-embossing step, but not far enough to completely disengage the part from the stock, and then the punch is retracted. Hence, the mechanical portion of the instant mechanochemical sheet metal blanking system operates on the

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stock far enough to at least reach, i.e., complete, the boss-embossing stage, wherein the part still is tight (held) in the stock, but there is a definite line (crack) of peripheral division between the part and stock which constitutes opposed fracture zones of the part and stock. Usually the shear zones have a height of up to about one-third of the thickness of the stock and part and the fracture zones have a height of about two-thirds or more of the thickness of the stock and part. The part may be further displaced but must not be completely (around its periphery) pushed fully through the stock. Desirably, the part is depressed not in excess of its fracture distance (the height of its fracture zone) i.e., somewhat further than the part is located at completion of the boss-embossing step.

The stock is now advanced longitudinally to remove the part and surrounding parent stock (now scrap) from the punch and die. Because the part still is retained in the parent stock, it is not, unless the stock is thick, necessary to employ strippers to disengage either the scrap or the part from the punch; however, means may be included to assist in stripping the embossed portion of the part from the die. The parent stock itself, by holding back the scrap and the part, performs a punch-stripping function which is highly desirable where delicate, complex parts are to be blanked from thin stock, as with integrated circuit parts.

Prior or subsequent to the boss-embossing operation the broad faces of the part, and optionally one or both broad faces of the scrap, are provided with an etch-resist coating, that is to say, a coating which is not attacked by the chemical etchant subsequent to be used. One convenient method of applying the etch-resist coatings is to form the same on both broad surfaces of the sheet metal stock before the boss-embossing operation. These coatings do not interfere with the boss-embossing step.

Alternatively, the resist coating may be applied only to the punch facing side of the sheet metal stock before the boss-embossing step and the resist coating thereafter applied only to the opposite boss face of the part which protrudes from the opposite face of the stock. Still further, neither face of the stock may be resist coated prior to the boss-embossing step, and after this step has been completed the resist coating can be applied only to the opposite faces of the part which still is carried by the stock. This last method is not presently preferred due to the difficulty of precisely applying a resist coating to the punch facing side of the boss-embossed part. It will be noted that the application of the resist coating to the exposed bossed face of the part is simpler because this part protrudes from the corresponding face of the stock, whereas the embossed face of the part is sunk into the corresponding face of the stock. When the stock is thick, e.g., 0.015 inches or thicker, or when the thickness of the part is not critical, the application of the etch resist coating can be omitted.

The stock with its bossed-embossed part and with the resist coating on both broad surfaces of the part and with the peripheral edges of the part as well as the peripheral edges of the embryo opening of the stock bare, that is to say, uncoated with a resist, is now treated with a chemical etchant. The chemical etchant will attack the peripheral surface of the part where the semi-detached part is still held in the stock at opposed fracture faces. It also will attack the matching surface of the embryo opening in the stock. In particular, the etchant will attack the opposite faces of the crack where the part is held in the stock, i.e., trickle or be forced into the crack between the fracture faces where they still abut one another. The etchant will erode these faces sufficiently to relieve, i.e., lessen, the holding engagement between the part and the stock. Either the part remains loosely held in the stock, as stated, or the part will drop out of the stock at the etching station. At this point etching is terminated. Termination is effected as by treating the stock and part with water or an etch neutralizing solution.

It is to be observed that in addition to eroding the surfaces of the peripheral crack between the part and the embryo opening in the stock for the purpose aforementioned, the etchant also will attack any other part of the stock or part which is unprotected by the resist coating. One part so attacked will be the shear zone in the stock which has been left bare by embossing of the part. This attack performs no useful function, its only drawback, which is a minor one, being the extent to which it depletes the active etching agent. The etchant also attacks the peripheral protruding shear surface of the part and the corner where such surface meets the adjacent broad surface of the part. This too slightly depletes the etchant. However, it serves a useful function in that it smooths this surface, so that it is not necessary to further smooth this portion of the part, as by tumbling. The etchant also attacks the exposed face of any burr that may be present and will substantially reduce or even eliminate the burr. Thus, in sum, the useful operation of the etchant is to erode the wall of the embryo hole in the stock and the peripheral edge of the part, so as to free the part or loosen it preparatory to its ejection from the stock and also to minimize or remove burrs and to smooth out the peripheral surface of the part.

Finally, if the part still is retained loosely in the stock, the part is fully displaced from the stock. This may be carried out by striking the part with a mechanical member, by directing a blast of air against the embossed face of the part, or by mechanically vibrating the stock or by other suitable means.

It will be appreciated that the new system as thus briefly described retains the advantage of high speed operation because the boss-embossing step can be carried out rapidly, indeed, more rapidly than a punching step, due to the shorter stroke. The part accuracy secured with a punch and die is retained, the speed of the system is not unduly hampered by the etching step because it is not necessary to erode through a full thickness of stock, but merely to erode the walls forming the crack between the part and the stock, the finished part is substantially burr-free and smooth, and extremely complex shapes can be cut in very thin ductile sheet metal.

Referring now in detail to the drawings, and more particularly, to FIGS. 1-5, the reference numeral 10 denotes a mechanochemical sheet metal blanking system embodying the present invention, the same constituting several pieces of mechanical equipment which are schematically illustrated in FIG. 1. The system is fed with thin sheet metal stock 12 taken from any suitable source of supply, such, for example, as a coil 14 of sheet metal stock. The sheet metal stock is intermittently advanced into the system by a pair of intermittently actuated feed rolls 16. The stock will be of any metal from which it is desired to fabricate the parts designed to be made in a run. By way of example and without limitation, such metal may be brass, copper, aluminum, cold rolled steel, precious metal alloys, zinc-plated steel, tin-plated steel and steel alloys of all constitutions. The thickness of the sheet metal stock will be the same as the thickness of the part to be blanked. Only thin stock is employed, varying from 0.003 inch to 0.06 inch. A preferred range is 0.003 inch to 0.025 inch. The stock preferably is degreased and clean to form a good bond with the etch resist coating.

The stock is fed from the coil 14 to a coating station 18 at which an etch resist coherent coating is applied to both faces of the stock. Conventional coating equipment is employed. This may constitute such equipment as a brush applicator, a dip applicator, a spray applicator or a roller applicator. A roller application has been illustrated. The applicators lay down an etch resist coating on both broad faces of the stock, specifically, on the top face and on the bottom face.

The roller applicators shown constitute "ink" fountains 20, one of which is above and the other of which is below the path of travel of the sheet metal stock 12 through

the coating station 18. Rotating transfer rollers 22 withdraw fluid resist material from the fountains 20 and supply this material to applicator rollers 24, one of which lightly engages the top surface of the sheet metal stock and the other of which lightly engages the bottom surface of the sheet metal stock.

The fluid etch resistant material 26 located in the fountains 20, is of any type well-known in the chemical blanking system. It is a material which is fluid in the fountain and is solid at room temperature and ambient conditions. The material can be rendered fluid by the addition thereto of a volatile liquid in which the material is either dissolved or dispersed or can be liquefied by heating, being in effect thermoplastic. By way of example, a suitable material is pitch, asphalt or wax, which are solid at room temperature and can be easily liquefied by heating. For this purpose, the fountains are provided with electric heaters 28. The resist material also is characterized by its ability to bond well to the exposed surface of the sheet metal stock. Pitch, asphalt and wax have this characteristic.

Another material which is suitable for use as an etch resist is a synthetic resin, for example, nitrocellulose dissolved in a volatile organic solvent such as acetone or toluene.

After leaving the coating station 18 the sheet metal stock carries on its top and bottom surfaces a thin coherent film of still liquid etch resist material. This material now is hardened at a setting station 30. Construction of the setting station will, as is well-known in the chemical blanking system, depend on the nature of the etch resist material employed. Some materials are quick setting and will set without any special equipment at the setting station. For example, the volatile solvent employed may evaporate so quickly that the setting station simply may constitute a span long enough to permit the solvent to evaporate. Similarly, the setting station with pitch, asphalt or wax used as the etch resist material may constitute a span long enough to allow these materials to cool and harden.

However, since space frequently is at a premium, it is preferable to additionally include at the setting station means for accelerating the hardening of the fluid etch resist material. Such means may constitute a cool stream of air where a heat fluidified resist material is employed. If the material is fluidified by the presence of a volatile solvent, the accelerating means may assume the form of a heat-applying means such as is shown, for example, a bank of heat lamps 32, the radiant energy from which plays on the sheet metal stock. Also the resist material may set chemically, e.g., where a fast-setting two component epoxy resin system is employed.

When the sheet metal stock leaves the setting station it has a cross-sectional configuration which is shown on a considerably enlarged scale in FIG. 2 wherein the reference numeral 12 denotes the sheet metal stock, the reference numeral 34 denotes the top etch resist coating and reference numeral 36 denotes the bottom etch resist coating. In a typical example, the sheet metal stock has a thickness of 0.005 inches and the two resist coatings have a thickness of about 0.002 inches each. Heavier resist coatings may be employed up to about 0.005 inches. Generally speaking, the resist coating is maintained thin since there is no particular advantage in using extra amounts of this coating which ultimately is discarded.

After leaving the setting station 30 the coated sheet metal stock 12 passes to a punching station 38. At this station a boss-embossing step is performed upon the coated sheet metal stock with the use of male and female dies. For this purpose there may be employed at the punching station a power press 40, as illustrated in FIG. 1, or, if higher speeds are desired and lesser accuracy is acceptable, a pair of mating boss-embossed rolls can be employed, the bossed roll constituting the male portion of the punching equipment and the matchingly embossed

roll constituting the female portion (cavity) of the punching equipment.

The punching equipment, as shown, the power press 40, is so adjusted that, as explained previously, the punch performs a boss-embossing step which for a portion of the thickness of the stock and part shears the part to be blanked from the stock and for the remaining thickness of the stock and part fractures the part to be blanked from the stock, but does not push the part completely out of the stock, although with very thin stock portions but not all of the periphery of the part may be pushed clear of the stock, the part being still held in the stock. The respective ratios of the shear thickness and fracture thickness will vary, depending upon the characteristics of the sheet metal stock and the clearance between the punch and the female die cavity. Typically, the shear thickness is about up to one-third of the thickness of the stock and the fracture thickness is about two-thirds or more of the thickness of the stock.

The stroke of the punch is adjusted so that the punch will descend sufficiently far into the sheet metal stock to effect the foregoing complete breaking away, but not pushing fully out, of the part to be blanked from the stock, i.e., at least to complete the boss-embossing step as above defined. If desired, the punch may descend somewhat further into the stock, but not in excess of the height of the fracture zone of the part, so that at least portions of the fracture zones of the part and stock remain interengaged so as to hold the part in the stock. This forms in the stock a depression on the punch facing side of the stock and a protuberance (boss) on the opposite face of the stock. However, the punch stroke is adjusted so that the punch does not descend into the stock sufficiently far to eject the part to be blanked from the stock. In other words, the punch descends into the stock far enough to form the shear line and the fracture line, but not so far that the part will be pushed out or will drop out. Thus, when the punch is retracted, the part to be blanked, although separated from the stock by a peripheral crack, is still frictionally retained within the embryo opening in the stock.

FIG. 3 shows the condition of the punch, stock, part and female cavity at the termination of the boss-embossing step, but before the punch has been retracted. The reference numeral 42 denotes the punch and the reference numeral 44 denotes the female cavity. The reference numeral 46 denotes the part to be blanked out. At the end of the boss-embossing step illustrated in this figure the punch has descended into the stock and in so doing has sheared the part 46 from the stock 12 for a fraction of the thickness of the stock facing the punch, thereby creating a shear zone in the stock. The reference numeral 48 denotes the surface in the embryo opening in the stock corresponding to the shear zone and the reference numeral 50 denotes the shear zone on the part 46 to be blanked. For the remaining thickness of the part and stock a fracture (crack) surrounds the part. The reference numeral 52 denotes the surface of the embryo opening in the stock for the fracture zone and the reference numeral 54 denotes the peripheral area of the fracture zone on the part to be blanked.

It will be seen that the portion 56 of the part to be blanked protrudes from the face of the stock opposite to the punch.

As exaggeratedly shown in FIG. 3, the fracture (crack) peripherally surrounding the part at the end of the boss-embossing step is finely jagged in nature and therefore aids in frictionally retaining the part in the stock at this time. The fracture is not precisely perpendicular to the broad faces of the stock, but generally, due to the clearance, if any, between the female die cavity and the punch, is such that it tapers inwardly from the shear zone of the part toward the punch facing surface thereof. The degree of taper usually is in the vicinity of from about 2° to about 5° to the faces of the stock.

It will be observed that as the part is being punched, the top coating 34 of resist material remains in place on the top surface of the part 46. This top resist coating does not noticeably interfere with the punching operation.

During the boss-embossing step the surface of the part 42 facing the punch may at its periphery, depending on the condition of the punch and die, the amount of clearance and the type of material in the stock 12, turn up slightly as indicated at 58, forming a burr.

The punch 42 is of completely conventional construction. It is made by metal removing operations to match the desired configuration of the part to be blanked. It is fabricated from a tough strong hard or hardened hardenable material, such, for instance, as tool steel. Its lower surface is flat and, optionally, may be coated with a film of good release properties, e.g., silicone. Its bottom corners are square. The shape of the female die cavity 44 matches the shape of the punch, as is usual, there being clearance between the punch and cavity, i.e., the cavity being slightly larger around than the punch. However, a conventional female die cavity usually is an opening extending all the way through a metal member or composite of members, so as to permit the part being blanked to be discharged through the metal member or composite. Contrariwise, the female die cavity 44 preferably is in the form of a cavity having a bottom. Thereby, the female die cavity can be manufactured at a lower cost since it is not necessary to cut all the way through a metal member. The die cavity can be made quickly by low cost tooling operations such as electrolytic erosion or electro discharge machining. In such a process an electrode in the shape of the punch is approached to a metal block and by electrolytic action or electro discharge action sinks into the block, reproducing its shape with a controllable desired clearance between the electrode and the cavity. Inasmuch as the cavity is quite shallow, it can be formed quickly, expeditiously and economically. As was pointed out above, a typical thickness of stock is five thousandths of an inch, and in the preferred form of the invention will vary from about three thousandths of an inch to twenty-five thousandths of an inch. Since the cavity only has to be deep enough to accommodate half the thickness of the stock with a little clearance, cavities as slight as five thousandths to twenty thousandths of an inch can be used and it will be appreciated that these are quite simple and rapid to make either by the methods just described or by older tooling methods such as milling.

Desirably, air passageways 60 lead from an inlet 62 to the bottom wall of the female die cavity for the purpose of intermittently introducing air under pressure into the cavity. This is done, if necessary, to assist in stripping the lower portion 56 of the part 46 from the die cavity at the end of a boss-embossing step after the punch 42 has partially retracted from the stock; alternatively mechanical strippers can be employed.

The appearance of the stock and part after retraction of the punch is illustrated in FIG. 4, where for convenience the punch and the female die have not been shown.

The feed of the stock is halted during a punching operation if the part to be blanked is large and if a stamping press is employed. It is contemplated that the stock feed may be steady rather than intermittent where the part to be blanked is small or where roll dies are employed instead of a stamping press.

As the stock emerges from the punching station, it constitutes a continuous strip of scrap carrying within an embryo hole (actually holes) the part 46 (actually parts) ultimately to be obtained, the part at this time being frictionally retained within the embryo stock opening at the shear and fracture areas. It is pointed out that the shear zone 48 in the stock is bare, that is to say, has no resist coating. The shear zone 50 of the part 46 also is bare of resist material. Finally, the fracture zones 52, 54 of the scrap and part are bare in the crack between the scrap and part. The broad top and bottom surfaces of the part

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are coated with etch resist material as are the broad top and bottom surfaces of the scrap.

In the operation of the present system as described, the top and bottom surfaces of the part to be blanked are coated with etch resist material prior to the next basic processing step which is the etch-erosion step. This coating is inherent because the etch resist material was applied to the top and bottom surfaces of the stock 12 prior to punching by top and bottom applicators at the coating station 18.

In an alternate form of the invention only the top applicator is employed at the coating station and the bottom applicator is either removed or not used prior to punching. In this alternate form a second coating station 64 is located beyond the punching station 38 so that the boss-embossed stock passes through the second coating station after leaving the punching station. At the second coating station an applicator is provided below the stock. Such applicator includes an "ink" fountain 66 in which a hardenable etch resist material is disposed. A rotating transfer roller 68 withdraws the fluid etch resist material from the ink fountain and supplies it to an applicator roller 70 directly below the stock. The applicator roller only contacts the bottom surface of the boss, i.e., projecting part 46, so that only this surface of the part has etch resist material applied thereto as a coating. Said material therefore is not applied to the bottom surface of the sheet metal stock, nor does it seal the bottom edge of the crack (formed by fracturing) that surrounds the part. It is essential to the operation of the invention that the peripheral crack be open at both surface of the stock and part.

FIGS. 6 and 7 illustrate the configuration of the punch, female die cavity, stock and part in the aforesaid alternate form of the invention wherein no lower coating of etch resist material is applied to the stock prior to the punching operation. These figures are similar to FIGS. 3 and 4 except for the elimination of the bottom resist coatings from the part and stock in FIG. 6 and from the stock in FIG. 7, and hence similar numerals have been applied thereto.

A second setting station 72 follows the second coating station and, as shown, consists of a bank of heat lamps 74.

The boss-embossed strip of sheet metal with the part 46 having its upper and lower surfaces protected by etch resist coatings, but with its periphery bare and with the periphery of the embryo opening in the stock bare, is now subjected to an etch-erosion step. This step consists of treating the stock with the contained parts to an etching material, i.e., to an etching liquid. The etching liquid employed is a suitable one for eroding the metal of which the stock is composed.

By way of example, a water solution of ferric chloride may be employed if the sheet metal stock is copper, stainless steel, steel, nickel, magnesium or aluminum. The solution is of 30° to 51° Baumé and the free hydrochloric acid is from about 0.3% to about 0.6%. Another etchant solution which can be used for copper sheet metal stock is a mixture of chromic acid and sulfuric acid with about 10 to 20% of chromic acid and about 20 to 40% of sulfuric acid, the balance being water. Other etch-erosion solutions which are useful for copper are a mixture of ammonium bicarbonate, ammonium hydroxide and sodium chlorite, as described in U.S. Letters Patent No. 3,231,503; a mixture of ammonium persulfate and mercuric chloride; and a water solution of cupric chloride. Dilute nitric acid is a useful etch-erosion solution for zinc and magnesium sheet metal stock. For aluminum stock another etch-erosion solution is a dilute water solution of sodium hydroxide and sodium carbonate with glucose as an additive. Etch-erosion solutions are well known to the art, being widely used for chemical blanking.

The etch-erosion liquid is applied to the stock with the contained parts in any suitable fashion, such, for example, as brushing, pressure spraying, roller application,

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or immersion, the last-named being illustrated. To accomplish immersion treatment, the stock with the contained parts is led by a roller 76 into a tank 78 where the stock forms a reach 80 below the surface of the etch-erosion liquid 82 in the tank. The stock leaves the tank by passage over a roller 84. The stock is treated with the etch-erosion liquid for a predetermined period of time which is a function of the length of the reach 80 and the average speed of feed of the stock and which varies widely with the etchant, the constitution of the stock and the thickness of the stock. This time is so selected that the surfaces defining the peripheral crack around the part will be eroded to such an extent, that the retaining engagement between the part and the stock is completely broken or is substantially lessened. During the treatment with the etch-erosion liquid, said liquid penetrates the peripheral crack around the part, and will attack, so as to erode, the fracture portions 52, 54 of the stock and the part, these being the lower portion of the embryo opening in the stock and the facing portion of the peripheral surface of the part. These portions of the stock and part are attacked by the etch-erosion liquid because such surfaces are bare, i.e., have no etch resist coatings thereon.

The etch resist liquid also will attack other portions of the stock and part. For example, it will attack the shear portions 48, 50 of the stock and part. Furthermore, the etch-erosion liquid will attack the burr 58, if any, and either reduce or eliminate the same, so that it is not necessary subsequently to tumble the part or otherwise treat the part, as by wire brushing or filing, so as to minimize or do away with the burr.

It is to be observed that the attack of the etch-erosion liquid on the fracture area 54 of the part to be blanked, in addition to aiding in removing the part from the embryo opening, reduces the fine irregularity of this fracture area, tending to smooth out such area and render the same more commercially desirable. Thus, the part should be smoother than would be obtained by a stamping out operation which would ordinarily require a tumbling, sanding, wire brushing or filing operation. The same is eliminated by the attack of the etch-erosion liquid.

The part, as just noted, may be completely freed from the stock by this etch-erosion step in which event it will drop out and be suitably withdrawn from the etching bath, as by a conveyor onto which it falls. However, as illustrated, the part remains lightly retained in the stock.

The stock with its contained part leaves the etch-erosion tank with the part now just loosely held in the stock and the stock and parts are guided by a roller 86 to a cleaning and ejection station 88 wherein the loosened part is disengaged from the stock and residual etch-erosion liquid is removed from the part.

The cleaning and ejection station include means to displace the part from the stock. Said means, as pointed out heretofore, may include an arrangement for striking the part from the punch side with a mechanical member or mechanically vibrating the stock. As shown, said displacement means is a nozzle 90 fed with compressed air from a line 92. The nozzle is pointed at the stock from the punch side (embossed side) and is oriented so that as the stock passes beneath the nozzle, the stream of compressed air issuing therefrom will strike the parts in succession, preferably along a medial line. The force of the compressed air is sufficient to eject the part downwardly from the stock. The residual scrap is withdrawn under a roller 94. The parts ejected by the air blast drop into a tank 96 containing water or a neutralizing solution for the etch-erosion liquid. A belt conveyor 98 has a reach inclined within the tank 96 to receive parts that are forced out of the stock by the air blast. Said reach leads the parts out of the cleaning tank to a suitable discharge point.

The resist coatings still on the part are removed in any convenient manner, e.g., by dissolving the same. For instance, pitch or tar is removed by immersion in an agi-

tated turpentine bath and nitrocellulose by immersion in an agitated acetone bath.

The etch-erosion liquid, depending upon the thickness of the part and stock, undercuts the peripheral surface of the stock beneath the etch resist coatings on the broad faces thereof. However, such undercutting is unnoticeable and does not affect the dimensional accuracy of the part because the time during which the part is exposed to erosion is so slight. Unlike the chemical blanking system in which the stock is subjected to erosion for a time long enough to eat completely through the stock, the erosion step of the present invention does not require full stock thickness erosion, but merely erosion of the peripheral edge of the stock to an extent sufficient to substantially loosen the frictional engagement between the part and the stock or to completely free the part. The crack erosion as employed in the present invention is only a small fraction of the thickness erosion which is necessary for freeing a blank from the stock in the standard chemical blanking system.

As seen in FIG. 3 erosion slightly widens the fracture crack, this being somewhat greater at the top and bottom of the crack than at its center due to the time required for the etchant to fully penetrate the crack.

Due to the high speed operation of the punching step which can perform as rapidly as two hundred times a minute or even more rapidly if desired, and to the relatively short period of treatment with the etch-erosion liquid, the new mechanochemical system is a very speedy method of blanking. Furthermore, because it is not necessary to make elaborate female dies, the punches and dies can be fabricated in a fraction of the time and at a considerably lower cost than in the conventional mechanical blanking system. Thereby, the present system retains the high speed advantage of the mechanical blanking system and the low cost die production advantages of the chemical blanking system.

It also should be pointed out that in the alternative form of the invention described above with reference to FIGS. 6 and 7, the scrap, which is to say, the portion of the parent stock not constituting the part to be blanked, is attacked by the etch-erosion liquid in the tank 78, inasmuch as the undersurface thereof is not protected by an etch resist coating. However, this has no deleterious effect on the part being blanked and only requires more frequent replenishment of the etch-erosion liquid.

Although in the preferred form of the invention, etch resist coatings are applied before the stock and parts are subjected to the etch-erosion liquid, the invention also contemplates the omission of etch resistant coatings to the parts and, of course, also to the stock, when the stock and part are not of extreme thinness, e.g., in the order of 0.015 inches and thicker, or when it is not critical to hold the part to an exact thickness. It will be understood that the etch-erosion liquid, since it only has to act for a short time on the stock and part at the crack for the purpose of loosening the engagement between the two or freeing the part, would not, if the etch resistant

coatings were omitted, materially reduce the thickness of the parts and this reduction becomes proportionately less as increasing thicknesses of stock are employed.

On occasion, under actual working conditions, a portion of the periphery of the part may be pushed clear of the parent stock without detaching the part from the stock, therefore it is to be understood that where it is stated that the periphery of the part is fractured, this includes the case in which substantially but not all the periphery is fractured, the balance of the periphery of the part being clear of the parent stock, and the part being retained in the stock by engagement of at least a portion of its fracture zone with at least a portion of the fracture zone of the embryo opening in the parent stock.

It thus will be seen that there are provided systems which achieve the several objects of the invention and which are well adapted to meet the conditions of practical use.

As various possible embodiments might be made of the above invention, and as various changes might be made in the embodiments above set forth, it is to be understood that all matter herein described or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described the invention, there is claimed as new and desired to be secured by Letters Patent:

1. A blanked thin sheet metal part, the peripheral edge surfaces of which include a shear zone extending from one surface toward the center and a fracture zone extending toward the shear zone from the opposite surface of the part, said part having been produced by:

(A) punching sheet metal stock, to boss-emboss a part therein to the extent that the periphery thereof is sheared from the stock for a portion of its thickness adjacent to the punch and the remainder of the periphery of the part is fractured from the stock leaving a depression in the surface of the stock facing the punch and a protuberance on the opposite face of the stock and leaving the part engaged in an opening in the stock with a crack separating the part and the stock, and

(B) then treating the stock and part with an etch-erosion liquid which enters the crack and attacks the mutually facing surfaces of the part and of the opening in the stock so as to substantially lessen the engagement between the stock and the part.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,764,276 Dated October 9, 1973
Inventor(s) Lawrence M. Rheingold et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The term of this patent subsequent to
Feb. 16, 1988, has been disclaimed.

Signed and sealed this 1st day of April 1975.

(SEAL)
Attest:

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