June 13, 1967 J. J. FRANTZEN 3,325,319

PROCESS FOR ETCHING ARCUATELY SHAPED METAL SHEETS

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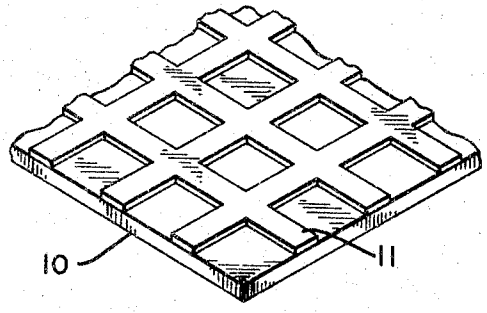


Fig. 1

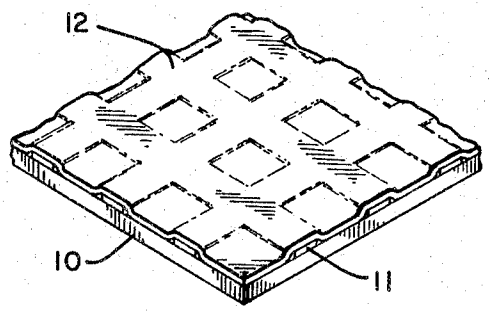


Fig. 2

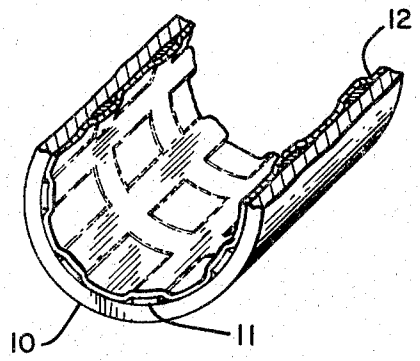


Fig. 3

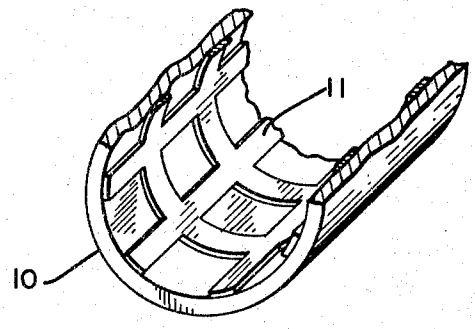


Fig. 4

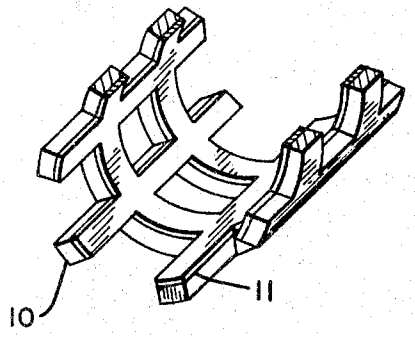


Fig. 5

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PROCESS FOR ETCHING ARCUATELY SHAPED METAL SHEETS

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This invention is directed toward a process for producing articles of a variety of shapes containing etched-out patterns.

Although attempts have been made to photoprint and etch-out patterns in articles after they have been shaped to the desired configuration, for example in cylindrical or hemispheric dome shapes, these attempts have not been too successful principally due to the difficulty encountered in attempting to photoprint a pattern on a contoured surface. Experience has shown it to be preferable to initially form the desired pattern in a flat sheet of stock material and then shape it to the desired configuration. A process in which the foregoing preferable sequence is incorporated is that described in the copending application of Norman B. Mears, Ser. No. 245,001, filed Dec. 17, 1962, titled, Method of Making Fine Mesh Dome-Shaped Grids, now Patent 3,130,487. Briefly, in the process described in the Mears application a flat fine metallic mesh or screen is electro-formed and then overplated with a protective coating layer to fill all of the apertures and then is shaped into the desired dome configuration. After shaping, the covering layer is removed leaving the fine mesh with clear apertures in the desired dome shape. The same process may also be used when the mesh is initially formed by electrolytic or chemical etching rather than by electroformation. Although the Mears process has been extremely successful in producing precision articles of a very fine mesh, it is costly to incorporate into production of less precise articles containing somewhat coarser mesh or pattern arrays. To reduce the cost and the time in producing shaped articles containing etched-out patterns it was considered feasible to initially photoprint and develop out the desired pattern on a flat sheet of the base metal and then form the metal sheet into the desired shape prior to etching-out the desired pattern. This procedure would eliminate the possibility of damaging the etched-out pattern during shaping. Two difficulties arise in this shortened process. The first difficulty is that the coating of light-sensitive material or enamel on the metallic sheet, which is utilized in photo-printing the desired pattern, deteriorates due to the annealing temperatures which the metallic material is subjected to before and after being shaped. The other major problem is the likelihood of the resist enamel being scratched, cracked or otherwise damaged during the step of shaping the metal article.

It is the object of this invention to provide an improved process for forming articles containing etched patterns while overcoming these problems.

In the preferred embodiment of this invention, which subsequently will be described in greater detail, a desired pattern is photoprinted and developed in the well known manner on a surface of a malleable sheet of metal, such as steel. A thin layer of gold is then electroformed on the steel sheet in those areas from which the light-sensitive enamel had been removed during photoprinting and developing so that the gold now serves as a resist to define the pattern to be formed in the steel sheet. The remaining enamel is removed and a covering layer of copper is then overplated on the gold to serve as a protective layer. This laminate is then shaped to the desired configuration and subjected to annealing to relieve the stresses built up in the steel sheet due to work hardening. Annealing

temperatures are chosen so that neither the gold nor the copper is adversely affected by the temperature encountered. Further, the copper protects the gold against being scratched or otherwise damaged while the article is being shaped and handled. Subsequently, the protective coating of copper is removed by stripping or chemical etching followed by etching of the base steel sheet with the gold acting as resist. After the pattern has been etched out of the steel the gold can be removed if desired.

Other objects and features of this invention will be disclosed in the course of the following detailed description with reference to the accompanying drawings in which:

FIGS. 1 thru 5 show the article in various production stages to illustrate the steps of the preferred process of this invention.

A thin malleable sheet of steel **10**, for example ranging in the order of .001 to .050 inch thick, is selectively plated on one surface with pattern-defining strips of gold **11** in the order of .00005 to .0002 inch thick. The process for plating the steel with the gold in the desired pattern array is a matter of choice and the procedures are well known in the art. Briefly, one process consists of suitably cleaning the surface of the steel and coating it with a thin layer of light-sensitive enamel; photoprinting the desired pattern on the coating by exposing it to a suitable light source through a suitable pattern-defining mask and developing to remove the enamel from those areas where it is desired to plate the gold; immersing the steel sheet in a suitable electroplating bath to selectively deposit the gold on those areas of the surface of the steel sheet from which the enamel had been removed; and, when the gold is deposited to the desired thickness, terminating the electroformation process and removing the remainder of the enamel by scrubbing and washing.

As a next step in the process, the steel sheet with the imprinted pattern-defining gold plating can be shaped to the desired configuration, for example, into a cylindrical shape as partially illustrated in FIG. 3. In order to prevent damaging the thin, soft layer of gold, a covering protective layer of copper **12** is preferably electroformed over the gold on the steel sheet before shaping. Only enough copper to protect the gold against scratching or otherwise being damaged during shaping of the article need be deposited over the gold and this may be in the order of .0005 to .005 inch thick. Following the step of overplating the gold with copper, the laminate is then bent, spun or otherwise shaped into the desired configuration such as the cylinder partially illustrated in FIG. 3. Prior to, during and immediately after the shaping step, it is generally necessary to subject the article to annealing to relieve any stresses that might have built up in the sheet of steel. The selected annealing temperature, of course, is dependent on the type of base metal. In a typical case the annealing may be done by subjecting a type 430 stainless steel sheet to 1325° F. for approximately thirty minutes. The characteristics of the gold and copper are such that the time-temperature requirement for the annealing of the steel does not adversely affect these metallic layers while the steel is being properly treated. This was not the case formerly when attempting to anneal an article containing a pattern defined by an enamel resist.

After the article has been shaped and annealed as desired, the protective covering of copper is removed either by mechanically stripping it from the surface of the steel and gold or by a chemical etching process which is well known in the art. The latter is preferable to ensure that the gold plating is not scratched, nicked or otherwise damaged by handling. The copper can be etched away by applying a suitable etchant, such as chromic acid which will not attack the gold or the steel but will remove all of the copper layer. Preferably the article is

then washed and dried to remove all traces of the copper etchant. Next is a further etching step in which a suitable etchant, such as iron chloride, is applied to the inner surface of the steel cylinder sheet, which is masked by the plated gold, so that the steel is etched away from those areas unprotected by gold plating. In other words, during this etching step the gold serves as an etch resist to define the pattern desired to be etched in the steel cylinder. When the pattern has been etched to the desired degree, generally to provide apertures therethrough, the cylinder is thoroughly washed and dried and, if desired, the gold can then be removed either by stripping it or applying a further etchant which will attack only the gold and not the steel.

To speed up the etching steps and to more accurately define the desired pattern so as to obtain a more precise etched-through aperture, the gold resist, **11**, in the desired pattern is plated on both sides of the steel sheet **10** in registration and covered or encased by a protective layer of copper **12**. After the article is shaped to the desired configuration and the copper covering layers removed, the steel can be etched away by applying etchant concurrently to both the inside and outside surface of the cylinder to achieve more rapid and more accurately defined etched patterns.

Obviously the teachings of this invention are applicable to the production of a wide variety of shaped articles made from a wide variety of materials. The steel sheet with gold resist and copper protective layer formed into a cylindrical shape is only intended to be illustrative and not limitive. Obviously a variety of base, resist and covering metals can be utilized and formed into any of a variety of shapes as taught herein with the attendant features and advantages of this invention.

I claim:

1. A process for making a perforated arcuate metal sheet, comprising the steps of:

(a) electroplating a surface of a flat, annealable metal sheet with a softer second metal in a predetermined pattern;

(b) covering the plated surface by electroplating a thin layer of a third metal which is harder than said second metal;

(c) bending the covered flat sheet into an arcuate shape;

(d) annealing the covered metal sheet at a temperature

to anneal the metal sheet without disassociating the second and third metals;

(e) removing the coating layer of third metal from the annealed arcuately shaped article without affecting the first and second metals;

(f) etching away only those areas of the metal sheet which are not covered by said second metal thereby etching the desired patterns through the arcuately shaped article; and

(g) removing the second metal layer from the etched arcuately shaped article.

2. A process for making a perforated arcuate metal sheet, comprising the steps of:

(a) electroplating a surface of a flat sheet of annealable first metal with a softer second metal in a predetermined pattern leaving selective areas of the first metal exposed;

(b) covering the plated surface by electroplating a thin layer of third metal which is harder than the second metal;

(c) shaping the flat covered sheet by bending it into an arcuate shape;

(d) annealing the first metal at a temperature which substantially does not affect the second or third metals;

(e) removing the covering metal after annealing without affecting the other metals;

(f) applying etchant to the plated surface of the first metal after the covering metal has been removed to etch away only the first metal thereby etching the patterns through in the arcuately shaped article; and

(g) removing the second metal from the arcuately shaped, etched article.

3. The process of claim **2** wherein the first metal is steel, the second metal is gold and the third metal is copper.

References Cited

UNITED STATES PATENTS

2,739,047	3/1956	Sanz	156—6 X
3,130,487	4/1964	Mears	29—424

FOREIGN PATENTS

926,715	4/1947	France.

JACOB H. STEINBERG, *Primary Examiner.*