

Dec. 5, 1933.

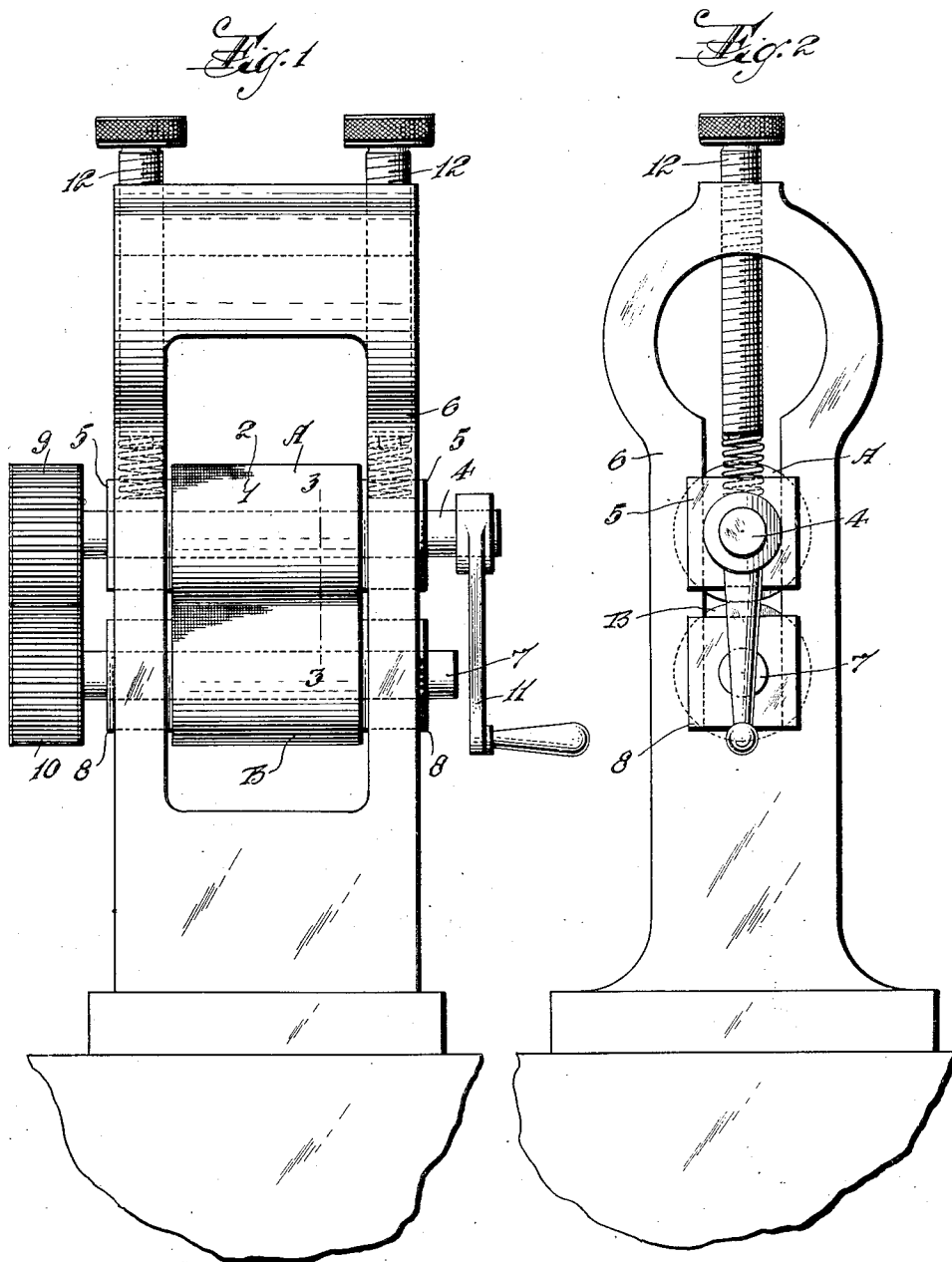
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METHOD OF AND APPARATUS FOR MAKING PERTUSED SHEETS

Original Filed Aug. 7, 1930

4 Sheets-Sheet 1



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METHOD OF AND APPARATUS FOR MAKING PERTUSED SHEETS

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4 Sheets-Sheet 2

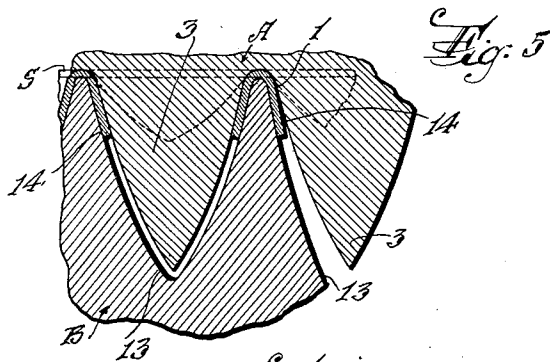


Fig. 5

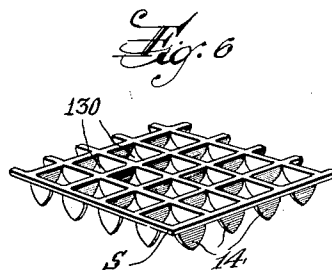


Fig. 6

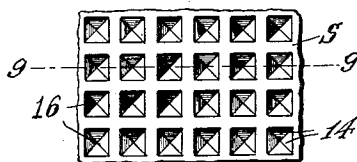


Fig. 8



Fig. 9

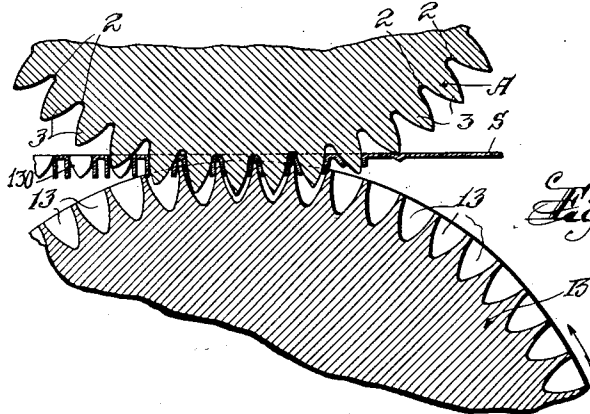


Fig. 3

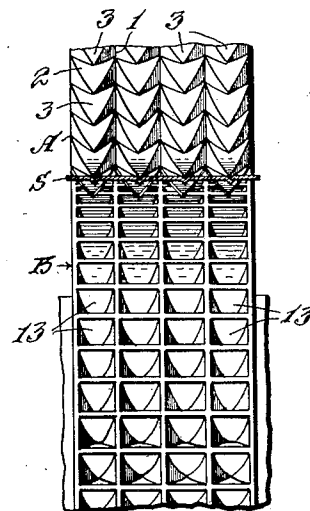


Fig. 4



Fig. 7

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METHOD OF AND APPARATUS FOR MAKING PERTUSED SHEETS

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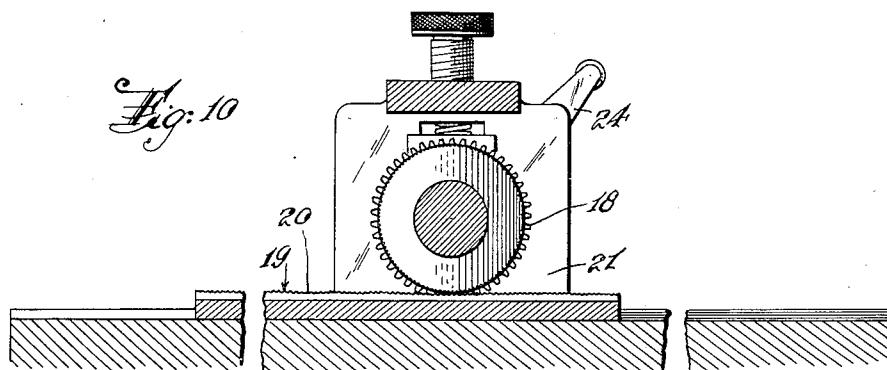
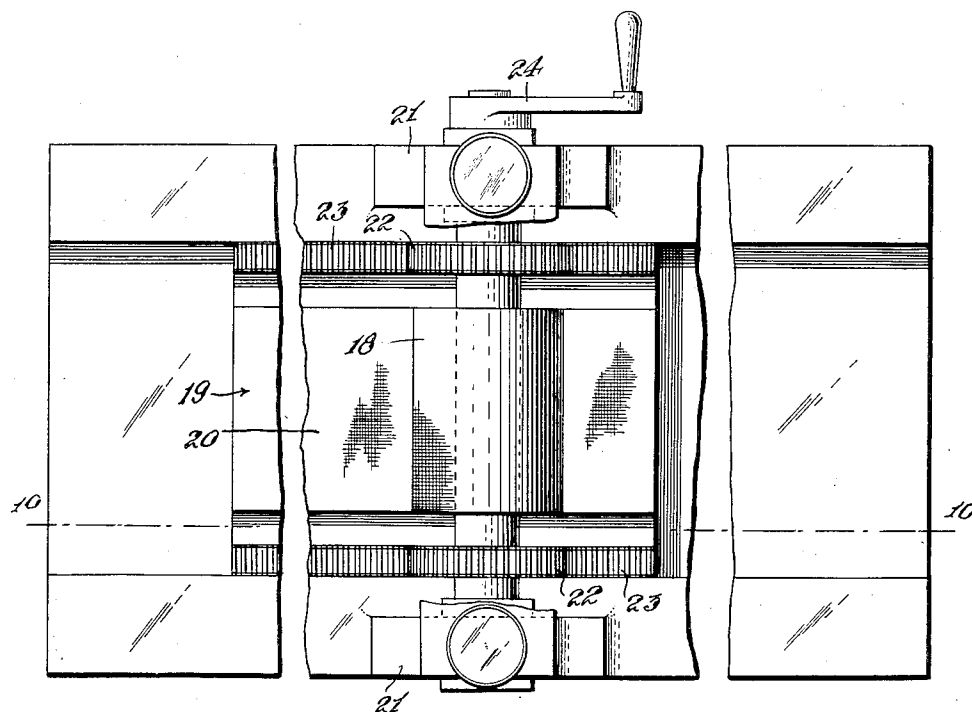


Fig. 11

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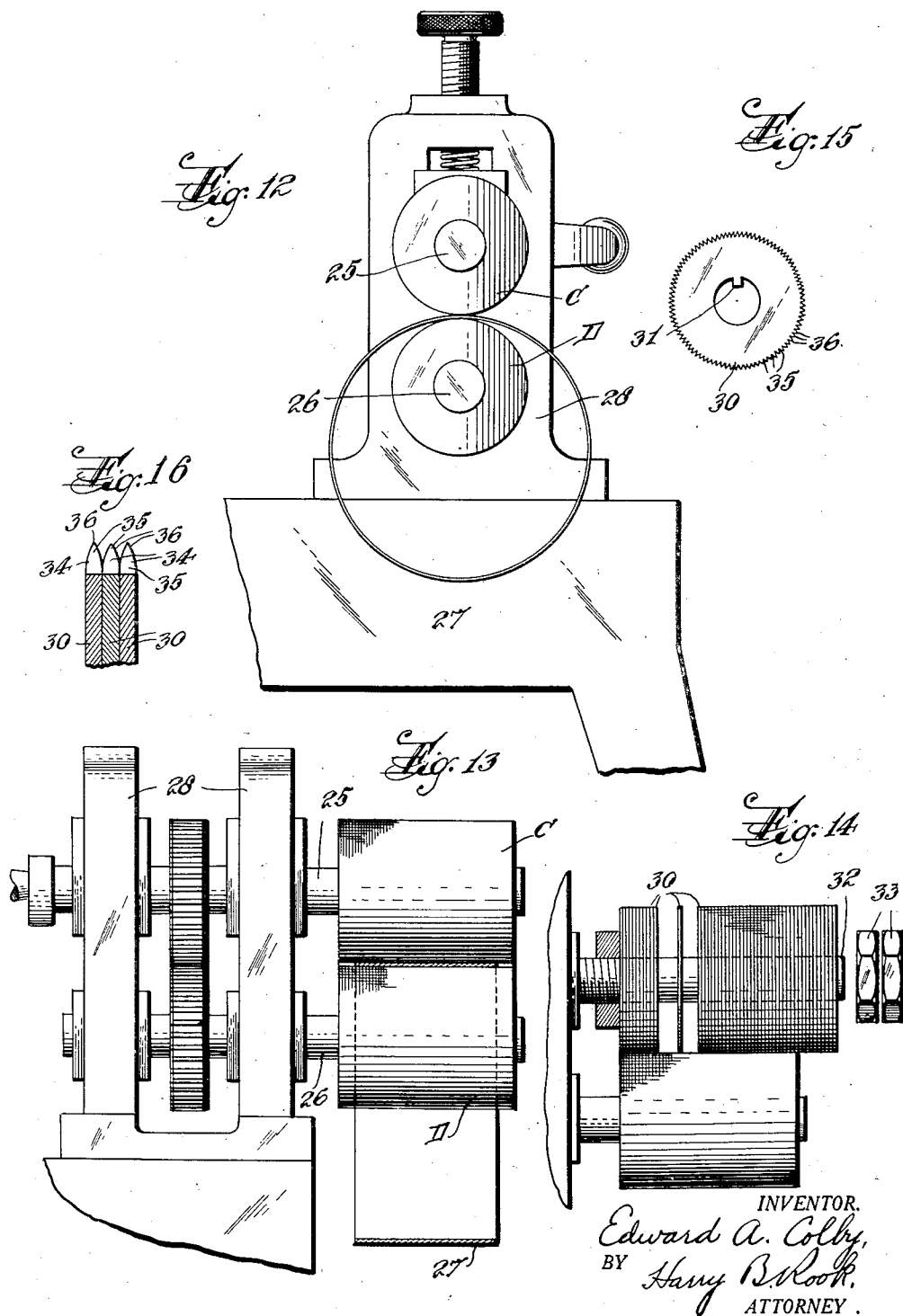
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METHOD OF AND APPARATUS FOR MAKING PERTUSED SHEETS

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4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

1,938,318

METHOD OF AND APPARATUS FOR MAKING
PERTUSED SHEETS

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Original application August 7, 1930, Serial No.
473,730. Divided and this application February
11, 1933. Serial No. 656,356

13 Claims. (Cl. 164—99)

This application is a continuation or division of my application Serial No. 473,730 filed August 7, 1930, and this invention relates to the provision of minute pertusions in ductile sheets of material by deformation of their surfaces without change in weight. The invention is applicable in a minor degree for imparting rigidity to thin sheets of metal by indentation of its surface, but more particularly for the production of thin perforated sheets, for example of a thickness of the order of foil in which the face area of individual perforations is small and the total number of perforations per unit of surface area is large. It relates particularly to the manufacture of fine mesh screens of sheet material having greater accuracy, uniformity and permanency of mesh opening area than is possible in woven wire screens.

Another object is to provide a method by which it shall be possible to make fine pertused sheets from materials which cannot economically be drawn into wire form for weaving. There are many cases in which metal screens produced by this invention are particularly applicable, for example, where uniformity of mesh openings, minimum weight of metal per unit of surface area, and rigidity of structure, are important factors. As one illustration, in one known method of producing nitric acid by the oxidation of ammonia, the mixture of air and ammonia gas is passed through fine mesh screens woven with platinum wire or alloys of the metal. Such screens vary in number of mesh openings from 45 to 150 per linear inch, and are woven with wire having a diameter from .0078 of an inch to .0016 of an inch. When the mixed gases in proper proportion come into contact with the platinum screen, chemical reaction takes place due to the catalytic action of platinum. As this action is exothermic, the platinum screens are raised to a high temperature from 700 to 900° C. This high temperature plus the pressure of rapidly flowing gases tends to distort the screens and alter the mesh opening. Since the chemical reactions take place at the surface of contact of the mixed gases with the platinum screen, it is most desirable to maintain uniformity of mesh opening and to so dispose the catalyzing metal as to expose to the gases the maximum surface of platinum per unit of its weight.

Theoretically in the application of this type of catalytic screen, the number of mesh openings per unit of screen area should be a practical maximum but the cross sectional area of the individual mesh openings should be relatively small compared with the surface area of its boundary walls in order that a maximum percentage of the mixed gases passing therethrough shall have physical contact with the catalyzing metal. While woven wire screens are most generally used, many trials of perforated sheet metal of relatively small surface area have been made, such screens comprising thin sheets of platinum perforated by boring or punching small holes therein of approximately .009 of an inch in diameter and spaced .015 of an inch on centers. In an 80 mesh woven platinum wire screen there are 6,400 mesh openings per square inch of surface, the area of each opening with .003 inch diameter wire being .000089 of a square inch. A round hole of this area would have a diameter of .0106 of an inch. To bore or punch from thin sheet metal 6,400 holes of this diameter per square inch of surface is a most difficult and expensive operation, especially when the surface area required runs into many hundreds of square inches for each screen.

Therefore, another object of this invention is to overcome these difficulties by passing thin sheets of metal of desired width and length between specially designed rolls, the periphery of one roll having the desired number and form of projecting points for pertusing the sheet, the other roll having corresponding recesses in its periphery into which are drawn the side walls of the perforations. By this method the time consumed in producing a perforated sheet per square foot is measured by minutes instead of by days as required by other current processes.

Further objects are to provide novel and improved rolls by which pertusion of thin sheets of ductile material can be produced in a simple operation with uniformity of size, shape and spacing of the pertusions ensured and without changing the weight or surface area of the sheets, and to provide a novel and improved method of making such rolls which shall be simple and inexpensive.

Other objects are to provide a novel and improved method and apparatus for producing sheets of ductile material in which the edges of the perforations have uniform integral extended side walls at one side of the sheet formed by the material displaced from the perforations, whereby the surface area of the perforate sheet is the same as or greater than that of the sheet before perforation thereof and the sheets are reinforced against flexing; to provide a method and apparatus of this character for producing sheets having a large number of uniformly shaped and spaced pertusions per unit of area, for example

a sheet having several hundred to several thousand openings per square inch and so spaced that the aggregate face area of the sheets between said openings is less than the aggregate face areas of the openings, so as to be suitable for use in many instances as a substitute for woven wire screens, for example as catalyzers in chemical processes and for screens, plates, and oxide coated filaments in electronic tubes. Screens and plates made by this process afford greater rigidity with less weight of metal for the same surface area than woven wire forms now used. Hum due to vibration of loosely crimped wires is eliminated by sheets embodying the invention, and the complete expulsion of gases occluded in metal parts by bombarding during evacuation of tubes is not limited by inequalities of electrical resistance and heat conductivity in right angularly disposed planes as is the case with woven wire screens. Pertused anodes and screens are better heat radiators than those with smooth surfaces. If carbonized metal is used, as is current practice in certain electronic tubes, pertused electrodes would still retain the advantage of lessened anode electron emission over smooth surface plates at operating temperature. Labor costs of forming and assembling pertused electrodes are less than with woven wire and greater accuracy of positioning and maintenance of same in transportation and service are assured. Other advantages and results of the invention will be brought out by the following description.

In the accompanying drawings I have shown several forms of apparatus for carrying out my invention, but it should be understood that this is primarily for the purpose of illustrating the principles of the invention and that various other types of apparatus may be utilized without departing from the spirit or scope of the invention. Referring to the accompanying drawings, in which corresponding and like parts are designated throughout the several views by the same reference characters,

Figure 1 is a front elevation of one apparatus for producing minute pertusions or deformations on the surfaces of sheets of ductile material, in accordance with my invention;

Figure 2 is an end elevation thereof;

Figure 3 is an enlarged fragmentary transverse vertical sectional view on the line 3-3 of Figure 1, showing the manner of passing the material between the rolls;

Figure 4 is a front elevation of the rolls illustrated in Figure 3;

Figure 5 is an enlarged fragmentary sectional view of the two rolls showing the manner of cooperation of the teeth and recesses in forming the pertusions;

Figure 6 is a fragmentary perspective view of a pertused sheet of material made in accordance with the invention;

Figure 7 is a vertical sectional view through the sheet;

Figure 8 is a top plan view of a sheet of material which has been deformed, as for reinforcement, in accordance with the invention;

Figure 9 is a vertical sectional view on the line 9-9 of Figure 8;

Figure 10 is a vertical longitudinal sectional view through a modified form of apparatus;

Figure 11 is a top plan view thereof;

Figure 12 is an end elevation of another apparatus for carrying out the invention, especially in making pertused seamless tubes;

Figure 13 is a front elevation thereof;

Figure 14 is a front elevation of a modified form of roll for piercing the sheets;

Figure 15 is an end elevation of one of the plates of which the roll shown in Figure 14 is formed, and

Figure 16 is an enlarged fragmentary vertical longitudinal sectional view through several plates shown in Figure 14.

Specially describing the embodiment of the invention illustrated in Figures 1-7, inclusive, the reference character A designates a steel cylinder or roll of the desired diameter and length, and which has on its periphery a plurality of teeth to cooperate with corresponding recesses in a second cylinder or roll B, in pertusing a sheet. The diameter of the rolls will vary in accordance with the thickness of the sheets to be operated upon and the number of pertusions desired for each unit of area, while the length of the rolls will vary with the width of the sheet to be produced.

In making the roll A, a cylinder of high grade steel, for example tool steel, has a groove 1 with or without lead, cut in its periphery of the desired pitch, shape and depth, according to known machine shop methods. The roll is then grooved longitudinally, as at 2, parallel to its axis, to form teeth 3, and preferably the longitudinal grooves or cross-cuts have the same shape, pitch and depth as the groove 1. The shape, pitch and depth will of course vary with the size and shape of the teeth desired; for example, if 80 teeth per linear inch or 6,400 teeth per square inch surface are desired, the pitch will be .0125 of an inch. Preferably each tooth is polygonal in plan, and has at least one side inclined to the axis of the tooth so as to displace rather than shear the material of the sheet to be pertused. For example, the teeth may be substantially square, and generally pyramidal, as shown. After the roll has been so machined, it is hardened according to known processes.

The roll B may be made of the same or softer material, or may have a surface formed of softer material, than the roll A, and I have found copper alloys mounted on a steel shaft to be very satisfactory.

If the material to be pertused is itself sufficiently hard to have a wearing action on the surfaces of the recesses in the roll B, the composition of this roll or its peripheral surface may be such that it can be hardened by heat treatment after formation of the recesses.

This roll B is formed with its recesses by a rolling action under pressure between the two rolls A and B, which action may be performed in any suitable manner. As shown, the roll A may be mounted on a shaft 4 journaled in slide bearings 5 in a frame 6, while the roll B may be mounted on a shaft 7 mounted in slide bearings 8 in the frame. The two shafts are geared together by pinions 9 and 10, and one of the shafts may be rotated by a crank 11. The two rolls are forced together into peripheral contact as by compression screws 12 engaging the slide bearings 5 of the shaft 4. With the rolls thus arranged the peripheral faces are gradually forced together by the compression screws 12 while the rolls are rotated, and as the result the teeth 3 of the roll A are forced into the surface of the roll B so as to form recesses 13 corresponding in size and shape to the teeth 3. The two rolls being geared together, the spacing and alinement of the teeth and recesses are maintained extremely accurate, the recesses forming matrices of exactly the same shape size and spacing as the teeth in the roll

A. For making a pertused sheet of the specific form herein described the teeth and recesses are of a number of the order of several hundred to several thousand per square inch, and preferably are spaced so that the aggregate face areas of the portions of the peripheries of the rolls between the teeth and recesses, respectively, is less than the aggregate areas of the bases of its teeth or the aggregate face areas of the recesses. Also, preferably the portions of said peripheries between the teeth and the recesses, respectively, are in the same plane.

In pertusing sheets of ductile material, for example platinum, a sheet S is fed continuously between the rolls A and B which are continuously rotated in the proper direction, as indicated by arrows on Figure 3, and the rolls being pressed together, the teeth 3 penetrate or pierce the sheet and force the displaced portions thereof into the recesses or matrices 13, as clearly shown in Figures 3 and 5, to form perforations or pertusions 130. These displaced portions 14 form side walls for the corresponding perforations and project from one side of the sheet. Also these side walls are of an aggregate surface area substantially equal to the area of the corresponding perforations, and the perforated sheets thus remains of the same weight and aggregate surface area as an imperforate sheet of the same dimensions. It will be observed that the perforations will be uniformly spaced, and that a large number of perforations per unit of area can be produced. Also the rigidity of the sheet is increased by the projections 14 which are disposed edgewise to the sheet and to each other in rows extending across the sheet.

Obviously, the length of the side walls 14 of the perforations will depend upon the space between the peripheral faces of the two rolls, the depth of the teeth, etc., while the area of the perforations depends upon the shape of the teeth and extent of penetration thereof. This is illustrated in Figure 5 of the drawings where the teeth are shown with convexly curved sides 15 whereby it is possible to obtain perforations of greater area for the same depth of penetration than would be possible with straight-sided teeth.

As shown, the pertusions are rectangular faced, that is they are rectangular in shape on the surface of the sheet, and the aggregate face areas of said pertusions is substantially greater than the aggregate areas on the face of the sheet of the portions of the sheet between the pertusions, as shown in Figures 6 and 7. All portions of the sheet between the openings are substantially in the same common plane of the sheet, the openings are uniform in size and regular in shape and the walls 14 are flat, uniform and regular in shape. Apparently this is made possible by the firm support by the roll B of the portions of the sheet between the openings at all sides of the openings during the pertusing operation, and the positive moving and continual support of the displaced portions 14 between the opposed surfaces of the teeth 3 and the recesses 13 simultaneously with the formation of the openings, which results from the recesses being exact counterparts of the teeth.

The rolls are preferably so mounted that the surfaces of the rolls A and B between the teeth and recesses respectively contact with opposite sides of said sheet, and the sides of the teeth and corresponding sides of the recesses contact with opposite sides of the displaced portions 14, when the teeth have completely penetrated the sheet,

as shown in Figure 5, this construction of the rolls and the method preventing deformation or tearing of the metal between the pertusions and accurately shaping the pertusions.

In the prior art of pertused sheets of ductile material, the mesh openings have functioned chiefly as anchorage for applied plastic materials in which case accuracy of dimension or number of mesh openings per unit of area are of minor importance. In the more general application of pertused metal sheets, the pertused projections are hard and rigid to function as abrasive teeth for the cutting of softer material. None of the methods heretofore available are capable of pertusing very thin or ductile material to meet present industrial specifications covering extreme accuracy of dimension, in number, spacing and area of mesh opening. The construction peculiar to my invention is that the recesses in roll B have continuous boundary walls which give support at all parts to the sheet being pertused with the result that all the face partition walls between the pertusions lie in one plane and the strains on the metal being pertused are evenly distributed. As an illustration, by my method I have produced on a commercial scale pertused aluminum sheets .0005 inch in thickness with over 4000 mesh openings per square inch.

It will be observed that if the teeth should be formed with flattened apexes, or if the rolls should be separated to a greater extent when passing the sheet therebetween, minute deformation without penetration of the sheet is possible, as illustrated in Figures 8 and 9 of the drawings, where the deformation consists of a plurality of depressions 16 at one side of the sheet and corresponding projections 17 at the other side. Such an operation results in hardening of the sheet and increases the rigidity or stiffness of very thin sheets of metal, especially in directions oblique to the rows of depressions. This operation is particularly advantageous where it is desired to obtain the maximum rigidity of extremely thin sheets of metal, without the perforation of the metal. Preferably, the sheet is cut into sections or pieces so that the depressions are disposed obliquely or diagonally of the sections.

In the drawings, the perforations or pertusions 130 are shown as approximately square and produced by teeth, the pitch of which in the two planes at right angles is the same. Should the pitch of the teeth in the two planes differ, the pertusions would have unequal sides. As clearly shown in Figures 3 and 5 of the drawings, the material is penetrated by the points of the individual teeth and then split into the four triangular-shaped segments or displaced portions 14 which have their apexes at the point of penetration. These four triangular-shaped segments are by proper shaping of the individual teeth spread apart as the rolling operation is completed, so that each pertusion has practically a uniform cross-section from base to apex. The sheet thus produced has one smooth flat side, while the other side is covered with several thousand triangular projections 14 per square inch of surface area. Assuming that the sheet of material is .001 of an inch in thickness, these triangular projections extend about .008 of an inch above the face side of the sheet. Accordingly, when the sheet is to be used as a catalyzer in nitric acid production processes, the surface for contact between the metal and gases is greater by the area of these triangular projec-

tions than is attainable with woven wire screens of the same weight. Therefore, other conditions being equal, the cost of catalyzing metal per ton of nitric acid produced is less with this form of perforated sheet screen than with a woven wire screen.

Also, sheets of metal made according to the invention may be used in making plates, screens, and oxide coated filaments for electronic tubes, providing greater rigidity with less weight of material for the same surface area than is possible in the forms now used; and the hum due to vibration of crimped wires now used is eliminated, while the complete expulsion of occluded gases in the material is facilitated in the bombarding process. Sheets embodying the invention have uniform electrical resistance and heat conductivity, and the sheets may be rolled or bent without breaking, which are especially desirable characteristics in the manufacture of electrodes for electronic tubes.

From the foregoing it will appear that the invention provides a perforated sheet metal screen of the order of woven wire screens formed of wire of from, for example, about .0078 to about .0016 of an inch in diameter, and having from several hundred to several thousand perforations per square inch which preferably are so spaced that the aggregate face areas of said perforation is substantially greater than the aggregate face areas of the portions of the sheet between the perforations. A perforated sheet of such thickness is of the general order of foil and metal leaf, but has much greater rigidity than an unpertused sheet of the same thickness, has a yielding resistance to bending which is substantially uniform in all directions, and has an aggregate surface area equal to or greater than that of an unpertused sheet of the same dimensions. The invention thus provides a perforate sheet having a minimum of material, a maximum of surface area and a maximum of rigidity which is uniform in all directions, such as is highly desirable especially in electrodes for electronic tubes and in catalyzer screens.

A modified apparatus for producing the pertused sheets is shown in Figures 10 and 11 of the drawings, where one of the perturbing members is a steel roll 18 identical with the roll A, and cooperates with a flat plate 19 having a surface 20 in rolling contact with the periphery of the roll 18 and carrying the recesses to cooperate with the teeth on the roll. The roll and plate are mounted in a suitable frame 21 and are geared together by a pinion 22 and rack 23. The sheet to be perforated is fed between the periphery of the roll and the surface 20 of the plate 19, the roll being rotated by a crank 24.

Where it is desired to perforate seamless tubes, the rolls C and D corresponding to the rolls A and B of Figure 1, may be mounted at the ends of shafts 25 and 26 so that the tube 27 may be slipped between the rolls from the ends thereof. The rolls may be mounted in a suitable frame 28 and geared together by gearing 29.

It is also possible to make the roll A in another way than that hereinbefore described. For example, I may form the roll of a plurality of separate circular plates 30 which have integral keys 31 and are keyed upon a mandrel or shaft 32. The plates are clamped together on the mandrel as by nuts 33. In making this type of roll, each plate preferably has its peripheral edge beveled as at 34 in Figure 16, and after the plates have been clamped on the mandrel, cross-cuts 35 are

made parallel to the axis of the roll to form teeth 36. One advantage of this construction is that should any of the teeth become broken off or deformed, it is possible to replace only the plate or plates 30 carrying the broken teeth instead of replacing the entire roll. Also, this type of roll is especially adapted for partusing wide sheets where it is necessary to enlarge the roll and also the number of teeth. It is extremely difficult to harden a solid roll of large dimensions without distortion, while with the roll formed of plates it is possible to harden the plates before they are finally assembled on the mandrel for use and thus provide an accurately straight roll.

Having thus described my invention, what I claim is:

1. The method of perturbing a sheet of ductile material consisting in forming perturbations in said sheet simultaneously at a plurality of points, firmly supporting all portions of the sheet between the perturbations at all portions of the sheet between the perturbations at all sides thereof during the completion of the perturbations, and simultaneously moving and continually supporting the portions of metal displaced by the perturbing operation between opposed surfaces into planes at angles to the plane of the sheet.

2. The method of perturbing a sheet of ductile material consisting in displacing under pressure the material of said sheet from one side thereof simultaneously at a plurality of points to form perturbations, firmly supporting during completion of said perturbations all portions of said sheet between said perturbations at all sides thereof at the side of the sheet toward which said material is displaced, and simultaneously moving and continually supporting the displaced portions of said material between opposed surfaces into planes at angles to the plane of said sheet.

3. The method of perturbing a sheet of ductile material consisting in holding one side of said sheet against a surface having a plurality of recesses therein whereby said sheet is firmly supported at all sides of said recesses, displacing the material of said sheet into all of said recesses simultaneously to form perturbations, and simultaneously moving and continually supporting the displaced portions of said material into snug conforming contact with the walls of the respective said recesses while said sheet is so held.

4. The method of perturbing a sheet of ductile material consisting in holding one side of said sheet against a surface having a plurality of recesses therein whereby said sheet is firmly supported at all sides of said recesses, and displacing the material of said sheet into all of said recesses simultaneously with an instrumentality having teeth constituting exact counterparts of said recesses to form perturbations in said sheet, whereby the displaced material is moved and continually supported between the walls of said recesses and the corresponding sides of said teeth into planes at angles to the plane of said sheet.

5. Apparatus for perturbing sheets of ductile material, comprising a pair of complementary members one of which has a plurality of teeth on its periphery each having at least one side inclined to its axis, while the other member has a matrix or recess for each of said teeth constituting exact counterparts thereof, at least one of which members is a roll, means for mounting said members to receive a sheet of ductile material between them and exerting a rolling action thereon, with said sheet in contact with the surface of the second-mentioned member, and

means for exerting pressure on at least one of said members to yieldingly force said members toward each other and cause said teeth to penetrate said sheet, enter and displace portions of said sheet into said matrices.

6. The apparatus set forth in claim 5 wherein said teeth have sides convexly curved from base to apex.

7. The apparatus set forth in claim 5 wherein said teeth are substantially pyramidal and have sides convexly curved from base to apex.

8. Apparatus for pertusing sheets of ductile material, comprising a pair of complemental members one of which has a plurality of teeth thereon each of which has at least one side inclined to its axis, while the other member has in its surface a plurality of recesses one for each of said teeth comprising impressions of the teeth of the first member in said surface of the second member and means mounting said members to receive a sheet between them and yieldingly force said members together to cause said teeth to penetrate the sheet and enter said recesses.

9. The apparatus set forth in claim 8 wherein said teeth are substantially pyramidal.

10. The apparatus set forth in claim 5 wherein the surfaces of said members between said teeth and said recesses respectively contact with opposite sides of said sheet and at least said side of each tooth and the corresponding side of the corresponding recess contact respectively with opposite sides of said displaced portions when said

teeth have completely penetrated said sheet and entered said recesses.

11. The apparatus set forth in claim 8 wherein the surfaces of said members between said teeth and said recesses respectively contact with opposite sides of said sheet and at least said side of each tooth and the corresponding side of the corresponding recess contact respectively with opposite sides of the displaced portions of the sheet when said teeth have completely penetrated said sheet and entered said recesses.

12. The apparatus set forth in claim 8 wherein the portions of the surfaces of said members between the teeth and the recesses respectively are in the same plane.

13. Apparatus for pertusing sheets of ductile material, comprising a pair of complemental members one of which has a plurality of pyramidal teeth on its periphery in number of the order of several hundred per square inch and spaced so that the aggregate area of the portions of said periphery between said teeth is less than the aggregate area of the bases of said teeth, the other member having in its surface a plurality of recesses one for each of said teeth and comprising impressions of the teeth of the first member in the surface of the second member, and means mounting said members to receive a sheet between them and yieldingly force said members toward each other to cause said teeth to penetrate said sheet and enter into said recesses.

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