

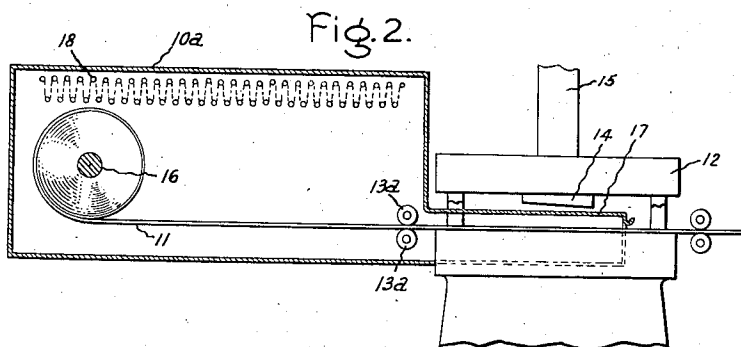
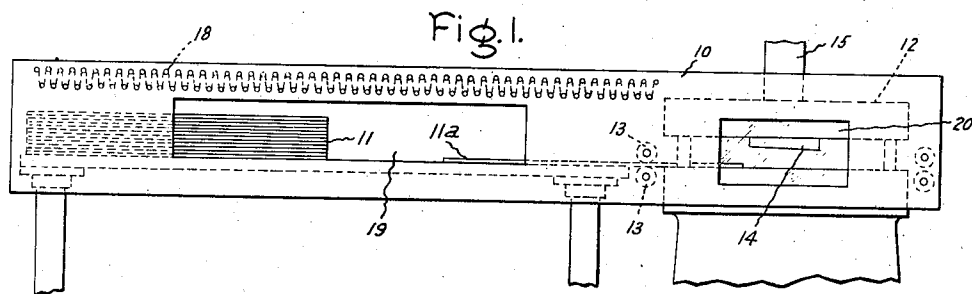
March 18, 1941.

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2,235,532

METHOD FOR SHEARING NORMALLY BRITTLE SHEET METAL

Filed Sept. 29, 1938



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UNITED STATES PATENT OFFICE

2,235,532

METHOD FOR SHEARING NORMALLY
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Application September 29, 1938, Serial No. 232,326

3 Claims. (Cl. 164-17)

The present invention relates to a method for shearing normally brittle sheet metal, and more particularly to a method of producing punchings from sheet silicon steels and the like that are brittle under normal temperature conditions.

It is an object of this invention to provide a method of obtaining smooth-edged, accurately dimensioned, sheared products formed of sheet ferro-magnetic metal such as silicon steel.

It is a further object of the invention to provide a method of improving the magnetic properties of punchings of normally brittle ferro-magnetic material, and to obtain such punchings with less breakage than heretofore has been possible.

Another object of the invention is to increase the useful shearing life of shearing tools as, for example, the punching or stamping dies used in producing steel laminations.

The novel features which I believe to be characteristic of the invention are set forth in the appended claims. The invention itself, however, will best be understood from the following description when considered in connection with the accompanying drawing wherein

Fig. 1 is a diagrammatic view illustrating one form of apparatus adapted for use in carrying this invention into effect; and

Fig. 2 is a view similar to Fig. 1 of another form of apparatus that may be employed in practicing this invention.

Ferrous alloys containing, for example, about 2 to 8% silicon have low hysteresis and eddy-current losses. Such alloys, commonly known as silicon steels, therefore are widely used in thin sheet form in manufacturing magnetic structures of electric apparatus, for instance motor stators, rotors, transformer cores, etc. In making such structures the sheet steel is punched to form laminations of a desired size and shape. These punched laminations are superposed to form a magnetic core. The addition of silicon to iron or steel imparts hardness and brittleness thereto, increasingly so above 3% silicon. The punching operation sets up stresses and strains in silicon steels, both hot rolled and mill annealed, detrimentally affecting their magnetic properties and often resulting in considerable damage.

It has been suggested heretofore that silicon steel to be punched or otherwise mechanically worked should be heated prior to such mechanical alteration, for instance within the temperature range of 30° to 200° C. Such heating of the steel produces ductility therein, but removes advantages sought in using high silicon steel as core

material of audio, power or reactor transformers, and in motor applications. For example, when the steel is hot and the punching dies are cold, variations in the dimensions of the punched laminae occur due to the unequal expansion between the work and the tool. These variations, in turn, result in air gaps in magnetic cores made from such laminae and a material decrease in the effectiveness of the magnetic structure. Further, particularly when a high speed punch press such as a Wright stamping machine is used, the non-uniform expansion and contraction between the work and the cutting portions of the press, cause binding in the dies. As a result, breakage of the laminae is relatively high, even after satisfactory punching, as the work moves through the press to stacking devices. Also, in punching either cold or preheated silicon steel or the like, frequent re-grinding of the cutting edges of the punch is necessary in order to obtain clean-cut laminae.

I have discovered that the above difficulties in shearing, as by punching or stamping, metals such as ferrous alloys which in sheet form are highly brittle, for example silicon steels containing from 3 to 8% silicon, can be avoided by punching or otherwise shearing the sheet metal while both the metal and at least the cutting edges of the shearing tool are at a temperature well above room temperature but materially below a visible heat (500° to 550° C.). Generally, the tool and the work at the time of shearing are at a temperature not exceeding substantially 200° C. but well above room temperature, specifically above 40° C.

With further reference to the drawing there is shown by way of illustration in Figs. 1 and 2 a chamber or oven which is designated in Fig. 1 by the numeral 10 and in Fig. 2 as 10a. This oven envelops the work 11 and, also, all or a substantial portion (and in any event the cutting portion during punching) of the punch press 12. In Fig. 1 I have shown the work 11 in the form of stacked sheets, one of such sheets being shown at 11a as removed from the stack and passing through the rollers 13 to a point beneath the cutting edge 14 of the hammer 15 of the punch press 12. In Fig. 2 the work 11 is shown as being of continuous length and in coil form upon a reel 16. With the aid of the rollers 13a the work is withdrawn from the reel 16 and led to the punch press as above described with reference to Fig. 1. The work 11 is usually slit sheet steel, specifically silicon steel, for example 14 to 25 mils thick, and of a width such that it will pass

through the punch press 12 and will yield a maximum number of laminae per surface unit with minimum waste of metal. It will be understood that after passing through the press only the skeleton of the original sheet remains, the punchings being separately withdrawn by any suitable means (not shown).

In Fig. 2 the oven 10a is shown as being provided with an elongation 17 fitting within the press frame. A suitable opening in the upper portion of this elongation permits the downward thrust of the hammer 15 and engagement of the cutting edge 14 with the work 11a when the latter is in position for punching. The oven design shown in Fig. 2 provides somewhat lower installation and heating costs as compared with that of Fig. 1.

The oven 10, 10a may be heated by any suitable means as, for example, by gas heat, electric heat, a combination of gas and electric heat, etc. For purpose of illustration I have shown the source of heat as being the electric heaters 18.

Suitable openings or windows are provided in the oven 10, 10a for introduction of the work and for observation during its passage through the press. For illustrative purposes I have shown the oven 10 as being provided with an opening 19 in the side wall of that portion of the furnace where the work is initially heated. This opening may take any suitable form as, for example, a hinged or sliding door which may be entirely glass-encased or may be of metal with smaller openings therein for observation of the work and for removing the individual sheets, with the aid of a suitable device from the stacked device and introducing the same between the rollers 13. I have also shown a window 20, which may be encased with glass or other suitable transparent material, in the side wall of that part of the furnace 10 where the press is located. This window permits visual observation of the punching operation, and may be slidably arranged so as to permit ready access to the press if and when necessary.

In carrying my invention into effect the work 11, which is a normally brittle sheet metal, is placed in the chamber or oven 10, 10a. The metal is heated in this chamber to a desired temperature well above room temperature. Heat is supplied from the chamber to at least the cutting edges of a shearing tool such, for example, as the punch press 12. The metal is then sheared while both the metal and the cutting edges of the shearing tool are at a temperature well above room temperature but below a visible heat. For best results the work and the stamping die or other shearing tool employed should be heated to approximately the same elevated temperature. The temperature employed may vary considerably, depending, for instance, upon the particular metal being sheared and the resistance of the shearing tool to heat. In most cases the work and the tool are heated and maintained during shearing at a temperature within the range of 40° to 200° C. In producing silicon steel laminations from sheet silicon steel containing 3 to 8% silicon, the optimum temperature of heating the steel and at least the cutting edges of the shearing tool is within the range of 100° to 200° C. The higher the silicon content of the steel, the more brittle the material and the higher, for best results, should be the temperature of the work and the tool during shearing. Temperatures during shearing ranging from about 200° C. up to a visible heat are not

objectionable provided the tool is formed of a heat-resisting alloy capable of withstanding successfully such temperatures.

If desired, the work initially may be brought to a temperature somewhat higher than its temperature during shearing. For example, the metal may be preheated to 100° to 550° C. Thereafter, by suitably regulating the heating means and varying the operating speed of the punch press or other shearing tool employed, the metal can be cooled during its passage to the tool so that at the time of punching its temperature is of the order of 40° to 200° C. In this way advantage can be taken of the higher temporary ductility created in the metal by reason of the higher preheating temperature, which ductility decreases relatively slowly as the metal cools to punching temperature.

In certain cases, for example in treating normalized, hot rolled or semi-mill-annealed sheet silicon steel or other ferro-magnetic material, I may apply a stabilizing anneal for improving the magnetic properties of the metal in conjunction with the production of punchings therefrom. This may be done by heating the sheet material at a temperature above 400° C., usually above 450° C., and below a temperature which would materially deform the sheet, for a period of time sufficient to improve its magnetic properties. Thereafter the heated sheet material is suitably cooled to a temperature ranging from well above room temperature to 200° C. or above. The cooled metal is directed to a punch press at least the cutting edges of which have been heated to approximately the same temperature as that of the sheet metal immediately before being punched, and the thus treated material is then punched to form punchings thereof.

The maximum annealing temperature to which the sheet metal is heated will depend upon the particular steel being processed. For example, with silicon steels such as those containing from 3 to 8% silicon the maximum temperature to which the sheet material is heated to improve its magnetic properties advantageously is of the order of 800° to 860° C. With other ferro-magnetic materials, for instance iron-nickel alloys, the maximum annealing temperature may be as high as 1100° to 1200° C. Such annealing operation may be carried out in an oxidizing, reducing or inert atmosphere, as desired or as conditions may require. When an oxidizing atmosphere is used in annealing steel not already having an oxide film thereon, the treatment results in forming a tightly adhering insulating oxide film on the metal surface. Such treatment may be modified as described in my co-pending application Serial No. 127,405, filed February 24, 1937, and assigned to the same assignee as the present invention.

While I have shown the work 11 in Fig. 2 in the form of a coil and in that same figure the oven 10a as being adapted to encase only the operating portions of the press 11, it will be understood, of course, that the work may be introduced in coil form into the oven 10 of Fig. 1 and in the form of stacked sheets into the oven 10a of Fig. 2.

Although the invention has been described with particular reference to silicon steels, it is applicable to other metals which in thin sheet form, as, for instance, 14 to 25 mils in thickness, are excessively brittle at room temperature (20° to 25° C.). Examples of such metals are 75

chrome and tungsten magnet steels, high manganese steels, iron-cobalt steels, etc.

The present invention materially increases the period of usefulness of the shearing or cutting tools before regrinding becomes necessary, thereby decreasing unit costs of producing laminations. The magnetic properties of the metal are improved, since fewer stresses and strains are produced therein during punching. Breakage is reduced to a negligible amount. Further, products of this invention have new utility. For example, high silicon steel laminae produced as herein described can be used in cores of electro-magnetic devices in lieu of the higher priced iron-nickel and similar alloys heretofore required where minimum noise during operation of the completed device is an important factor, for example in radio transformers.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of improving the magnetic properties of punchings of ferro-magnetic material which comprises heating such material in sheet form at a temperature above 400° C. and below a temperature which would materially deform the sheet for a period of time sufficient to improve its magnetic properties, cooling the heated sheet material, to a temperature ranging

from well above room temperature to 200° C., heating at least the cutting edges of a punch press to approximately the same temperature as that of the sheet material immediately before being punched, and then punching the thus treated material to form punchings thereof.

2. The method of treating sheet silicon steel containing from 3 to 8 per cent silicon which consists in annealing the said steel at a maximum temperature of 800° to 860° C. to improve its magnetic properties, cooling the heated steel to a temperature within the range of 40° to 200° C., and then shearing it with a stamping die heated to approximately the same temperature as the said steel within the range of 40° to 200° C.

3. The method of treating sheet silicon steel which comprises annealing said sheet steel at a temperature above 400° C. and below a temperature at which the sheet would materially deform for a period of time sufficient to improve its magnetic properties, cooling the heated sheet steel to a temperature within the range of 40° to 200° C. and then shearing it with a die heated to approximately the same temperature as the said steel within the range of 40° to 200° C.

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