

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO THE MANUFACTURE BY ELECTROFORMING OF METAL COMPONENTS OF OPEN CHANNEL SECTION

(71) We, KABUSHIKI KAISHA DAINI SEIKOSHA, a Japanese company of 31-1, 6-chome, Kameido, Koto-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the manufacture by electroforming of metal components of open channel section. The invention is very advantageous for and primarily intended for the manufacture of parts for watches, notably for the manufacture of watch pallet forks and escapement wheels. However the invention is not limited to this application but may be used with advantage for the manufacture of other open channel sectioned metal components of comparable small size. As will be seen later the invention provides improved methods of manufacture by electro-forming which result in strong and light parts of high dimensional accuracy, low internal stress and therefore good wearing qualities. As applied to the manufacture of watch escapement parts the invention results in the manufacture of parts of an escapement having excellent transfer function, low escapement error and low weight.

In conventional manufacturing processes for watch parts such as those above mentioned, the parts are usually pressed out from brass plate, nickel silver plate or steel plate and then finished by cutting and/or grinding although manufacture by electro-forming using a matrix made to the shape of the required watch part has also been proposed.

Manufacture by pressing from plate is, however, most general and has been used for a long time. However, it has the disadvantage that, if brass, nickel silver or steel plate is used a pallet fork made by the method is undesirably heavy. If, in order to attain lighter weight, aluminium alloy is used there is the defect of poor wearing quality for this material is soft and easily worn and the guard

pin of a pallet fork colliding with the roller jewel of a balance wheel is subject to very considerable wearing forces.

Known methods of manufacture of watch parts by electroforming have the defect that such parts (notably a pallet fork) are as heavy as the more conventional pressed parts or even heavier. Moreover, owing to the internal stressing which is present in such parts when made by known electroforming processes, it is difficult to achieve the desired high accuracy of dimensioning, although electro formed parts are of much the same strength as comparable conventional pressed parts.

Although it has been proposed to obtain electro-formed parts by designing them to have in the cross section a deep groove which is made during the process of electrodeposition, known electro-formed parts of this nature are too lacking in mechanical strength to be satisfactory in practice. This lack of strength occurs because, in practice, the thickness of the metal at the corners of the groove is much smaller — usually only about 1/10th of — that at the flat areas. This greatly weakening reduction of thickness arises because, in plating, the metal ions have great difficulty in reaching the corners at the bottom of a deep groove.

According to this invention a method of making metal components of open channel cross section includes the steps of making a metal master conforming in size and shape to that of a component to be made; inserting said master into a resin plate or body to form therein at least one groove or recess; providing an electrical connection in said plate or body under said groove or recess; providing a thin electrically conducting coating on the interior walls of said groove or recess; electro-depositing metal on said coating in an electrolytic solution in a bath; removing the product resulting after electrodeposition; and finishing the removed product by grinding or otherwise eliminating unrequired portions of

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the removed product. Preferably the height/width dimensions ratio of the groove does not exceed 3:1. The electrically conducting coating which is quite thin—only thick enough to provide a good surface for subsequent electrodeposition—may be a deposit of vacuum evaporated silver.

As will be apparent later, the invention lends itself admirably to the manufacture by mass production of parts which require a minimum of subsequent finishing by grinding or cutting operations and which are practically unstressed internally, of light weight, high dimensional accuracy and of good strength and wearing qualities—all matters of great importance for such parts as watch pallet forks and escapement wheels.

The invention is illustrated in and explained in connection with the accompanying drawings, in which:—

Figures 1 (A), (B) and (C) are three schematic cross sectional views illustrating the principle of this invention,

Figure 2 is an explanatory graphical figure showing thickness ratios of electrodeposition under different conditions of the electroforming,

Figure 3 is a diagrammatic perspective view to show how electrodeposition occurs in several directions,

Figure 4 (A) and (B) illustrate the application of the method of the invention to a watch pallet fork, (A) being a view looking down into the hollow former used in making the fork and (B) being a cross sectional view on the line A—A' in Figure 4(A),

Figure 5 (A) and (B) show one form of watch pallet fork made by the method of this invention, (A) being a plan view of the fork and (B) being a cross sectional view on the line B—B' in Figure 5(A),

Figure 6 (A) and (B) illustrates another way of carrying out the invention for the manufacture of watch pallet forks, (A) being a plan view of the hollow former used in making the forks and (B) being a cross sectional view on the line C—C' in Figure 6(A),

Figure 7 illustrates the making of an electrode for use in carrying out the invention, and

Figure 8 shows part of a watch escapement wheel made by a manufacturing process in accordance with this invention.

The processes of this invention, for the manufacture of very small parts such as the pallet forks and escapement wheels of watches, or the manufacture of other very small parts, result in parts which are of open channel section. The principle of these methods will now be explained in general terms with the aid of the three drawings (A), (B) and (C) of Figure 1.

First of all, a metal master conforming with the part to be manufactured by electroforming is made from a metal block, is heated and

is pressed into a resin plate-like body 1 to produce therein a groove 2 the overall dimensions of which correspond with those of the part to be made. The ratio of the depth h to the width d of the groove 2 preferably does not exceed 3:1. Figure 1 (A), (B) and (C) illustrate three different examples the ratio being 1:1, 2:1 and 3:1 in (A), (B) and (C) respectively.

The surface of the groove 2 is then provided with a silver coating 4 to act as an electrode for electrodeposition to electroform the desired part. The electrode 4 is electrically connected to a connection 3 and electric power for electroforming is supplied via this connection.

A series of experiments were carried out to effect electroforming with arrangements as shown in Figure 1(A), (B) and (C). The composition of the electrolytic solution was:

Nickel sulphamate	250 g/litre
Boric acid	30 g/litre
Nickel chloride	5 g/litre
Sodium dodecyl sulfonate	2.5 g/litre
Sodium 1,3,6-naphthalene-trisulphonate	2.5 g/litre

The temperature of the solution was 48°C. Current densities (amperes per square decimetre) as shown below are used for the times shown below:—

Current density (A/dm ²)	time of electroforming (hours)
1.5, 2.0, 3.0, 4.0, 5.0	
6.7, 5.0, 3.3, 2.5, 2.0	

The results of these experiments are shown graphically in Figure 2. The ordinates of the curves are deposit thickness, ratios expressed as the percentage ratio of the thickness (b) deposited on the bottom or sides of the groove to the thickness (a) where the deposit is thickest. The dimensions (a) and (b) are indicated in Figure 1(A). The curves show how the deposit thickness ratio decreases with increase in current density and increase in time.

With a current density of 5A/dm², the electrodeposit near the mouth of the groove 2 is expedited but the deposit thickness on the side walls and on the bottom of the groove 2 remains relatively small. As will also be seen the deposit thickness ratio is decreased with increase in the dimension ratio (h/d). This is because the greater the dimension ratio the more difficult it is for the metal ions to reach into the inside of the groove 2.

To achieve uniform thickness of the manufactured products, the current density preferably does not exceed 5A/dm² for a dimension ratio of 1:1 or 4A/dm² for a dimension ratio of 2:1.

When the electro-forming is finished, the resulting product 9 (shown by double hachur-

ing) is removed from the former and finished by cutting away the unrequired portion (the portion above the chain line which is shown in Figure 1) and uniform thickness is obtained, if required, by grinding or other suitable method.

In another successful series of experiments the same electroforming solution and same temperature as set forth above were used, but the current density was $3A/dm^2$. The time of electrodeposition was 3.3 hours, the formers used having (as shown in Figure 1) the dimension ratios of 1:1, 2:1 and 3:1.

As shown in Figure 1, the products 9 obtained were, in each case, of practically uniform thickness except at the regions 9a near the mouths of the grooves 2. Because the inner wall surfaces of the said grooves 2 are made electrically conductive, the electroform deposits grow in three directions simultaneously as shown by the arrows in Figure 3. As will therefore be seen, the manufacturing method of this invention does not produce stresses (with resulting subsequent wear) in the parts manufactured. Furthermore the method results in manufactured parts of high dimensional accuracy.

Figures 4 to 7 illustrate the manufacture, in accordance with this invention, of a watch pallet fork.

A metal master having the shape and size of the desired pallet fork is first made. The dimension ratio (h/d) of the cross section is preferably less than 3:1. The master is then heated and pressed into the surface of a resin plate 1 as shown in Figure 4 (A). The resin plate may be made of a thermo-plastic resin such as vinylchloride resin or so-called A,B,S resin, (Acryl-butadiene-styrene-copolymer) or acrylic resin, or polyvinyl-acetate resin, or polyethylene resin or polypropylene resin.

A connection 3 is provided and when the metal master is inserted into the resin plate 1 it is pressed onto the said connection which is under the bottom of the groove 2 as shown in Figure 4 (B).

A thin electrically conductive layer constituted by a silver coating 4 is then applied over the surface of the resin plate 1 including the walls of the hollow groove 2. The part of the conductive layer 4 sticking on

the upper face of the resin plate 1 is not required and it is therefore removed by grinding or some other convenient method. The remainder of the layer 4 is electrically connected to the connection 3 and acts as an electrode for electro-forming.

If a plurality of pallet forks are to be manufactured at the same time, the connection 3 may be arranged as shown in Figure 6 to connect with all of them. A cast or master embodying all the pallet forks and the required connection 3 is pressed into the resin plate 1, and a coating of silver provided over the walls of the grooves formed where the master has been pushed in.

Figure 7 shows another way of obtaining the connection 3. In Figure 7 references 2 indicate a plurality of pallet fork grooves in the resin plate 1. 10 is a screen plate or mask having a plurality of slots 10a and metal is deposited through the slots by evaporation in vacuo to provide thin electrical conductors between the pallet fork grooves. This method has, however, the disadvantage of requiring the expenditure of more finishing time in grinding away unrequired electro-deposits produced because of the existence of unnecessary lengths of electric conductor on the surface of the resin plate 1.

A number of thus prepared formers may be connected in parallel in the same plating path so as to manufacture a large number of required parts by electroforming simultaneously.

The following gives a satisfactory electrolytic solution and conditions of electro-forming:—

Nickel sulphamate	250 g/litre	
Boric acid	30 g/litre	
Nickel chloride	5 g/litre	
Sodium dodecyl-sulfonate	2.5 g/litre	
Sodium 1,3,6-naphthalene-trisulphamate	2.5 g/litre	
temperature of solution	45—50°C	
current density	2A/dm ²	
time of electrodeposition	5 hr	

Using the foregoing particulars the following thicknesses in microns (μ) were obtained:—

Dimension ratio h/d	1:1	2:1	3:1
Centre of the bottom	57 μ	39 μ	21 μ
Corner of the bottom	54	37	19
Centre of the side	63	52	46
Top of the side	80	82	82

When the electroforming is finished, the pallet forks are removed and finished by cutting away unrequired metal of uniform thickness by grinding or some other convenient method.

Figure 5 shows a finished pallet fork 5 made by a process as above described. It is of open channel section having a groove 6. The strength (expressed in relative breaking loads) of the portion 5a in which, in use, is inserted a pallet jewel, compared with that if the corresponding part of a known comparable nickel silver or of a known comparable steel pallet fork is given

15	Known Nickel silver pallet fork	225
	Known Steel pallet fork	532
	Electroformed nickel pallet fork	342

The strength of the electroformed pallet fork is thus inferior to the steel pallet fork but superior to the nickel silver pallet fork. Its strength is, however, quite adequate for practical use.

Figure 8 shows part of a watch escapement wheel when made by the process of this invention. The manufacturing process is as already described for a pallet fork. The shape of the escapement wheel is transcribed onto the resin plate and a connection is buried under the bottom of the hollow groove. Then a thin electrically conductive coating (e.g. of silver) is applied and the escapement wheel made by electro-forming as described above. In Figure 8 the wheel is referenced 8 and the groove of the open channel section is referenced 7.

The present invention is particularly described above as applied to the manufacture of watch parts but it is not limited to this and is applicable to the manufacture of other open channel sectional parts of comparable small size.

In the foregoing the use of electrolytic baths for depositing nickel has been described, the components resulting from the electro-deposition being, accordingly, made of nickel. However, the method of the invention may be used for the manufacture, by electroforming, of components of metal other than nickel, suitable electrolytic baths, known per se, being employed.

In the claims which follow the word "under" as employed with reference to the groove or recess means under as viewed in Figure 1 i.e. when the top or mouth of the groove or recess is uppermost.

WHAT WE CLAIM IS:—

1. A method of making metal components of open channel cross section said method including the steps of making a metal master

conforming in size and shape to that of a component to be made; inserting said master into a resin plate or body to form therein at least one groove or recess; providing an electrical connection in said plate or body under said groove or recess; providing a thin electrically conducting coating on the interior walls of said groove or recess; electro-depositing metal on said coating in an electrolytic solution in a bath; removing the product resulting after electro-deposition; and finishing the removed product by grinding or otherwise eliminating unrequired portions of the removed product.

2. A method as claimed in claim 1 wherein the thin conductive coating is deposited vacuum evaporated silver.

3. A method as claimed in claim 1 or 2 wherein the height/width dimension ratio (h/d) of the groove or recess does not exceed 3:1.

4. A method in accordance with any of claims 1 to 3 for making nickel components wherein electro-deposition of nickel is effected in a solution of the following composition:—

Nickel sulphamate	250 g/litre
Boric acid	30 g/litre
Nickel chloride	5 g/litre
Sodium dodecyl-sulfonate	2.5 g/litre
Sodium 1,3,6-naphthalene trisulphonate	2.5 g/litre

at a temperature of 45—50°C and with a current density of 1.5—5 A/dm².

5. A method as claimed in any of the preceding claims for manufacturing a plurality of components simultaneously wherein at least one metal master conforming in size and shape with a plurality of parts to be manufactured is inserted into the resin plate or body to form a plurality of grooves or recesses therein and wherein, instead of providing a connection to the bottoms of the grooves or recesses, connections are provided on the face of said resin plate or body into which the master is inserted by evaporating in vacuo or otherwise depositing metal thereon through slots in a mask.

6. Methods of manufacturing metal components of open channel cross-section substantially as herein described with reference to the accompanying drawings.

7. Metal components of open channel cross-section when made by a method as claimed in any of claims 1 to 6.

8. Watch pallet forks and escapement wheels when made by a method as claimed in any of claims 1 to 6.

9. Watches having parts as claimed in claim 7 or 8.

When the electroforming is finished, the pallet forks are removed and finished by cutting away unrequired metal of uniform thickness by grinding or some other convenient method.

Figure 5 shows a finished pallet fork 5 made by a process as above described. It is of open channel section having a groove 6. The strength (expressed in relative breaking loads) of the portion 5a in which, in use, is inserted a pallet jewel, compared with that if the corresponding part of a known comparable nickel silver or of a known comparable steel pallet fork is given

15	Known Nickel silver pallet fork	225
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The present invention is particularly described above as applied to the manufacture of watch parts but it is not limited to this and is applicable to the manufacture of other open channel sectional parts of comparable small size.

In the foregoing the use of electrolytic baths for depositing nickel has been described, the components resulting from the electro-deposition being, accordingly, made of nickel. However, the method of the invention may be used for the manufacture, by electroforming, of components of metal other than nickel, suitable electrolytic baths, known per se, being employed.

In the claims which follow the word "under" as employed with reference to the groove or recess means under as viewed in Figure 1 i.e. when the top or mouth of the groove or recess is uppermost.

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conforming in size and shape to that of a component to be made; inserting said master into a resin plate or body to form therein at least one groove or recess; providing an electrical connection in said plate or body under said groove or recess; providing a thin electrically conducting coating on the interior walls of said groove or recess; electro-depositing metal on said coating in an electrolytic solution in a bath; removing the product resulting after electro-deposition; and finishing the removed product by grinding or otherwise eliminating unrequired portions of the removed product.

2. A method as claimed in claim 1 wherein the thin conductive coating is deposited vacuum evaporated silver.

3. A method as claimed in claim 1 or 2 wherein the height/width dimension ratio (h/d) of the groove or recess does not exceed 3:1.

4. A method in accordance with any of claims 1 to 3 for making nickel components wherein electro-deposition of nickel is effected in a solution of the following composition:—

Nickel sulphamate	250 g/litre
Boric acid	30 g/litre
Nickel chloride	5 g/litre
Sodium dodecyl-sulfonate	2.5 g/litre
Sodium 1,3,6-naphthalene trisulphonate	2.5 g/litre

at a temperature of 45—50°C and with a current density of 1.5—5 A/dm².

5. A method as claimed in any of the preceding claims for manufacturing a plurality of components simultaneously wherein at least one metal master conforming in size and shape with a plurality of parts to be manufactured is inserted into the resin plate or body to form a plurality of grooves or recesses therein and wherein, instead of providing a connection to the bottoms of the grooves or recesses, connections are provided on the face of said resin plate or body into which the master is inserted by evaporating in vacuo or otherwise depositing metal thereon through slots in a mask.

6. Methods of manufacturing metal components of open channel cross-section substantially as herein described with reference to the accompanying drawings.

7. Metal components of open channel cross-section when made by a method as claimed in any of claims 1 to 6.

8. Watch pallet forks and escapement wheels when made by a method as claimed in any of claims 1 to 6.

9. Watches having parts as claimed in claim 7 or 8.



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