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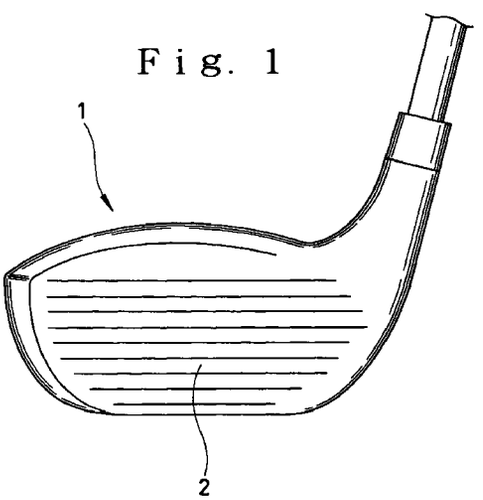
(54) Head for golf club

(57) The invention provides a head for a golf club which is able to achieve an increase of a moment of inertia, an expansion of a sweet spot and the like without making higher a technique for producing the head, and does not deteriorate a batting feeling during a golf play. A plated layer is provided on a surface of a metal head, or a plated layer made of a material having a specific gravity larger than that of material a metal head is provided on a surface of the metal head. The metal head is one selected from titanium, aluminum, stainless steel and soft iron, the surface of the metal head is applied with a plated layer whose material property is provided to the surface of the metal head, and a chrome, a nickel, a copper and their alloy is suitable for the plated material. The plated layer is made in a multiple layer structure having two or more layers. The nickel is excellent in an adhesion property and a bonding property against the material to be plated therewith and the chrome is great in both of a specific gravity and a hardness, and a combination of the nickel and the chrome is preferable.

Fig. 1



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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a head for a golf club.

DESCRIPTION OF THE PRIOR ART

[0002] In order to improve a recovery of a miss-shot during a golf play and a flying distance of a ball, in recent years, it has been extensively intended to increase a moment of inertia of a head and expand a sweet spot of the head. Particularly, with respect to a metal wood driver, a lighter and stronger material is desired for a material of the metal portion, and presently days, the metal portion made of a titanium alloy has been mainly used.

[0003] Since the head made of the titanium alloy has a specific gravity about 40 % smaller than that of the head made of a stainless steel 630 which were used in the early days of the metal head and also has a larger mechanical strength, it is an optimum material for achieving a large size of the head, that is, an increase of a moment of inertia and an expansion of the sweet spot.

[0004] However, because it is necessary to design a thickness of the head thinner so as to achieve the large size of the head, a higher technique is necessary for producing the head and a batting feeling during a golf play is readily deteriorated.

SUMMARY OF THE INVENTION

[0005] The present invention is made by taking the points mentioned above into consideration, and an object of the present invention is to provide a head for a golf club which can achieve an increase of a moment of inertia, an expansion of a sweet spot and the like without making higher a technique for producing the head, and not to deteriorate a batting feeling during a golf play.

[0006] In order to achieve the object mentioned above, a head for a golf club in accordance with the present invention is characterized in that a plated layer is provided on a surface of a metal head, or a plated layer made of a material having a specific gravity larger than that of a metal head is provided on a surface of the metal head. A titanium alloy, an aluminum alloy or a stainless alloy is suitable for the material for the metal head, and a chrome, a nickel, a copper or the like is suitable for the plated material. The chrome, nickel, copper or the like includes the respective alloy. Further, the plated layer may be made in a multiple layer structure having two or more layers, and particularly in the case of the two layer structure, since the nickel is excellent in an adhesion property and a bonding property against the material to be plated therewith and the chrome is great in both a specific gravity and a hardness, a combination of the nickel and the chrome is preferable.

[0007] Therefore, in accordance with a first aspect of the present invention, there is provided a head for a golf club made of one of the metal materials of titanium, aluminum, stainless steel and soft iron, the surface of said metal head is applied with a plated layer whose material property is provided to the surface of said metal head.

[0008] Further, in accordance with a second aspect of the present invention, there is provided a head for a golf club as cited in the first aspect, wherein the plated layer is made of a material having a specific gravity larger than that of the material for the metal head.

[0009] Still further, in accordance with a third aspect of the present invention, there is provided a head for a golf club as cited in the first aspect, wherein the metal head is made of a titanium alloy, an aluminum alloy or a stainless alloy, and the plated layer is made of a chrome alloy, a nickel alloy or a copper alloy.

[0010] Furthermore, in accordance with a fourth aspect of the present invention, there is provided a head for a golf club as cited in the first aspect, wherein the plated layer is formed by a multiple layer structure.

[0011] Moreover, in accordance with a fifth aspect of the present invention, there is provided a head for a golf club as cited in the first aspect, wherein the plated layer is formed by a two-layered structure made of a nickel alloy and a chrome alloy.

[0012] Further, in accordance with a sixth aspect of the present invention, there is provided a head for a golf club as cited in the first aspect, wherein the metal head is made of a titanium alloy and the plated layer is formed by a multiple layer structure including an internal nickel layer, an external nickel layer and a chrome layer.

[0013] Still further, in accordance with a seventh aspect of the present invention, there is provided a head for a golf club as cited in the first aspect, wherein the metal head is made of a titanium alloy and the plated layer is formed by a multiple layer structure including a nickel layer, a copper layer and a chrome layer.

[0014] Furthermore, in accordance with an eighth aspect of the present invention, there is provided a head for a golf

club as cited in the first aspect, wherein the metal head is made of a soft iron alloy and the plated layer is formed by a multiple layer structure including a copper layer, a nickel layer and a chrome layer.

[0015] Moreover, in accordance with a ninth aspect of the present invention, there is provided a head for a golf club as cited in the first aspect, wherein the plated layer includes an anchor plating bath, and the anchor plating bath comprises a nickel watt bath, a nickel sulfamate bath, a nickel sulfamate high concentration bath, a copper pyrophosphate bath, a copper sulfate bath or a gold strike bath.

[0016] In the head for the golf club in accordance with the present invention provided with the structure mentioned above, since the plated layer is provided on the surface of the metal head, it is possible to provide a property of the plating material constituting the plated layer in the head or the surface thereof as it is. Accordingly, for example, when the material having a specific gravity greater than that of the material for the head is plated on the surface of the metal head, it is possible to efficiently increase a moment of inertia and expand a sweet spot. Further, when the hardness of the surface of the head is made harder by the plating material, it is easy to obtain an optimum spinning amount necessary for improving a flying distance of the ball and it is also possible to improve a batting feeling.

[0017] A titanium alloy, an aluminum alloy or a stainless alloy is used for the material of the metal head, however, as mentioned above, the titanium alloy has been mainly used in the recent days. In the titanium alloy material or the aluminum alloy material, since the specific gravity thereof is comparatively small, there is an advantage that a difference in the specific gravity with respect to the plating material can be set greater. The specific gravity of the titanium material is about 4.5, the specific gravity of the aluminum material is about 2.7, the specific gravity of the chrome material is about 7.2 and the specific gravity of the nickel material is about 8.8.

(1) A metal wood head with a volume of 240 cc is produced by setting a titanium material as a raw material in accordance with a normal method, and a double structured plated layer is coated on the metal head by setting an internal nickel layer to a thickness of 10 μm and an external chrome layer to a thickness of 5 μm. In the same manner, a metal wood head with a volume of 240 cc is produced by setting a titanium material as a raw material in accordance with a normal method, and a double structured plated layer is coated on the metal head by setting an internal nickel layer to a thickness of 20 μm and an external chrome layer to a thickness of 5 μm. Further, in the same manner, a metal wood with a volume of 240 cc is produced by setting a titanium material as a raw material in accordance with a normal method, and a double structured plated layer is coated on the head by setting an internal nickel layer to a thickness of 40 μm and an external chrome layer to a thickness of 5 μm. Still further, as a comparative example, there is prepared a metal wood head with a volume of 240 cc without a plated layer produced by setting a titanium material as a raw material in accordance with a normal method.

Then, the result in the following Table 1 is obtained by measuring an estimated volume of a head in these four kinds of metal heads.

Table 1

Titanium 240 cc

Tickness of plating	No plating	Ni10μ+Cr5μ	Ni20μ+Cr5μ	Ni40μ+Cr5μ
Moment of inertia ($g \cdot cm^2$)	2,650	2,750	2,890	3,100
* Estimated volume of head (cc)	240	245	255	270

* The estimated volume of the head is a volume value estimated from a moment of inertia.

As is understood from the result, in all of the head provided with the plated layer on the surface, the estimated volume of the head is increased, that is, the moment of inertia is increased. Further, the effect is particularly significant in an area which has a thickness of the plated layer over 20 μm (a plating weight of 7 to 10 g).

(2) when a hardness of the head surface is increased (is made harder), a slip effect is generated so as neither to apply an unnecessary rotation to a ball nor to blow up the ball, thereby obtaining a path of the ball with run. Generally, there is a method of hardening the surface by shot peening the head surface, or performing an ion plating treatment in accordance with a CVD and PVD, however, because the method is to improve a surface within a thickness of 0.1 to 1 μm, a durability of the effect is questionable. On the contrary, in the plating, because it is possible to process an optional film thickness with respect to the head surface, there is an advantage that an effect by the plating

can be secured for a long time.

Further, with respect to the hardness of the surface, as shown in the following Table 2, since the chrome plating is much harder than the nickel plating, it is desirable to apply the chrome plating onto the topmost surface.

Table 2

	Titanium alloy	Nickel plating	Chrome plating	Urethane coating
Vickers hardness	300 - 350	330 - 370	800 - 1000	* Not measurable

* With respect to an urethane coated product, measurement not possible by a Vickers hardness meter since the surface hardness is too soft.

Further, a ball spin amount at a time of improving the hardness of the head surface is as described in the following Table 3.

Table 3

Ball spin amount (rpm) 240cc Loft 10.5°

Surface treatment \ Head speed (m/s)	40	45	50
Ni20μ+Cr5μ Plated product	3,400	3,600	4,100
	3,800	3,900	4,400
Urethane coated product	3,700	4,100	4,400
	2,700	3,000	3,200

Upper stage in each column: Fine condition
Lower stage in each column: Rain condition

As is understood from the result, in accordance with the head provided with the plated layer, in comparison with the general coated head product, it is possible to restrict about 10 % of the ball spin amount when it is fine and to obtain a ball or a batted ball with run. Further, at a time of rainy weather, it is possible to obtain an optimum ball rotation owing to a water repellant effect of the plating and to prevent a drop phenomenon of the ball frequently occurring in rainy days.

(3) In general, the batting sound is one of the major factors of the batting feeling, and in particular, most of the amateur players feels a sound of the wood club having a strong metal sound as a sound of a nice shot and tends to prefer. Among the metal heads, in particular, the metal head made of a titanium alloy has a good batting sound in comparison with the metal head made of an aluminum alloy or a stainless steel, however, it is experientially known that the batting sound is deteriorated as the thickness of the head is made thinner so as to achieve a large size of the head.

When the frequency of batting sound is analyzed, the sound having a strong metal sound and preferred by the general amateur players has a great peak near 6000 Hz. It is understood that the head in which a plating of a metal having a high hardness such as a chrome and the like is applied to the outermost periphery thereof in accordance with the present invention greatly improves the batting sound in the sound of about 6000 Hz.

That is, a metal wood head with a volume of 240 cc is produced by setting a titanium material as a raw material in accordance with a normal method, and a double structured plated layer is coated on the metal head by setting an internal nickel layer to a thickness of 20 μm and an external chrome layer to a thickness of 5 μm. Further, in the same manner, a metal wood head with a volume of 300 cc is produced by setting a titanium material as a raw material in accordance with a normal method, and a double structured plated layer is coated on the metal head by setting an internal nickel layer to a thickness of 20 μm and an external chrome layer to a thickness of 5 μm. Still further, as a comparative example, there is prepared a metal wood head with a volume of 240 cc produced by setting a titanium material as a raw material in accordance with a normal method and to which an urethane coating is applied. Furthermore, in the same manner, as a comparative example, there is prepared a metal wood head with a volume of 300 cc produced by setting a titanium material as a raw material in accordance with a normal method and to

which an urethane coating is applied.

Then, the result of the following Table 4 is obtained by analyzing the frequency of the batting sound in these four kinds of heads.

Table 4

Result of frequency analysis

Volume of head (cc) / Surface treatment	240	300
Ni20μ+Cr5μ Plated product	6,300Hz	6,000Hz
Urethane coated product	6,300Hz	4,800Hz

* The frequency is described as the greatest peak portion.

As is understood from the result, in accordance with the head provided with the plated layer on the surface, it is possible to maintain the frequency near 6000 Hz even when the volume is great, and to thereby give a generally preferred batting feeling to the player.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a front elevational view of a head for a golf club in accordance with an embodiment of the present invention;
Fig. 2 is an enlarged cross sectional view of the main portion which shows a plating structure in the head;
Fig. 3 is a cross sectional view of the main portion which shows a plating structure of a head for a golf club in accordance with another embodiment of the present invention;
Fig. 4 is a cross sectional view of the main portion which shows a plating structure of a head for a golf club in accordance with the other embodiment of the present invention;
Fig. 5 is a cross sectional view of the main portion which shows a plating structure of a head for a golf club in accordance with the other embodiment of the present invention; and
Fig. 6 is a graph which shows a range of a stress electrodeposits.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] An embodiment in accordance with the present invention will now be described below with reference to the accompanying drawings.

[0020] Fig. 1 shows an outer appearance of a head for a golf club in accordance with the present embodiment, the head for the golf club is a hollow metal head (a metal wood head) 1 formed by a titanium alloy, and is structured such that a plating layer 3 shown in Fig. 2 is provided on all over the outer surface including a face 2 of the metal head 1 and the plating layer 3 is constituted by a nickel plated layer 4 excellent in an adhesion property and a bonding property against a titanium corresponding to a subject to be plated.

[0021] Further, in the embodiment shown in Fig. 3, the plated layer 3 is constituted by a two-layered structure comprising an internal nickel plated layer 4 excellent in an adhesion property and a bonding property against the titanium and chrome on an external layer to be plated therewith and an external chrome plated layer 5 having a great specific gravity and a great hardness.

[0022] The surface of the metal head 1 is properly roughed so as to further improve the adhesion property and the bonding property against the nickel plated layer 4, and each of the surface of the nickel plated layer 4 in Fig. 2 and the surface of the chrome plated layer 5 in Fig. 3 is finished by a satin or a sandblast as a surface finish.

[0023] As mentioned above, there are a lot of advantages in the present invention, however, they are listed up with respect to the head in which the chrome plating is applied to the topmost surface of the metal head 1 made of the titanium alloy in accordance with the embodiment shown in Fig. 3 as follows.

(1) The surface of the head 1 on which the chrome plating is applied has a Vickers hardness of 800 to 1000 corresponding to about three times higher than that of the surface of the head on which the plating is not applied or the head on which the coating is applied. Accordingly, on the basis of a difference in the surface hardness, a flying dis-

tance of a ball which has never been experienced can be achieved, an initial velocity of the ball can be increased, and a spin amount of the ball can be decreased. Further, because a good batting sound is generated, it is possible to achieve a batting feeling good for the player.

(2) Since a water deflection on the surface of the face 2 is improved owing to a water repellant effect of the chrome plating so as to restrict the spin amount, it is possible to prevent a drop ball which is likely generated on rainy days.

(3) It is possible to increase a moment of inertia by applying a chrome plating having a great specific gravity onto the topmost surface of the head 1 made of the titanium alloy. Accordingly, it is possible to expand a sweet area so as to cover a miss shot in a significant range.

(4) Further,for the same reason, as is different from the coated product, the surface is neither injured nor soiled and the coating is not pealed.

[0024] A layered structure of the plated layer may be constituted by three or more layers, for example, as shown in Fig. 4, four layers comprising a nickel 6, a copper 7, a nickel 8 and a chrome 9 may be plated to the metal head 1 made of the titanium alloy from a side of an internal layer. The nickel 6 and 8, the copper 7 and the chrome 9 respectively include the alloys thereof.

[0025] Further, as shown in Fig. 5, an internal nickel layer 10, an external nickel layer 11 and a chrome layer 12 may be provided on the metal head 1 made of the titanium alloy from a side of an internal layer. Still further, a nickel layer, a copper layer and a chrome layer may be provided on the metal head made of the titanium alloy from a side of an internal layer. Furthermore, in the case that the metal head is made of materials of a soft iron alloy, a copper layer, a nickel layer and a chrome layer may be provided from a side of an internal layer. The nickel, the chrome and the copper respectively include the alloys thereof.

[0026] As mentioned above, in the case that the internal nickel layer 10, the external nickel layer 11 and the chrome layer 12 are provided on the metal head 1 made of the titanium alloy from the side of the internal layer, a plating is applied to the metal head 1 in accordance with the following procedure.

[0027] That is, first, the surface of the metal head is blasted and next the surface is alkaline degreased. The blasting treatment is performed in order to increase the adhesion property of the plated layer by roughing the surface of the head, and the alkaline degreasing treatment is performed in order to remove stains attached to the surface of the head. Then, a nickel sulfamate is plated on the surface of the head as the ground plating. This is performed in order to stabilize the plated layer by plating the nickel sulfamate having a low stress. then, after the alkaline degreasing treatment is again applied, a bright nickel is plated as an intermediate layer. This is performed in order to increase a uniform electrodeposition property of the next chrome plating by plating the bright nickel as the intermediate nickel. The chrome is then plated on the outermost layer.

[0028] Further, in the case that nickel layer, the copper layer and the chrome layer are provided on the metal head made of the titanium alloy from the side of the internal layer, the copper is plated in place of the bright nickel in the procedure mentioned above. In the manner mentioned above, in the case of plating the copper as the intermediate layer, there is an advantage that the adhesion property of the plated layer is further improved. As mentioned above, the adhesion property of the plated layer is further improved because the copper plating is excellent in an impact resistance, to thereby has an effect of preventing a peeling. This is caused by a property of the copper plating, that is, a flexibility of the copper plating is high and a stress of the copper plating is less than that of the nickel plating. Further, in the case of plating the copper, there is an advantage that a moment of inertia of the head is increased owing to a difference of the specific gravity between the both (a specific gravity of the copper: 8.93, a specific gravity of the nickel: 8.85) in comparison with the case of plating the nickel, and there is also an advantage that a batting feeling becomes soft owing to a flexibility of the copper.

[0029] In the case that the copper layer, the nickel layer and the chrome layer are provided on the metal head made of the soft iron alloy from the side of the internal layer, a copper strike plating, a copper plating, a bright nickel plating and a chrome plating are applied after applying the alkaline degreasing treatment onto the surface of the metal head.

[0030] In general, in the case of applying the plating to the titanium alloy recognized as a plating retardant material, it is not possible to obtain a plated film capable of standing an impact at a time of being batted or the like unless the anchor plating is applied on the ground. Accordingly, it is effective to apply the anchor plating, however, it is important to consider the stress in electrodeposits at a time of selecting the kinds of the anchor plating.

[0031] That is, when the stress in electrodeposits is high, a deformation of the plated layer is caused, so that a firm adhesion property is not achieved. The stress in electrodeposits comprises a tensile stress and a compressive stress. In the case of the tensile stress, a peeling or a crack tends to be generated at the electrodeposited layer in the periphery and on the end of the material, and in the case of the compressive stress, an expansion or folds tend to be generated. Accordingly, it is necessary to select an anchor plating solution which has the lowest stress in electrodeposits, and as a plating bath suitable therefor, there can be listed up a nickel watt bath, a nickel sulfamate bath, a nickel sulfamate high concentration bath and the like.

[0032] A range of the stress in electrodeposits of the film obtained from each of the various kinds of nickel plating

baths will be shown in Fig. 6, as shown in Fig. 6, the stress in electrodeposits can be readily adjusted to the lowest value by a current density in the nickel sulfamate high concentration bath, so that it is said that it is the most suitable plating bath for the titanium alloy material corresponding to the plating retarding material. In addition, as a bath capable of being used for the anchor plating of the titanium alloy material, there can be listed up a copper pyrophosphate bath, a copper sulfate bath, a gold strike bath and the like.

[0033] In order to confirm the anchor effect, comparative experiments are performed with respect to the wood head made of the titanium alloy between the nickel sulfamate high concentration bath and the bright nickel plating corresponding to the normal plating. The following result shown in Table 5 is obtained.

Table 5

Plating process	Batted number by robot (Head speed 48 m/s)	Judgement (N=3)
Bright nickel plating ↓ Chrome plating	5 to 26 times	Plating on batted surface is peeled
Nickel sulfamate high concentration bath ↓ Bright nickel plating ↓ Chrome plating	8,000 times	No abnormality

[0034] As is understood from the result of Table 5, when the anchor plating in the nickel sulfamate high concentration bath is applied to the wood head made of the titanium alloy, the adhesion property of the plating on the face surface brought into contact with the ball is significantly high, so that the anchor effect is significantly great.

[0035] Further, when the batting experiments are performed by varying the combination of the plated layer, as shown in Table 6 mentioned below, a slight crack was recognized within the face groove at a batting number of 8000 to 10000. It is estimated that the crack is generated because the bright nickel plating in the intermediate layer could not follow a bending of the face surface. In this experiments, in the case that the copper plating having a flexibility capable of standing an expansion and compression of the bending is applied to the wood head made of the titanium alloy, a durability was greatly improved and no crack was recognized till the batting number of 12000.

Table 6

Plating process	Batted number by robot (Head speed 48 m/s)	Judgement (N=3)
Nickel sulfamate high concentration bath ↓ Bright nickel plating ↓ Chrome plating	8,000 to 10,000 times	Plating within face groove is cracked
Nickel sulfamate high concentration bath ↓ Copper pyrophosphate plating ↓ Chrome plating	12,000 times	No abnormality

[0036] The present invention can obtain the following effects.

[0037] That is, when the plated layer is provided on the surface of the metal head as in the head for the golf club in accordance with each of the aspects of the present invention in which the structure mentioned above is provided, the surface of the head can have the feature corresponding to the property of the plating material constituting the plated layer. For example, the hardness of the surface of the head can be increased by providing the plated layer made of the material having a hardness greater than that of the material for the head on the surface of the head. Accordingly, a flying distance of the ball which has never been experienced can be achieved, an initial velocity of the ball can be increased, and a spin amount of the ball can be decreased. Further, because a good batting sound is generated, it is possible to achieve a batting feeling good for the player.

[0038] Further, by providing the plated layer having a water repellant effect on the surface of the metal head, a water deflection on the surface of the face is improved so as to restrict the spin amount, so that it is possible to prevent a drop ball readily generated when it rains from generating.

[0039] Still further, by providing the plated layer made of a material having a specific gravity greater than that of the material for the head on the surface of the metal head, it is possible to increase a moment of inertia. Accordingly, it is possible to expand a sweet area so as to cover a miss shot in a significant range.

[0040] Furthermore, for the same reason, as is different from the coated product, the surface is neither injured nor soiled and the coating is not pealed.

[0041] Further, in the case that the plated layer is structured to be a multiple layer structure, it is possible to give the

feature corresponding to the property of the plating material in each of the layers to the surface of the head. The plated layer made of the nickel alloy and the copper alloy has a feature excellent in the adhesion property and the bonding property, and the plated layer made of the chrome alloy has a feature having a great specific gravity and hardness. Further, it is possible to expect a water propellant effect.

[0042] Still further, in the case of providing the anchor plating bath such as the nickel watt bath, the nickel sulfamate bath, the nickel sulfamate high concentration bath, the copper pyrophosphate bath, a copper sulfate bath, a gold strike bath and the like, it is possible to form a firm plated film capable of standing the impact and the like at a time of batting owing to the anchor effect.

Claims

1. A head for a golf club having a metal head formed of metal materials of lightweight and strength, said metal head is processed by a surface treatment characterized in that:

   the metal material formed of said metal head is one selected from titanium alloy, aluminum alloy, stainless steel alloy and soft iron alloy, the surface of said metal head is applied with a plated layer whose material property is provided to the surface of said metal head.

2. A head for a golf club as claimed in Claim 1 characterized in that said plated layer provided on the surface of said metal head is made of materials having a specific gravity larger than that of the material for said metal head.

3. A head for a golf club as claimed in Claim 1 characterized in that said metal head is made of materials of titanium alloy, aluminum alloy or stainless steel alloy, said plated layer is formed of materials of chronium alloy, nickel alloy or copper alloy.

4. A head for a golf club as claimed in Claim 1 characterized in that said plated layer provided on the surface of said metal head is a multiple layer structure.

5. A head for a golf club as claimed in Claim 4 characterized in that said plated layer provided on the surface of said metal head is a two-layer structure made of materials of nickel alloy and chronium alloy.

6. A head for a golf club as claimed in Claim 4 characterized in that said metal head is made of materials of titanium alloy, said plated layer provided on the surface of said metal head is a multiple layer structure having an internal nickel layer and external nickel layer and chronium layer.

7. A head for a golf club as claimed in Claim 4 characterized in that said metal head is made of materials of titanium alloy, said plated layer provided on the surface of said metal head is a multiple layer structure having nickel layer, copper layer and chronium layer.

8. A head for a golf club as claimed in Claim 4 characterized in chat said metal head is made of materials of soft iron alloy, said plated layer provided on the surface of said metal head is a multiple layer structure having cupper layer, nickel layer and chronium layer.

9. A head for a golf club claimed in Claim 1 characterized in that said plated layer provided on the surface of said metal head includes an anchor plating bath, said anchor plating bath comprises a nickel watt bath, a nickel sulfamate bath, a nickel sulfamate high concentration bath, a copper pyrophosphate bath, a copper sulfate bath or a gold strike bath.

Fig. 1

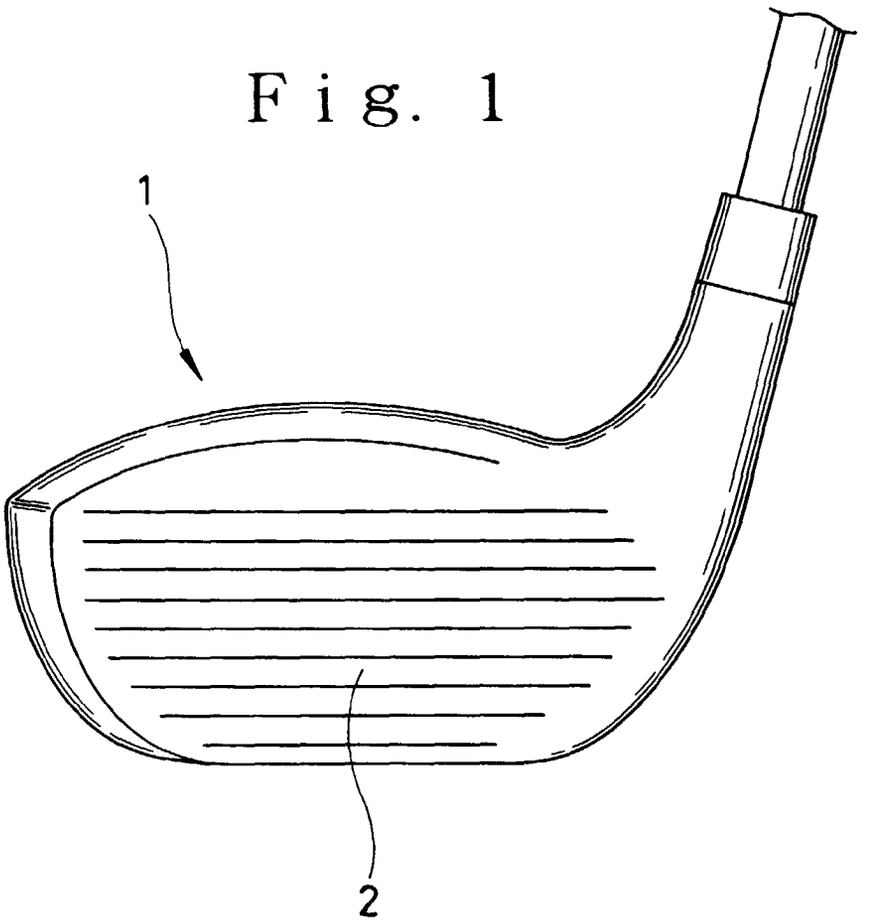


Fig. 2

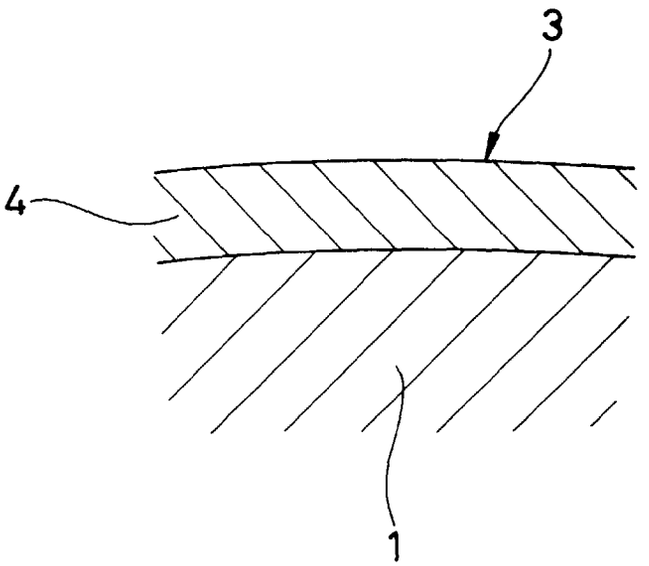


Fig. 3

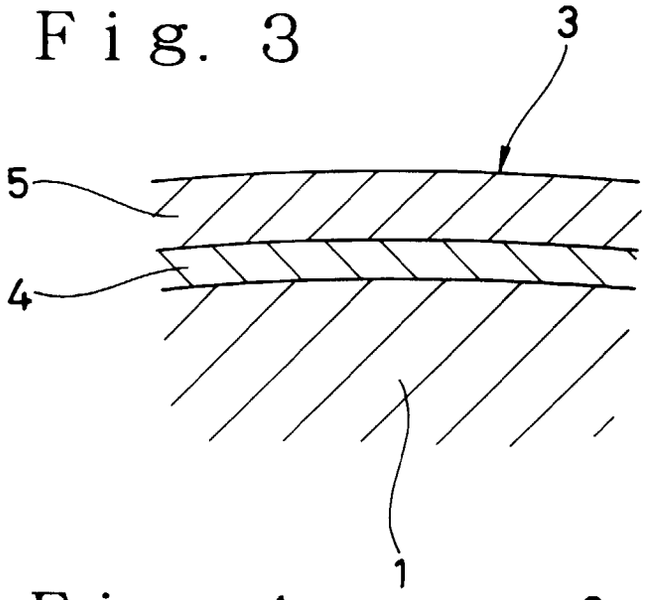


Fig. 4

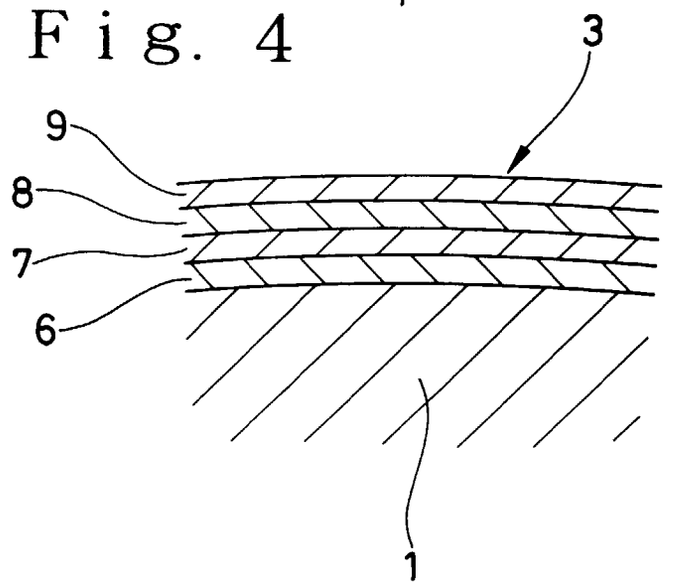


Fig. 5

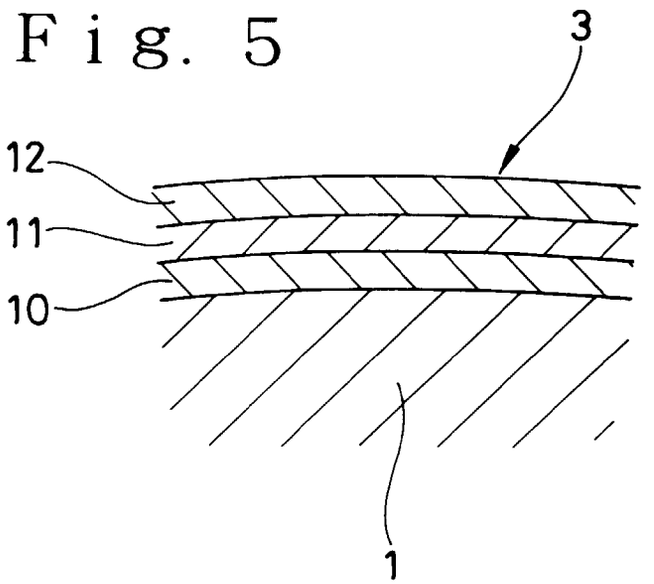
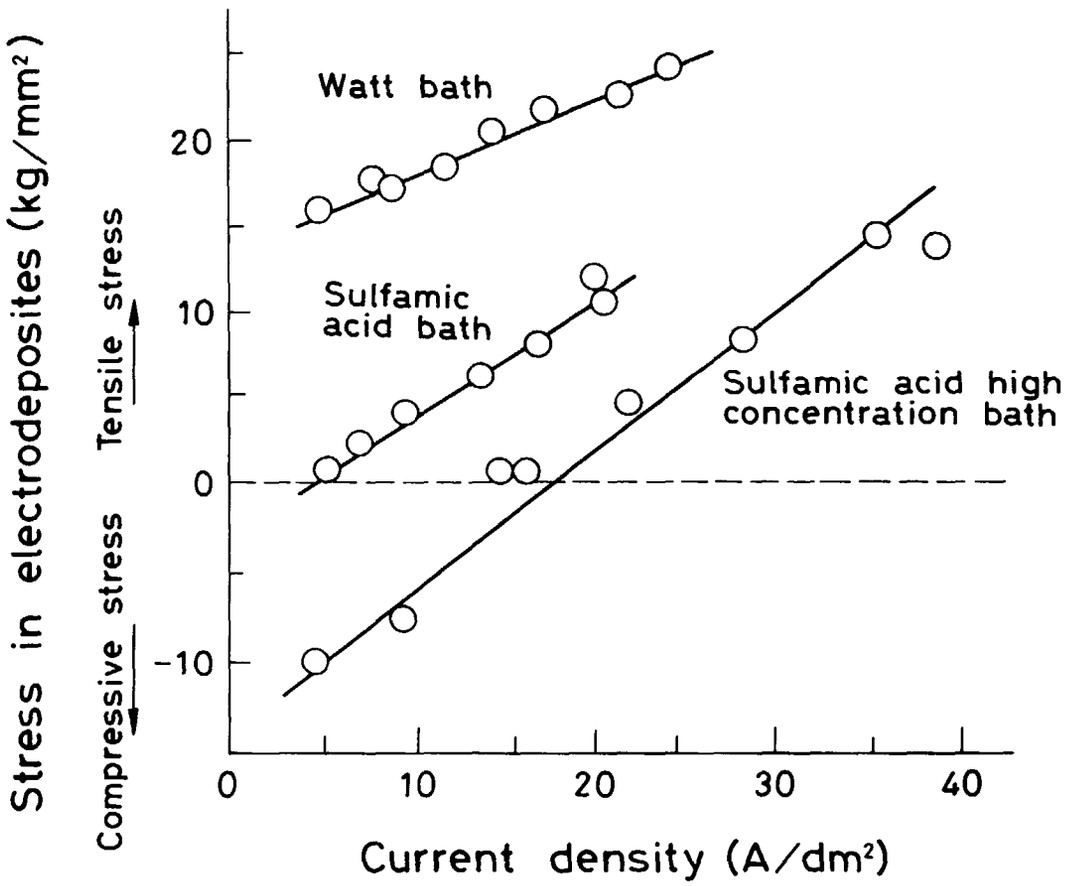


Fig. 6


Stress in electrodeposites (kg/mm²)
Tensile stress
Compressive stress
20
10
0
-10
Watt bath
Sulfamic acid bath
Sulfamic acid high concentration bath
0
10
20
30
40
Current density (A/dm²)