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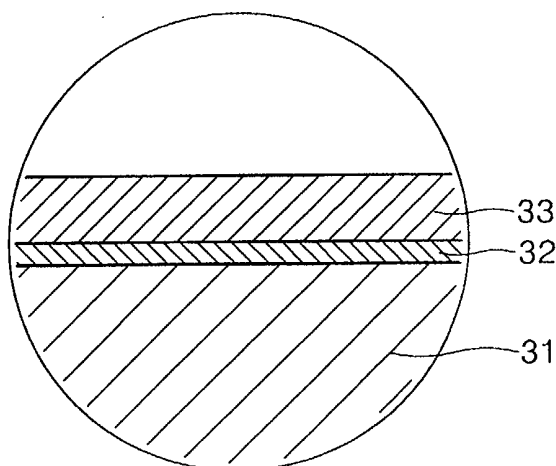
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(54) **Swash plate and compressor utilizing the same**

(57) A swash plate (30) of a compressor (10) comprising a plate member (31) supported by a rotation shaft (13) and contacting a shoe (16) supported capable of sliding with respect to a piston (15), for reciprocating the piston, wherein an intermediary layer (32) is formed on the surface of the plate member, and a solid lubrication layer (33) formed of silver or silver alloy in which an adhesive force to the plate member is strengthened by

the intermediary layer. Thus, the swash plate of the compressor according to the present invention exhibits an improved lubrication feature at a high temperature and under heavy load while frictionally contacting the shoe and rotating at a high speed and is prevented from being seized into the shoe. Also, reliability according to driving of the compressor is improved. Further, the lubrication features of the swash plate and the shoe are improved and the life span of the compressor is extended.

FIG. 3



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Description

[0001] The present invention relates to a swash plate for use in an air conditioning apparatus for an automobile, and more particularly, to a swash plate for reciprocating a piston, and to a compressor utilizing the same.

[0002] In general, a compressor used in an air conditioning apparatus for an automobile inhales heat exchange medium evaporated in an evaporator, compresses the inhaled heat exchange medium, and pumps the compressed heat exchange medium, so that a refrigerant can continuously circulate. The compressor has a variety of types such as a swash plate type, a scroll type, a rotary type, and a wobble plate type according to the type of driving.

[0003] FIG. 1 shows an example of a swash plate type compressor among the various types of compressors. In the compressor shown in FIG. 1, there are two separate main bodies 11 and 11', and cylinders 12 and 12' are fixedly installed in the main bodies 11 and 11', respectively. A swash plate 14 supported by a rotation shaft 13 is installed between the cylinders 12 and 12'. A plurality of pistons 15 where a bridge 15a is formed in the middle and an insertion portion 15b into which the edge of the swash plate 14 is inserted, are installed to be capable of sliding at each of the cylinders 12 and 12'. A shoe 16 reducing a frictional force due to contact and enabling smooth movement of the swash plate 14 with respect to the pistons 15, is installed at a contact portion between the swash plate 14 inserted into the insertion portion 15b and the pistons 15. Valve units 17 and 17' are installed between both side surfaces of the cylinders 12 and 12' and the inner surfaces of the main bodies 11 and 11', respectively.

[0004] In the compressor 10 having the above structure, as the rotation shaft 13 rotates, the swash plate 14 fixed to the rotation shaft 13 is rotated. Accordingly, the pistons 15 contacting the shoe 16 which frictionally contacts the swash plate 14, and supported thereby, reciprocate with respect to the cylinders 12 and 12' and compress heat exchange medium.

[0005] In the above operation, since the swash plate 14 and the shoe 16 are in frictional contact with one another and the swash plate 14 rotates in a high speed in the state of a high temperature and a load applied, when oil is not sufficiently provided, a lubricating oil film is discontinued. Thus, the swash plate 14 and shoe 16 directly contacting each other make heat and are seized. In particular, when the lubricant filled in the compressor begins to operate after in a long halt state, the lubricant in liquid state flows down and causes many problems in the initial operation.

[0006] To solve the above problem, a solid lubrication film is formed by thermal spray coating a surface of a swash plate with Cu based alloy to improve a lubricating performance.

[0007] However, the coating film formed of Cu based alloy in the thermal spray coating method has a limited bonding effectiveness with respect to a material of the swash plate, and so reliability is lowered. In particular, under the operation of the compressor at a high speed, since the bonding between the swash plate and the Cu based coating film is insufficient, the Cu coating film is separated from the swash plate. In the case of the thermal spray coating method, since tiny metal powder is accumulated on the surface of the swash plate, particles are separated from the accumulated metal powder causing friction between parts.

[0008] Another example of a solid lubricant is disclosed in U.S. Patent No. 4,473,481. The disclosed solid lubricant is to prevent damage of a metal surface on which a sliding movement occurs. The solid lubricant is a lubricant compound including molybdenum disulfide, or a combination of molybdenum disulfide and graphite of 60-80 weight percent, and any of antimony oxide, steel, zinc, or gold particles in 10-30 weight percent as an additive to provide heat stability and prevent oxidation, and any of epoxy-ester resin, acryl resin and urea resin.

[0009] Other molybdenum disulfide-resin based lubricants are disclosed in U.S. Patent No. 3,051,586, 4,303,537, 3,146,142, and 4,206,060.

[0010] In Japanese Patent Publication No. 4-26777, a method of forming a film exhibiting superior anti-heat abrasion and anti-sliding features on titanium or titanium alloy, is shown. According to the above publication, before a solid lubrication film is coated on a surface of a material, as a pre-treatment process, the surface of the material is heated at 500°C in vacuum atmosphere and a chemical activation process is performed to the surface, to thus make the surface of the material porous. Then, a compound material such as nickel-phosphorous and silicon-carbide is electro-plated on the surface of the material to improve an anti-abrasion feature.

[0011] However, it is difficult to control the thickness of the solid lubrication film which includes a pigment or colouring agent and an organic or non-organic binder. Due to the difficulty in controlling the ratio of the solid lubrication material (the colouring agent also acts as a lubricant) and the binder, and the uneven thickness of part of the film according to the shape of a product, the above-described method is difficult to apply to parts in which precise dimensions are required.

[0012] When the solid lubrication film contains a large amount of resin, the lubrication feature deteriorates. When a pigment which is a lubricant is included much, the solid lubrication film is easily abraded and the life span of the film is curtailed.

[0013] To solve the above-described problems, it is an object of the present invention to provide a swash plate which has an improved close contacting force of a plated layer for lubrication on a surface, can prevent being seized into a shoe due to frictional heat generated at a high temperature and in a high-speed rotation, and has an extended life span.

[0014] To achieve the above object, there is provided a swash plate of a compressor comprising a plate member supported by a rotation shaft and contacting a shoe supported capable of sliding with respect to a piston, for reciprocating the piston, wherein an intermediary layer is formed on the surface of the plate member, and a solid lubrication layer formed of silver or silver alloy in which an adhesive force to the plate member is strengthened by the intermediary layer.

[0015] It is preferred in the present invention that the intermediary layer is formed of any of copper, nickel, manganese, and cobalt, or an alloy thereof, and that the solid lubrication layer is formed into an alloy layer of silver and at least one of soft metal elements of Sn, In, Pd, Cd, Zn, and Au.

[0016] It is preferred in the present invention that the solid lubrication layer is compound-plated with a mixture of a solid lubricant and silver, and that the solid lubricant is formed of at least one of molybdenum disulphide, tungsten disulphide, graphite, boron nitride, and Teflon^{RTM} including polytetrafluoroethylene.

[0017] It is preferred in the present invention that an auxiliary lubrication layer formed of any of Sn, In, Pd, Cd, Zn, and Au, or an alloy thereof is provided. Still more preferably, the auxiliary lubrication layer is formed any of Sn, In, Pd, Cd, Zn, and Au, or an alloy of these elements and silver.

[0018] It is preferred in the present invention that the thickness of the solid lubrication layer is 2 through 30 μm and the thickness of the intermediary layer is 0.05 through 3 μm , and that the surface roughness Ra of the solid lubrication layer is 1.0 μm or less.

[0019] To achieve the above object, a compressor using the above swash plate can be provided.

[0020] Alternatively, the present invention comprises an intermediary layer formed at at least one side of a friction surface of a driving portion of the compressor and a solid lubrication layer formed of silver or a silver alloy and having an adhesive force strengthened by the intermediary layer.

[0021] Preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a sectional view of a typical compressor:

FIG. 2 is a perspective view of the swash plate according to the present invention shown in FIG. 1;

FIG. 3 is a sectional view showing a plate member forming the swash plate in which an intermediary layer and a solid lubrication layer are formed;

FIG. 4 is a sectional view showing a plate member forming the swash plate in which an intermediary layer, a solid lubrication layer, and an auxiliary lubrication layer are formed;

FIGS. 5 through 7 are graphs showing the results of tests according to the formation of the solid lubrication layer of the swash plate;

FIGS. 8 through 12 are graphs showing the results of comparison tests with respect to FIGS. 5 through 7; and

FIGS. 13 through 16 are graphs showing the results of tests according to the formation of the solid lubrication layer of the swash plate.

[0022] Referring to FIGS. 1 and 2, the cylinders 12 and 12' are fixedly installed in the main bodies 11 and 11' of a compressor. A swash plate 30 is installed between the cylinders 12 and 12' and supported by the rotation shaft 13. The piston 15 is installed in the cylinders 12 and 12' to be capable of sliding. The piston 15 includes the bridge 15a formed at the center thereof and the insertion portion 15b into which the edge of the swash plate 30 is inserted is formed. The shoe 16 is installed at a contact portion between the swash plate 30 inserted into the insertion portion 15b and the piston 15 to reduce a frictional force due to contact and facilitate smooth movement of the piston 15 by the swash plate 30.

[0023] The swash plate 30 is formed of a plate member 31 installed at the rotation shaft 13. As shown in FIGS. 3 and 4, an intermediary layer 32 is formed on the plate member 31 forming the swash plate 30. A solid lubrication layer 33 is formed on the intermediary layer 32 such that the solid lubrication layer 33 is in close contact with or bonded strongly to the plate member 31 by means of the intermediary layer 32. This provides lubrication for contact with the shoe.

[0024] The intermediary layer 32 is formed of any of copper, nickel, manganese, and cobalt, or an alloy thereof, by electroplating or chemical plating. Preferably, the thickness of the intermediary layer 32 is formed to be between 0.05 μm and 3.0 μm . When the intermediary layer 32 is 0.05 μm or less thick, the management of thickness cannot be well performed in a plating step. When the thickness is 3.0 μm or more, a large amount of intermetallic compounds are subsequently formed with the solid lubrication layer 33 so that the solid lubrication layer 33 is not easily detached under the conditions of a high speed and a high load during the operation of the compressor.

[0025] The material and thickness forming the intermediary layer 32 is however not limited to the above preferred embodiment, and any material and thickness capable of improving a close contact force or bond between the solid lubrication layer 33 and the plate member 31 can be used.

[0026] The solid lubrication layer 33 is formed on the upper surface of the intermediary layer 32 by electroplating or

chemical plating using silver or silver alloy. Meanwhile, the solid lubrication layer 33 may be formed of at least one of soft metal elements of Sn, In, Pd, Cd, Zn, and Au, and a silver alloy layer. Also, the solid lubrication layer 33 can be plated with a mixture of a solid lubricant and silver or silver alloy.

[0027] The solid lubricant mixed with silver and silver alloy can be formed of any of molybdenum disulphide, tungsten disulphide, graphite, boron nitride, and Teflon^{RTM} or polytetrafluoroethylene, and a compound thereof. Preferably, the thickness of the solid lubrication layer 33 is formed to be between 2 and 30 μm and a surface roughness Ra is formed to be 0.1 μm .

[0028] The solid lubricant and silver can be mixed and plated on the upper surface of the solid lubrication layer 33. Here, the solid lubricant can be formed of any of molybdenum disulphide, tungsten disulphide, graphite, boron nitride, and Teflon^{RTM} or polytetrafluoroethylene, and a compound thereof.

[0029] An auxiliary lubrication layer 34 may further be provided on the upper surface of the solid lubrication layer 33 for smooth lubrication with the shoe 16, as shown in FIG. 4. The auxiliary lubrication layer 34 is formed of any of Sn, In, Pd, Cd, Zn, and Au, or an alloy thereof, or silver with any of Sn, In, Pd, Cd, Zn, and Au, or an alloy made of these elements and silver.

[0030] The solid lubrication layer 33 and the auxiliary lubrication layer 34 having the above structure are not limited to the above preferred embodiment. The intermediary layer 32, the solid lubrication layer 33, and the auxiliary lubrication layer 34 are preferably formed along a trace made on the plate 31 as it contacts the shoe 16 during the rotation of the swash plate 30 for the lubrication with the shoe 16, or alternatively they can be formed on the entire surface of the plate member 31 forming the swash plate 30.

[0031] Meanwhile, in the compressor, the intermediary layer, the solid lubrication layer, and the auxiliary lubrication layer can also be applied to a driving portion that frictionally contacts them. For example, as shown in FIG. 1, the intermediary layer, the solid lubrication layer, and the auxiliary lubrication layer can be applied to the frictional contact portion of the cylinder 11 and the piston 12 or the shaft support portion of the rotation shaft 13.

[0032] The operation of the swash plate is described in relation to the operation of the compressor of an air conditioning apparatus according to the present invention.

[0033] In the compressor 10 according to the present invention, the swash plate 30 fixedly installed at the rotation shaft 13 rotates as the rotation shaft 13 rotates. Accordingly, the pistons 15 contacting the shoe 16 in frictional contact with the swash plate 30 and supported thereby reciprocate with respect to the cylinders 12 and 12' to compress a heat exchange medium.

[0034] In the above operation, since the solid lubrication layer 33 is formed on the plate member 31 forming the swash plate 30 in friction contact with the shoe 16, seizing of the swash plate 30 and the shoe 16 under irregular driving conditions such as high speed rotation at a high temperature and with a heavy load or quick drive of an automobile, is prevented. In particular, since the surface roughness of the solid lubrication layer 33 is 1.0 mm or less (and most preferably, 0.1 μm), an increase of torque according to friction between the shoe 16 and the solid lubrication layer 33 during high speed rotation of the swash plate 30 is prevented so that an increase of temperature in the compressor 10 is prevented.

[0035] The above-described operations will be more clear by the following tests performed by the present inventors.

[Test 1]

[0036] In each of test examples of Test 1, the plate member 31 of the swash plate 30 is manufactured using a steel member to have a diameter of 95 mm and a thickness of 5 mm. Here, the surface roughness of the plate member 31 before the solid lubrication layer 33 is added is 0.5 μm and the surface roughness after the solid lubrication layer 33 is added is measured to be around 0.5 μm . The swash plates in the following test examples are manufactured through the following steps.

[0037] First, the swash plate according to the present invention is manufactured by sequentially performing a dipping and degreasing step, a water rinsing step, an electrocleaning step, a water rinsing step, an activation process step, a water rinsing step, a neutralization step, a solid lubrication layer forming step using copper, nickel, manganese, and cobalt, a water rinsing step, an solid lubrication layer forming step using silver or silver alloy, a water rinsing step, and a drying step, to the plate member. In the case of plating to form the intermediary layer 32 among the above steps, the thickness of the intermediary layer 32 is controlled by adjusting current density and time in the state in which copper cyanide, soda cyanide, and glass soda cyanide are mixed in a predetermined ratio. In the step of forming the solid lubrication layer 33, the thickness of the solid lubrication layer 33 is controlled by adjusting current density and time in the state in which potassium silver cyanide, anhydrous potassium cyanide, and potassium carbonate are mixed in a predetermined ratio.

[0038] In the state in which the swash plate 30 manufactured in the above-described method is rotated at a speed of 6,000 rpm and the shoe 16 receives a pressure of a load of 250 kgf, time, a change in temperature, and a change in torque are measured and test examples 1 through 9 and comparison examples 1 through 5 are obtained and the

results thereof is shown in Table 1-1.

[Table 1-1]

	Thickness of intermediary layer (μm)	Thickness of solid lubrication layer (μm)	High speed lubrication test
Test example 1	0.05	2	Passed
Test example 2	0.05	10	passed
Test example 3	0.05	30	passed
Test example 4	1.5	2	Passed
Test example 5	1.5	10	Passed
Test example 6	1.5	30	Passed
Test example 7	3.0	2	Passed
Test example 8	3.0	10	Passed
Test example 9	3.0	30	Passed
Comparison example 1	0.01	10	Not passed (A)
Comparison example 2	3.5	10	Not passed (B)
Comparison example 3	1.5	1	Not passed (B)
Comparison example 4	1.5	40	Not passed (A)
Comparison example 5	1.5	10 (Ra 1.2)	Not passed (B)

[0039] In the above table, "Passed" means that the compressor is driven over 30 minutes at 6,000 rpm, "Not passed (A)" means that the swash plate and shoe are seized before the compressor is driven for 30 minutes at 6,000 rpm, and "Not passed (B)" means that the swash plate and shoe are seized before the compressor reaches 6,000 rpm.

[0040] In detail, graphs in FIGS. 5, 6, and 7 are obtained by measuring temperature, torque, and pressure applied to the swash plate when the swash plates of test examples 2, 5, and 8 are driven. Graphs in FIGS. 8 through 12 are obtained by measuring temperature, torque, and pressure applied to the swash plate when the swash plates of comparison examples 1 through 5 are driven.

[0041] As can be seen from Table 1-1 and the drawings, the thickness of the intermediary layer 32 formed of copper, nickel, manganese, and cobalt is set within a range of 0.05 through 3 μm . When the thickness of the solid lubrication layer 33 formed of silver is formed between 2 through 30 μm , an improved high lubrication feature can be obtained.

[Test 2]

[0042] In Test 2 of the present invention, the intermediary layer 32 is formed using copper, nickel, manganese, and cobalt on the plate member 31 forming the swash plate 30. In Test example 10, the solid lubrication layer 33 is formed of silver alloy on the upper surface of the intermediary layer 32. In Test example 11, the solid lubrication layer 33 is formed on the upper surface of the intermediary layer 32 using a compound plating layer formed of a mixture of silver alloy and any of molybdenum disulphide, tungsten disulphide, graphite, boron nitride, and Teflon^{RTM} or polytetrafluoroethylene which are solid lubricants, or a compound thereof. The test examples 10 and 11 are carried out under the same conditions of Test 1. The test results are shown in Table 1-2 and graphs in FIGS. 13 and 14.

[Table 1-2]

	Thickness of intermediary layer (μm)	Thickness of solid lubrication layer using silver alloy (μm)	Thickness of compound plating layer (μm)	High speed lubrication test
Test example 10	1.5	10	-	Passed
Test example 11	1.5	-	10	passed

[0043] As shown in the graphs and Table 1-2, a satisfactory lubrication feature can be maintained for 30 minutes or

more at 6,000 rpm.

[Test 3]

[0044] In the present test, the intermediary layer 32 is formed using copper, nickel, manganese, and cobalt on the plate member 31 forming the swash plate 30. The solid lubrication layer 33 is formed using silver on the upper surface of the intermediary layer 32. The auxiliary lubrication layer 34 is formed using any of Sn, In, Pb, Cd, Zn, and Au, or an alloy thereof, on the upper surface of the solid lubrication layer 33, so that the swash plate 30 is formed. The test examples 12 through 15 are carried out under the same conditions of Test 1. The test results are shown in Table 1-3 and graphs in FIGS. 15 and 16.

[Table 1-3]

	Thickness of intermediary layer (μm)	Thickness of solid lubrication layer (μm)	Thickness of auxiliary lubrication layer (μm)	High speed lubrication test
Test example 12	1.5	10	2 (tin)	Passed
Test example 13	1.5	10	2 (lead)	Passed
Test example 14	1.5	10	2 (silver-lead)	Passed
Test example 15	1.5	10	2 (silver-graphite)	passed

[0045] As shown in Table 1-3 and graphs in FIGS. 15 and 16, since the auxiliary lubrication layer 34 is formed on the upper surface of the solid lubrication layer 33, the swash plate 30 is not seized into the shoe 16 when it is driven at 6,000 rpm for 30 minutes or more.

[0046] As described above, the swash plate of the compressor according to the present invention exhibits an improved lubrication feature at a high temperature and under heavy load while frictionally contacting the shoe and rotating at a high speed and is prevented from being seized into the shoe. Also, reliability according to driving of the compressor is improved. Further, the lubrication features of the swash plate and the shoe are improved and the life span of the compressor is extended.

[0047] While the swash plate of the fixed capacity type swash plate compressor is described as a preferred embodiment of the present invention in the above, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention as defined by the appended claims. For example, the present invention can be applied to a swash plate of a variable capacity type compressor, a frictional contact surface of a variety of machine driving apparatuses, and a piston and shoe of a compressor.

Claims

1. A swash plate (30) of a compressor (10) comprising a plate member (31) adapted to be supported by a rotation shaft (13) and for contacting a shoe (16) supported to be capable of sliding with respect to a piston, for reciprocating the piston (15), wherein an intermediary layer (32) is formed on the surface of the plate member, and a solid lubrication layer (33) comprising silver or silver alloy is formed on said intermediary layer such that the bonding of said solid lubrication layer to the plate member is strengthened by the intermediary layer.
2. A swash plate (30) as claimed in claim 1, wherein the intermediary layer (32) is formed of any of copper, nickel, manganese, and cobalt, or an alloy thereof.
3. A swash plate (30) as claimed in claim 1 or 2, wherein the solid lubrication layer (33) is formed of an alloy of silver and at least one of tin, indium, palladium, cadmium, zinc and gold.
4. A swash plate (30) as claimed in claim 1 or claim 3, wherein the solid lubrication layer (33) is compound-plated with a mixture of a solid lubricant and silver.
5. A swash plate (30) as claimed in claim 4, wherein the solid lubricant comprises at least one of molybdenum disulphide, tungsten disulphide, graphite, boron nitride, and Teflon^{RTM} or polytetrafluoroethylene.

6. A swash plate (30) as claimed in any of claims 1 to 3, wherein an auxiliary lubrication layer (34) is formed on the upper surface of the solid lubrication layer (33).

7. A swash plate (30) as claimed in claim 6, wherein the auxiliary lubrication layer (34) comprises any of tin, indium, palladium, cadmium, zinc and gold, or an alloy thereof.

8. A swash plate (30) as claimed in claim 6, wherein the auxiliary lubrication layer (34) comprises any of tin, indium, palladium, cadmium, zinc and gold, or an alloy of these elements and silver.

9. A swash plate (30) as claimed in claim 6, wherein the upper surface of the solid lubrication layer (33) is compound-plated with a mixture of solid lubricant and silver.

10. A swash plate (30) as claimed in claim 9, wherein the solid lubricant comprises at least one of molybdenum disulphide, tungsten disulphide, graphite, boron nitride, and Teflon^{RTM} or polytetrafluoroethylene.

11. A swash plate (30) as claimed in any preceding claim, wherein the thickness of the solid lubrication layer (33) is between 2 μm and 30 μm .

12. A swash plate (30) as claimed in any preceding claim, wherein the thickness of the intermediary layer (32) is between 0.05 μm and 3 μm .

13. A swash plate (30) as claimed in any preceding claim, wherein the surface roughness Ra of the solid lubrication layer (33) is 1.0 μm or less.

14. A swash plate (30) as claimed in any preceding claim, wherein the intermediary layer (32) and the solid lubrication layer (33) are formed along a trace made as the swash plate contacts the shoe (16).

15. A compressor (10) using a swash plate (30) as claimed in any of claims 1 to 3, 5, and 7 to 14.

16. A compressor (10) comprising:

an intermediary layer (32) formed at at least one side of a friction surface of a driving portion of the compressor; and

a solid lubrication layer (33) comprising silver or a silver alloy formed on said intermediary layer and having an adhesive force strengthened by the intermediary layer.

FIG. 1

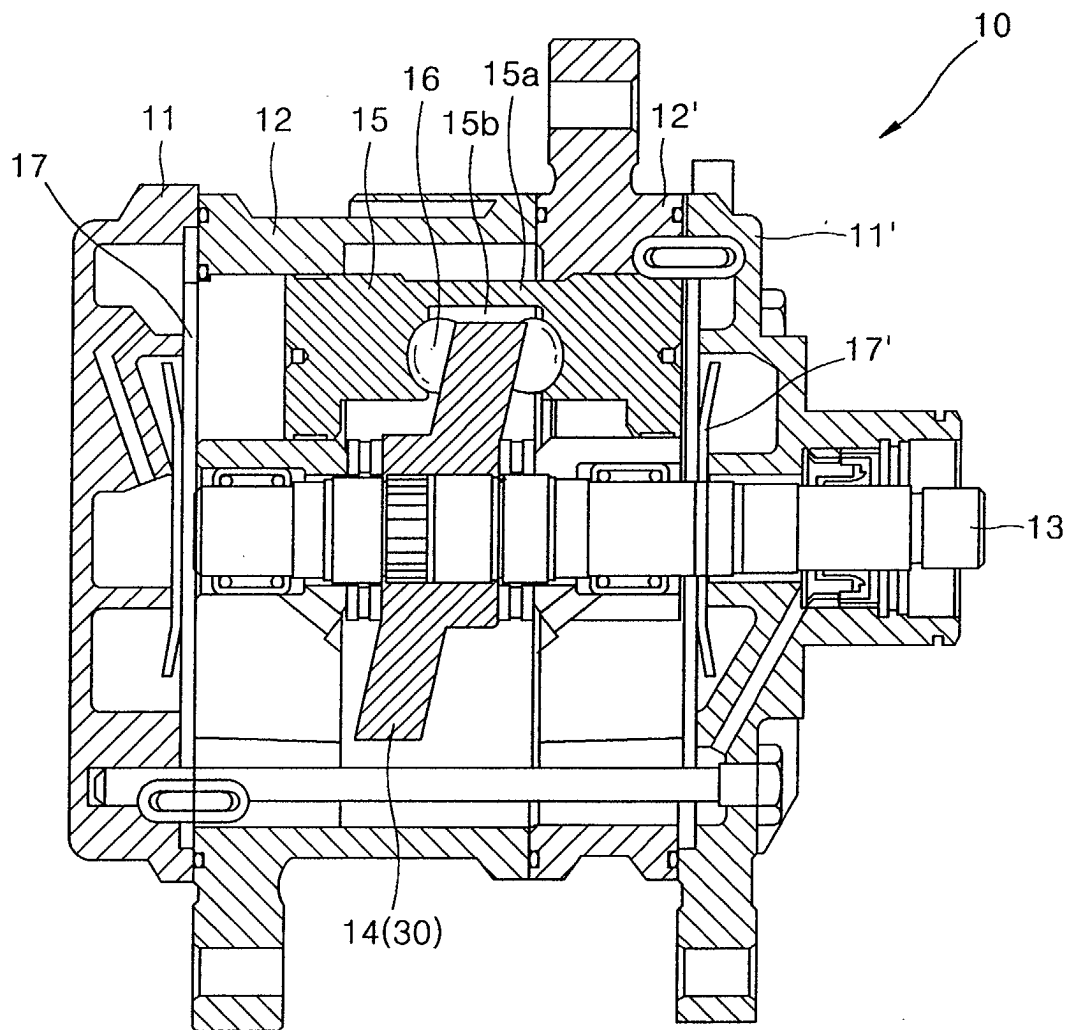


FIG. 2

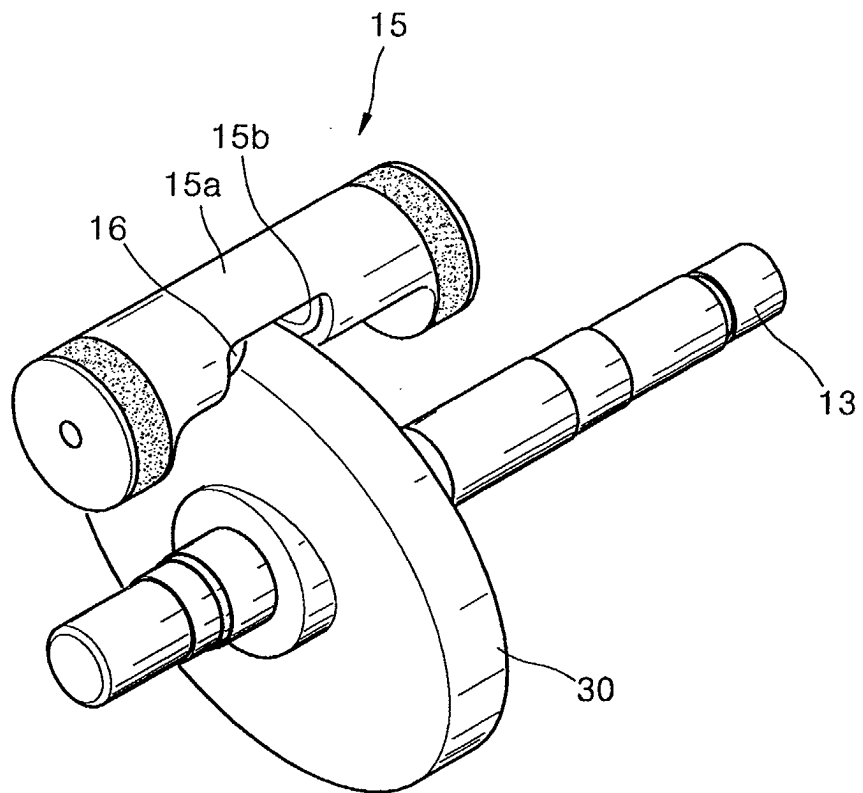


FIG. 3

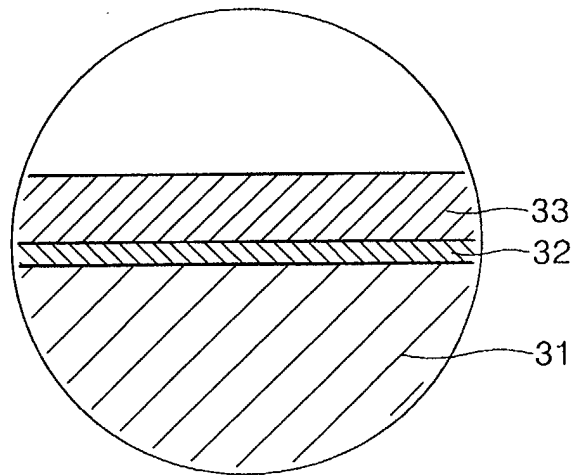


FIG. 4

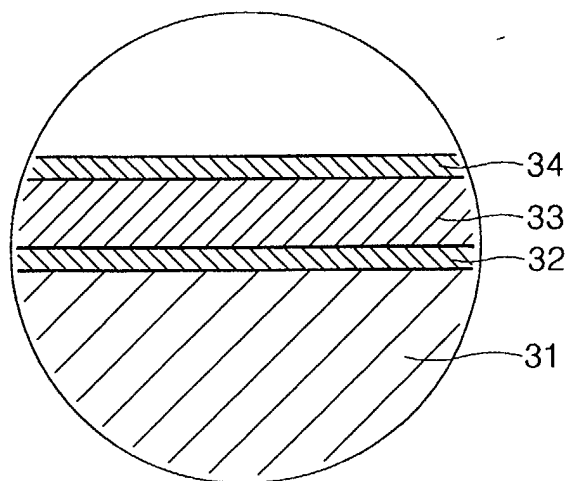


FIG. 5

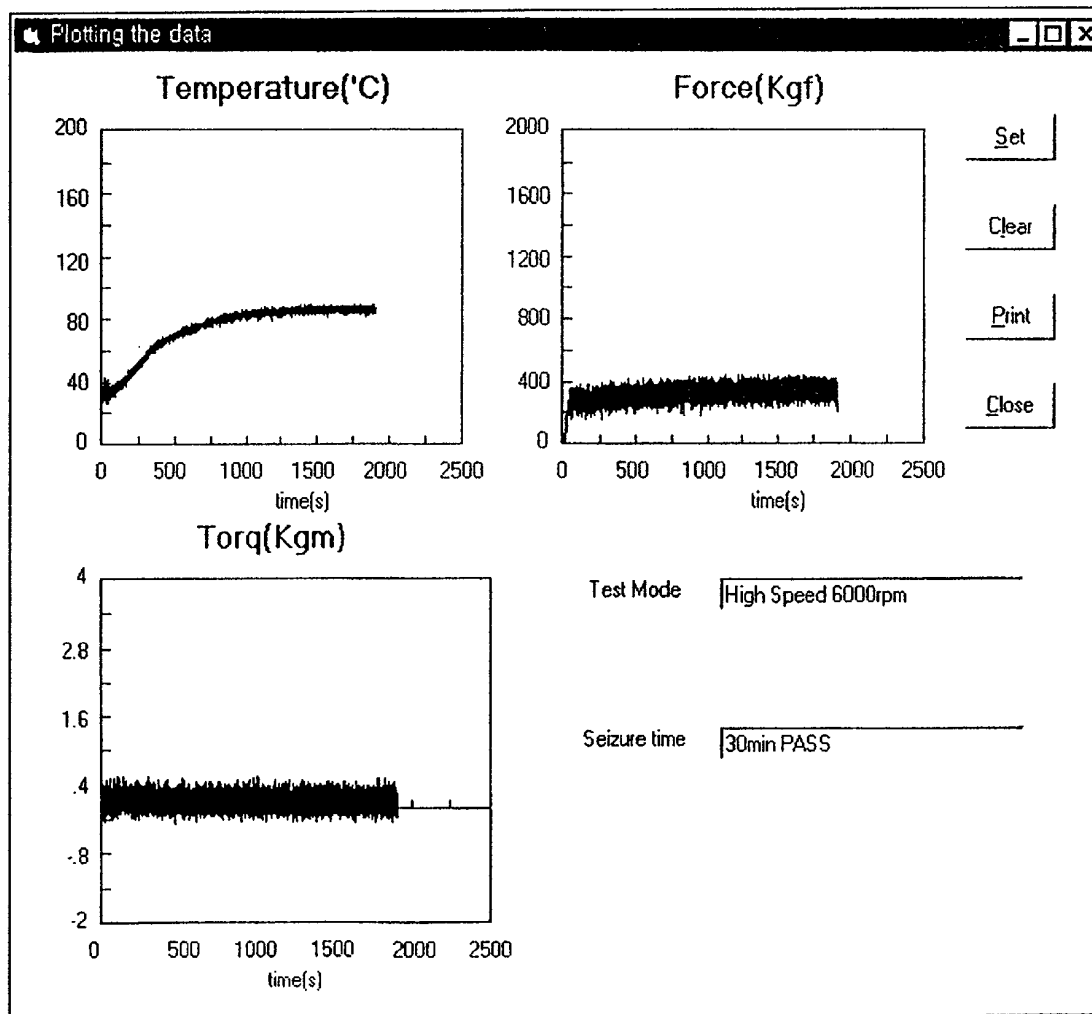


FIG. 6

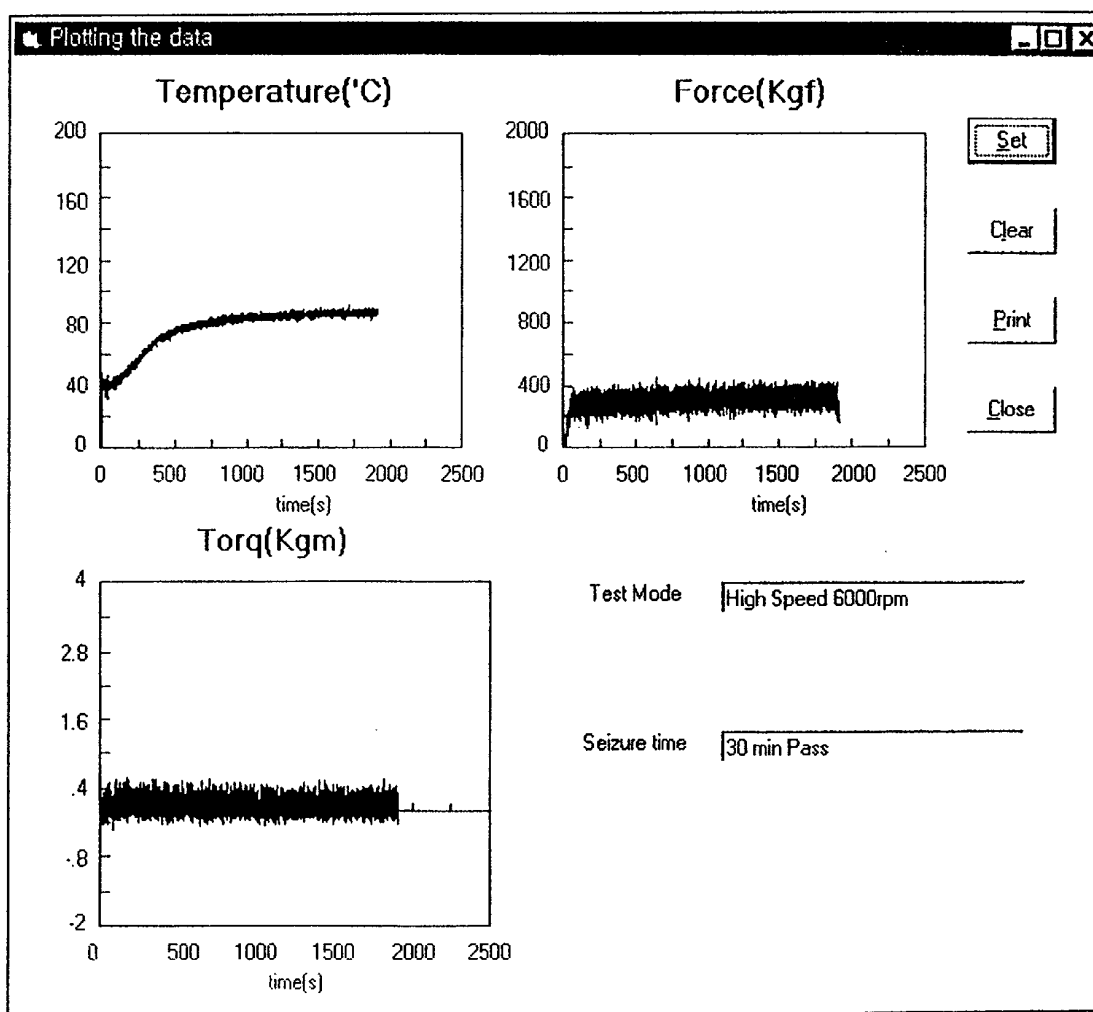


FIG. 7

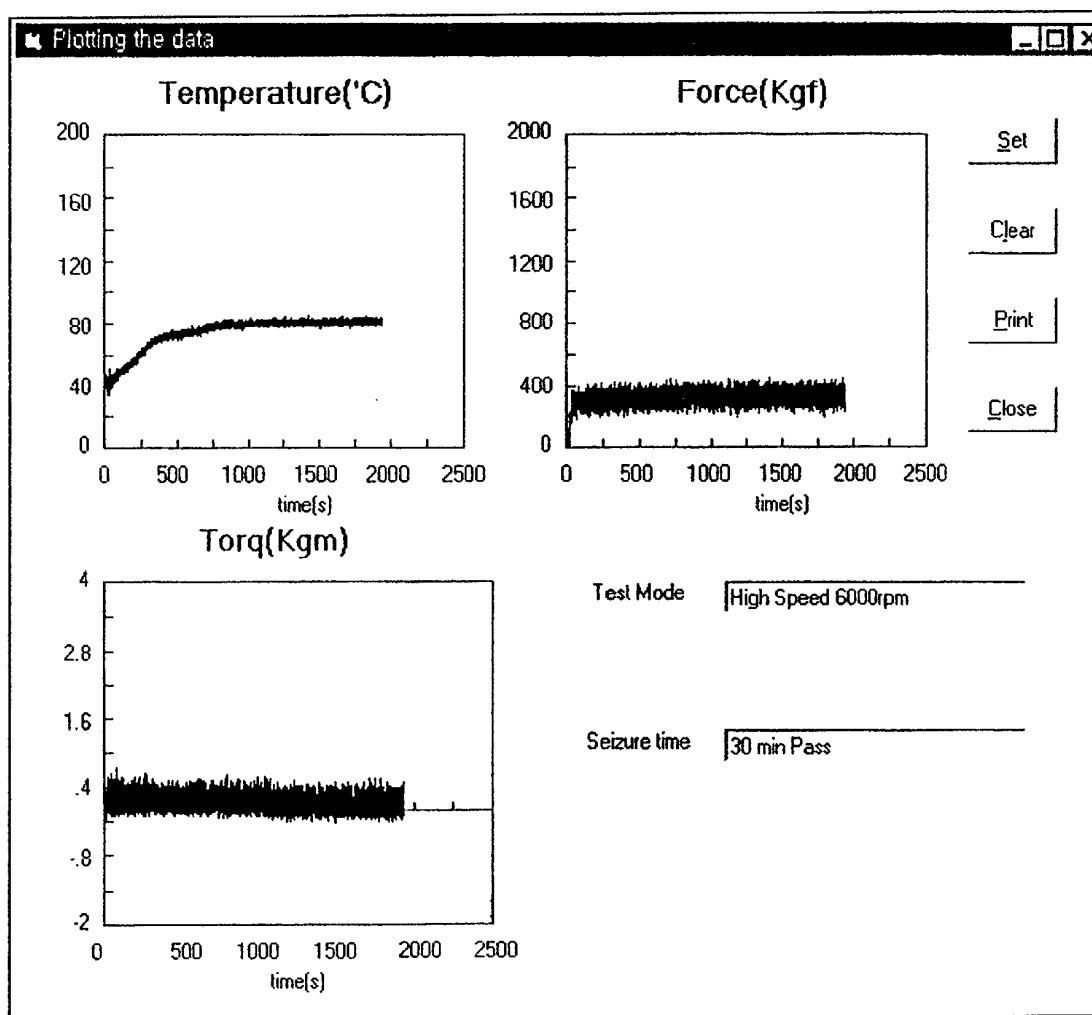


FIG. 8

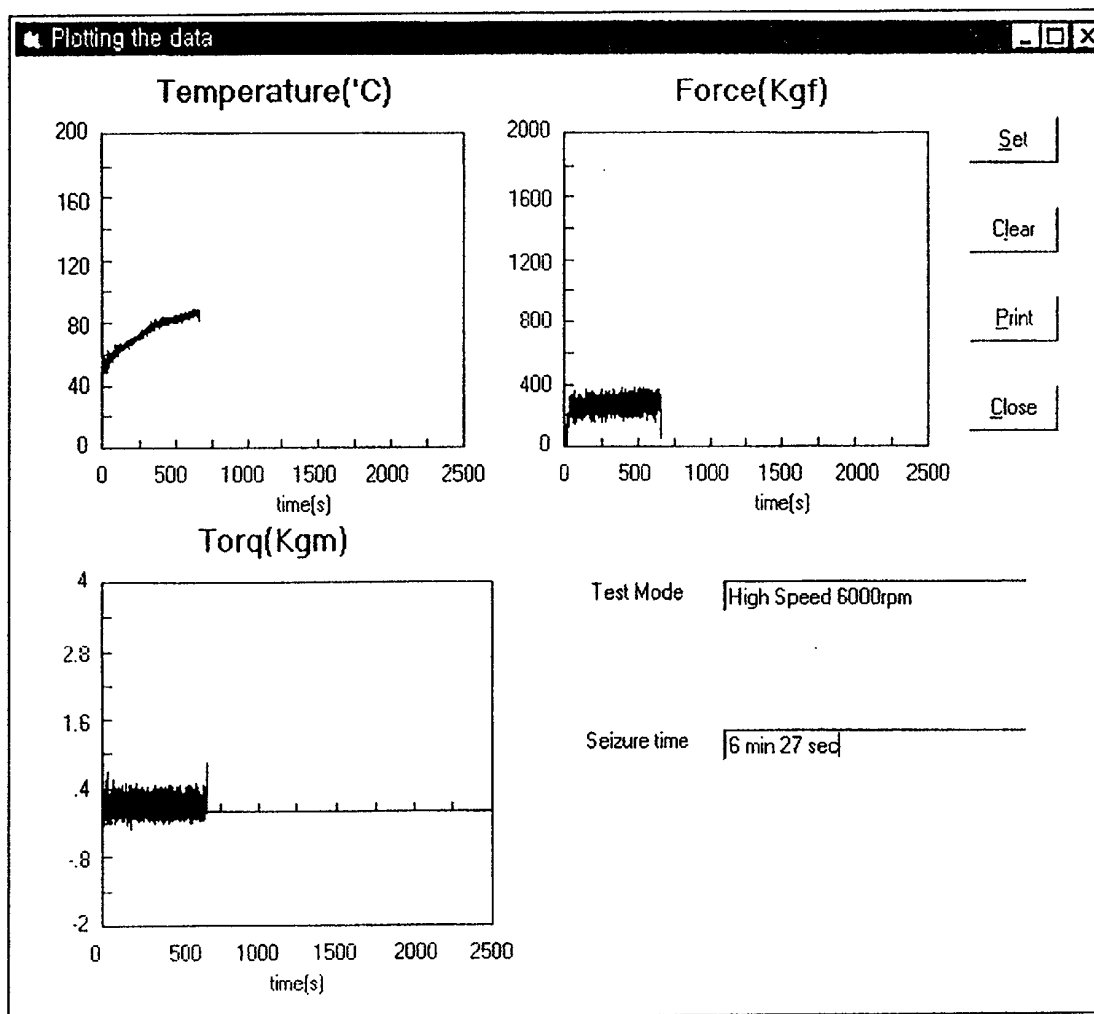


FIG. 9

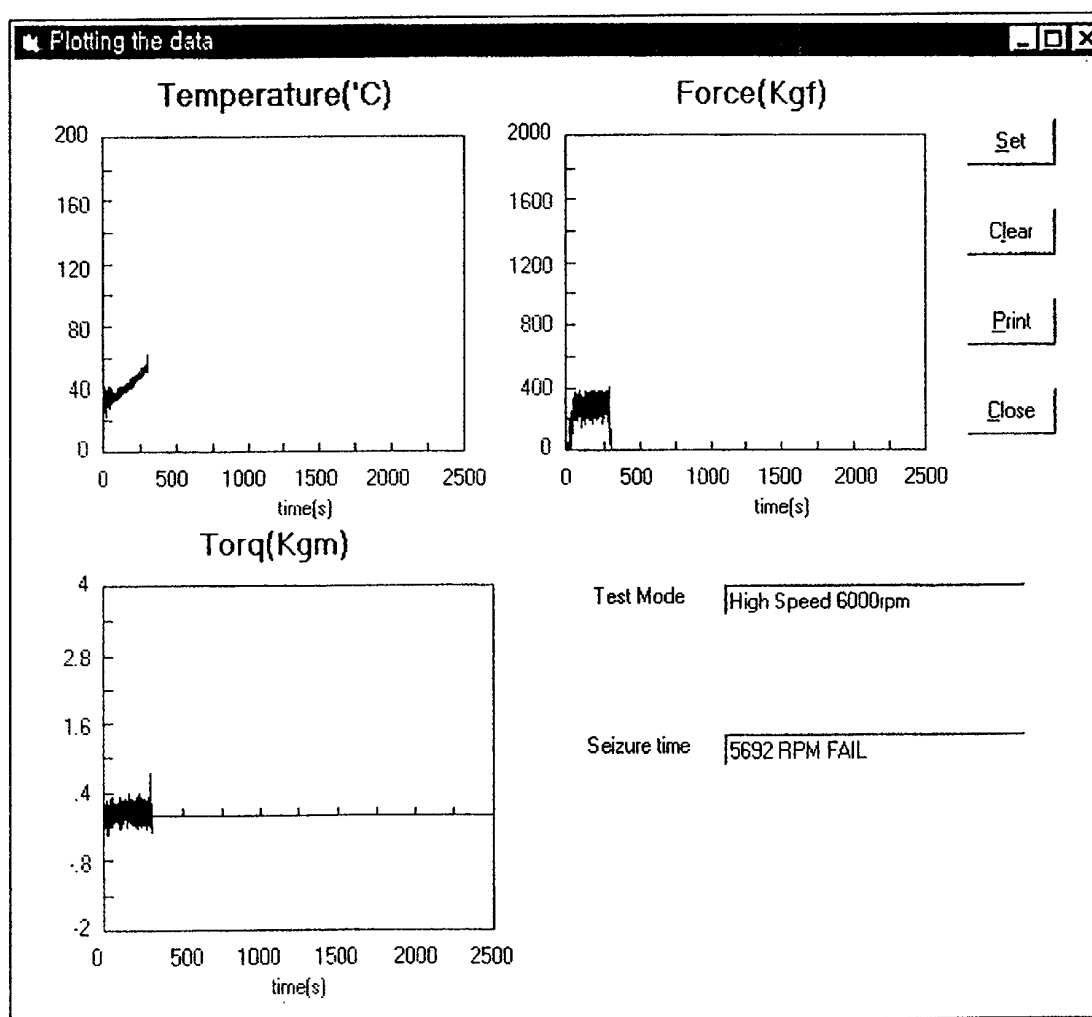


FIG. 10

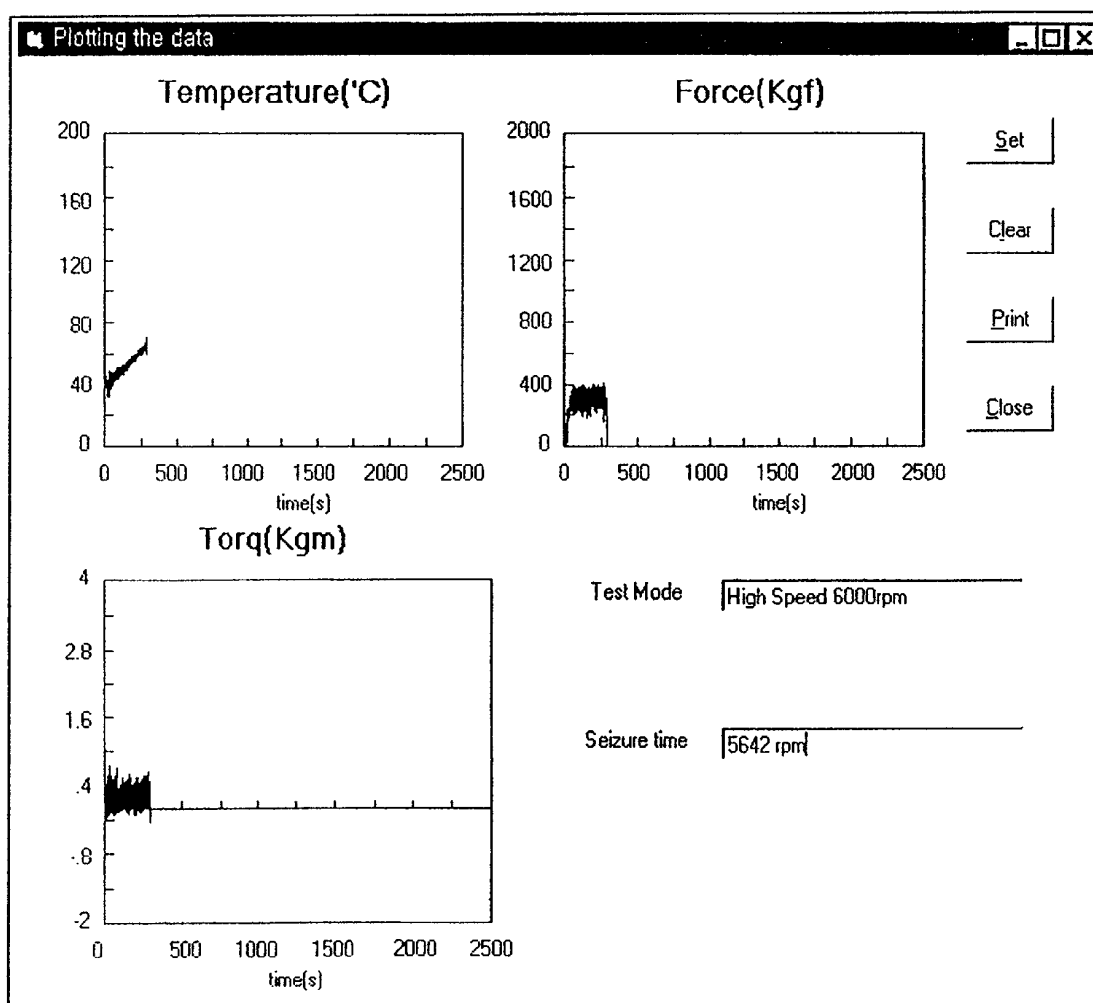


FIG. 11

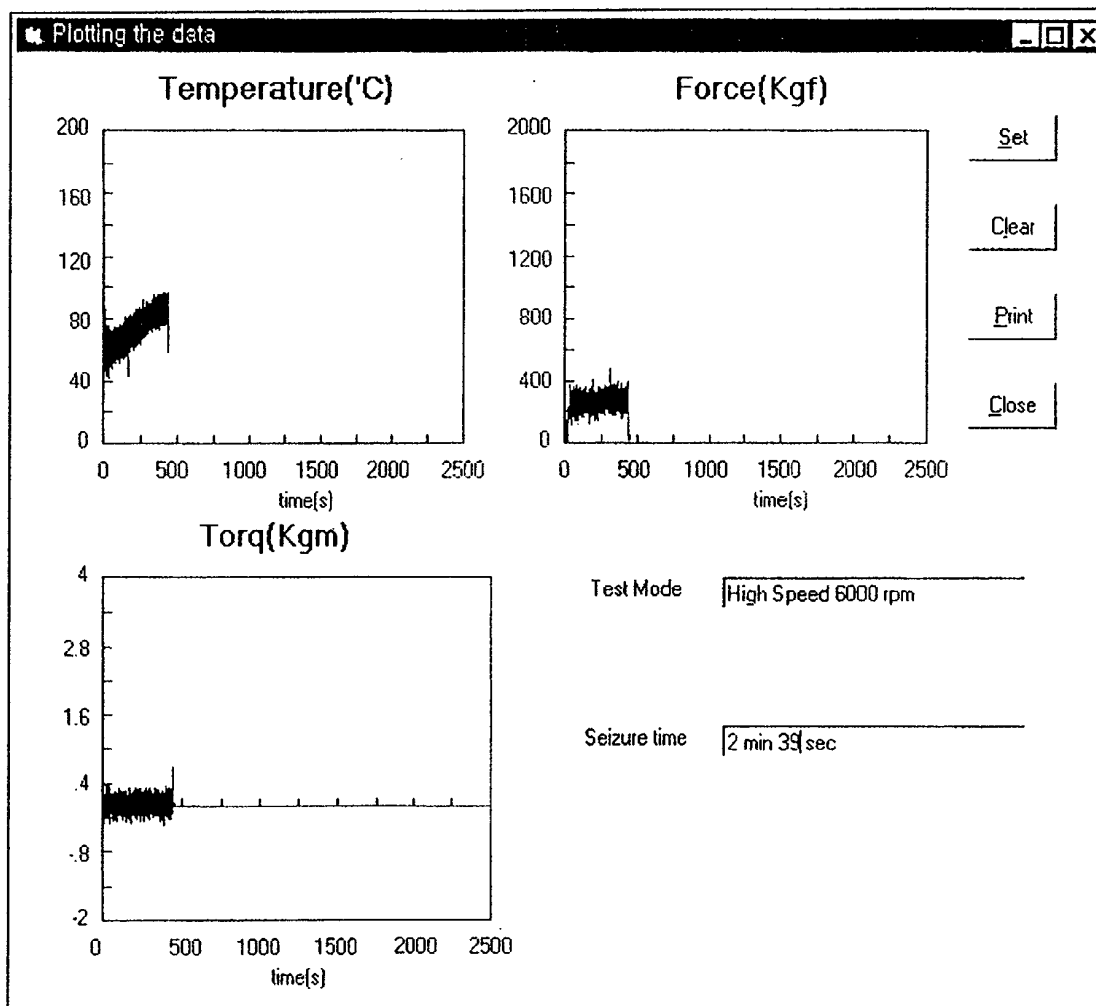


FIG. 12

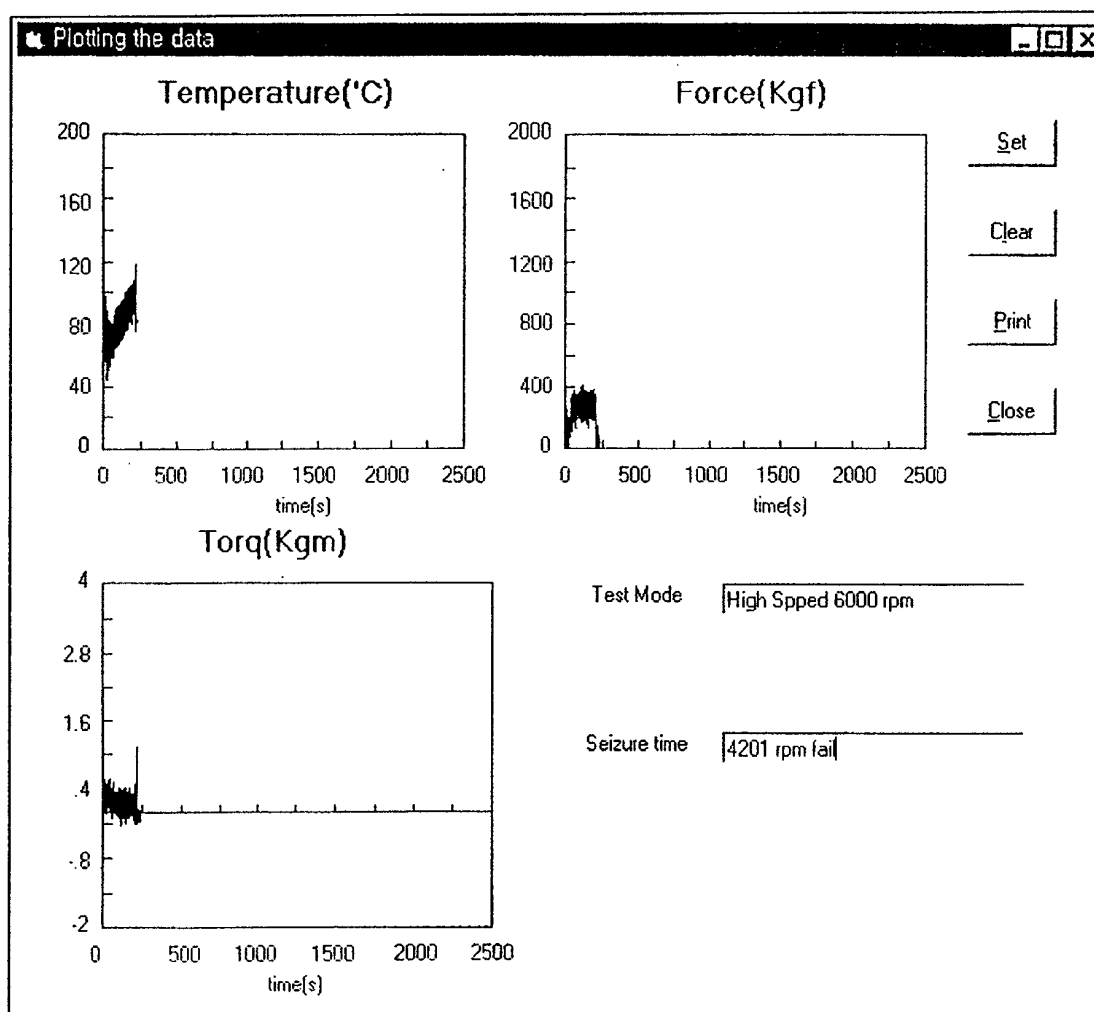


FIG. 13

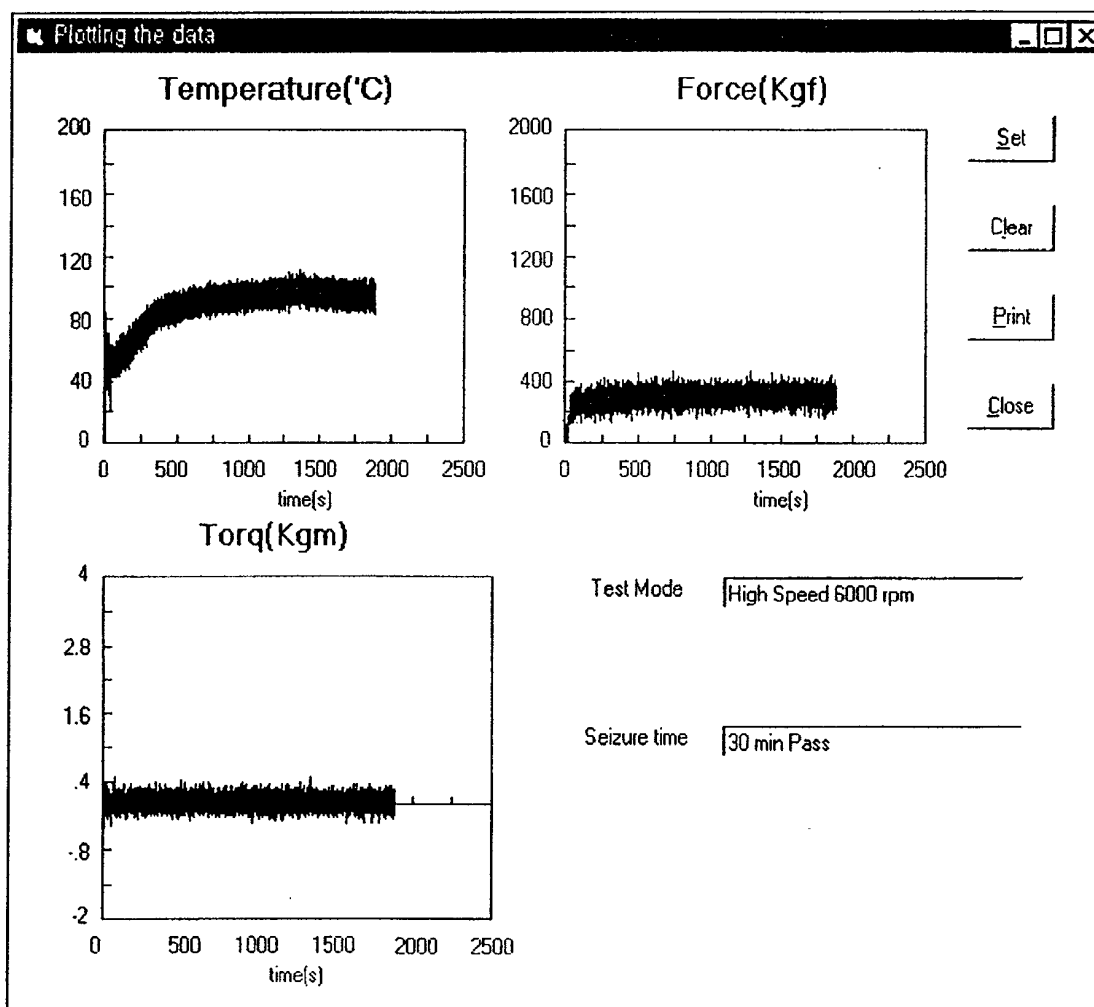


FIG. 14

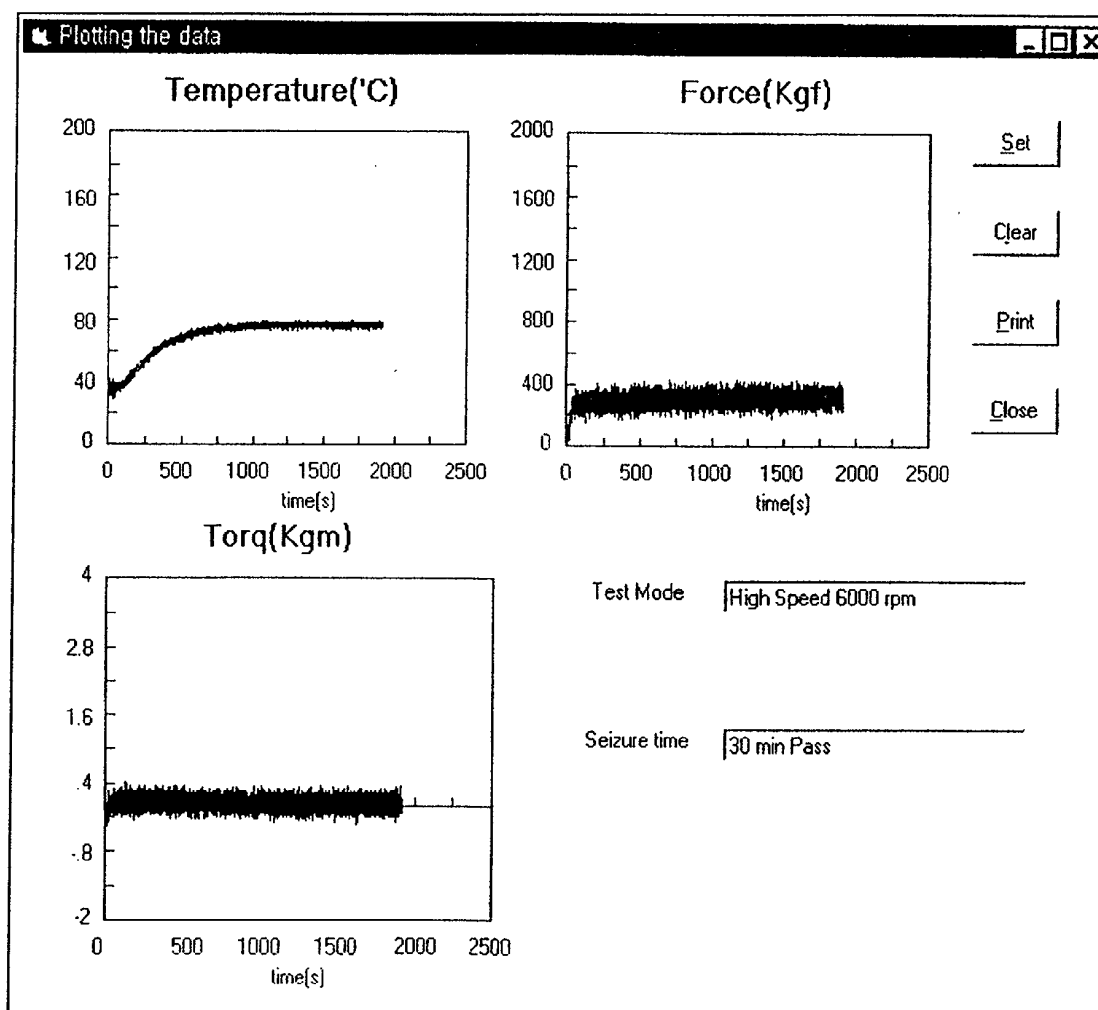


FIG. 15

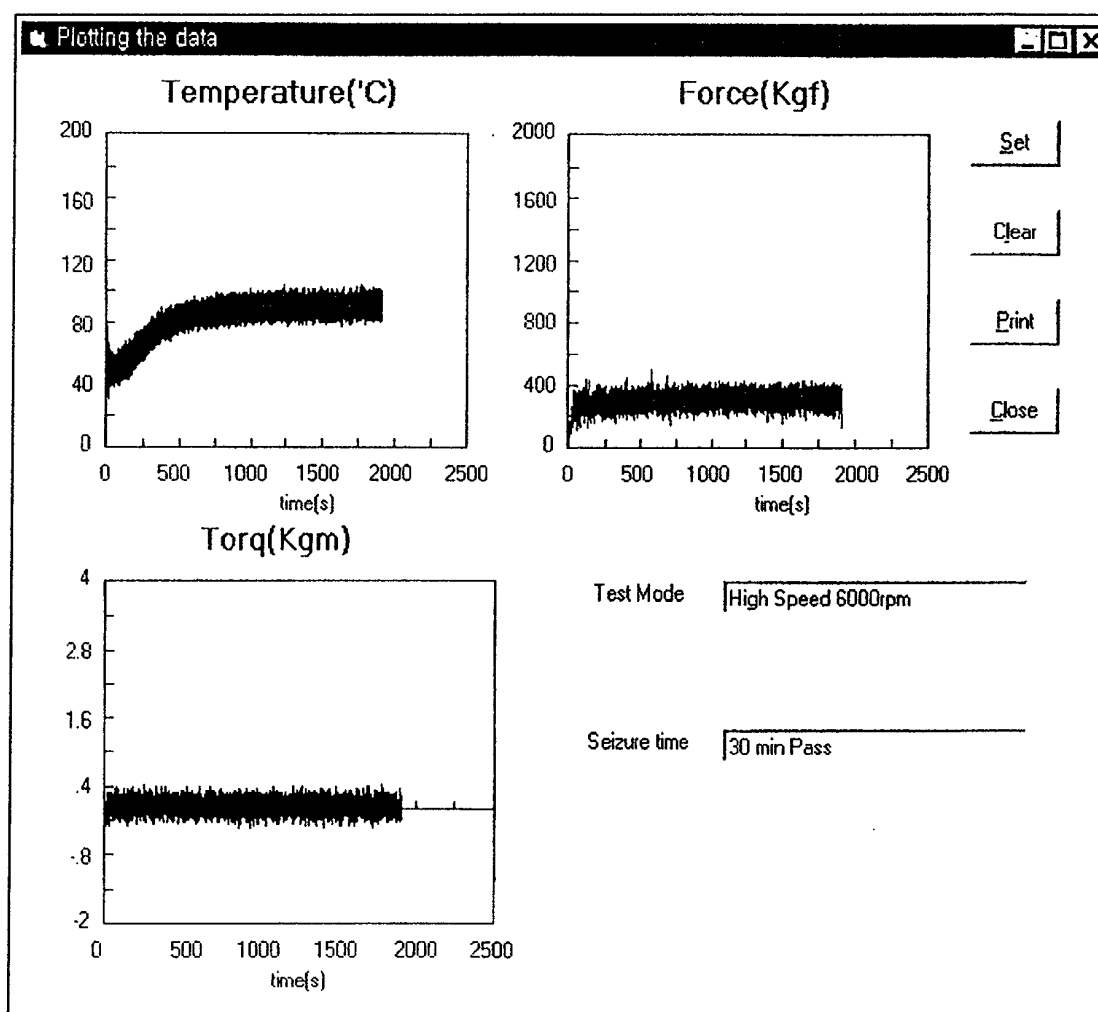
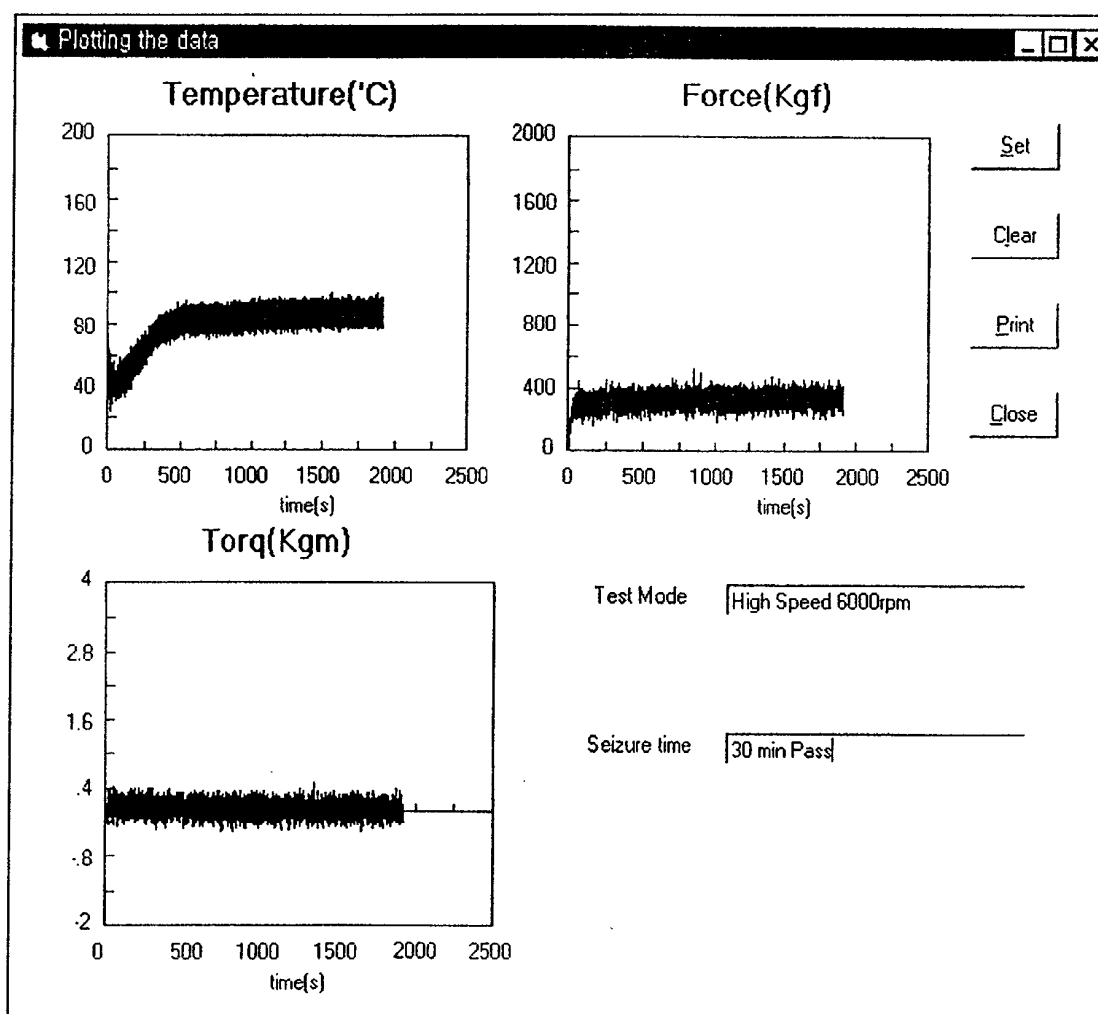


FIG. 16





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 25 3874

DOCUMENTS CONSIDERED TO BE RELEVANT			
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EUROPEAN SEARCH REPORT

Application Number
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