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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : D04H 3/08, F16D 69/00

A1

(11) International Publication Number: WO 92/13128

(43) International Publication Date: 6 August 1992 (06.08.92)

(21) International Application Number: PCT/US92/00665

(22) International Filing Date: 28 January 1992 (28.01.92)

(30) Priority data:
647,137 29 January 1991 (29.01.91) US

(60) Parent Application or Grant
(63) Related by Continuation
US 647,137 (CIP)
Filed on 29 January 1991 (29.01.91)

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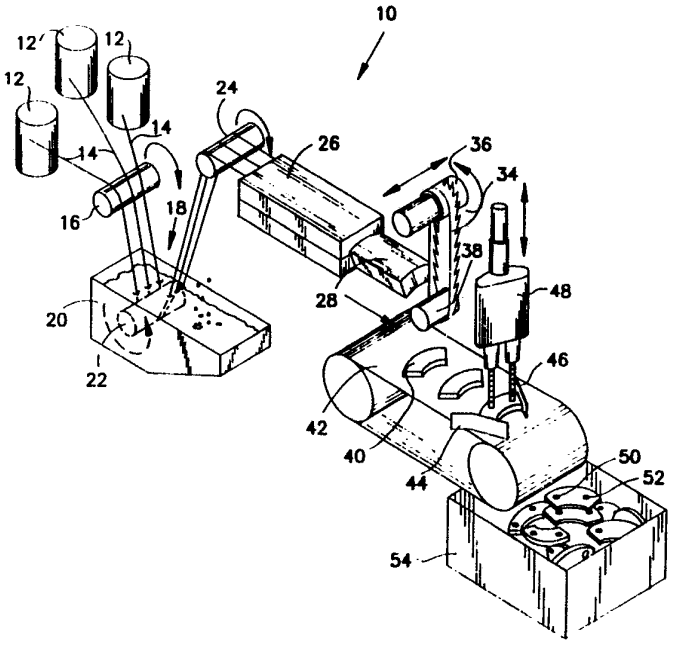
(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, KR, LU (European patent), MC (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: PULTRUDED BRAKE LININGS AND METHOD OF MAKING



(57) Abstract

A continuous process for the manufacture of friction units (40) comprises the steps of impregnating a plurality of strands (14) of reinforcing fibers with a phenolic resin (18) having zero to ten percent copper and graphite powders, pulling the impregnated strands of reinforcing fibers through a composite forming die (26) for forming a body (28) having the peripheral configuration of the friction units (40), and selectively cutting the body (28) into a plurality of the friction units (40).

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Description

Pultruded Brake Linings And Method Of Making

Reference To Related Application

This application is a Continuation-in-Part of my co-pending application Serial No. 07/647,137, filed January 29, 1991, and entitled "Pultruded Brake Linings And Method Of Making Same".

Technical Field

The present invention relates to brake pads and linings and pertains particularly to an improved method and composition for making same.

Background Art

A friction brake is basically a pair of friction elements, one rotating and one stationary, brought into engagement to produce a friction force measured as brake torque for either slowing or stopping the rotating element. Brakes are designed so that the brake torque is somewhat proportional to the input force used to engage the elements. Unfortunately, pressure is not the only factor that influences the frictional response of the brake elements. Friction effects between friction elements cause friction force and brake torque to vary with engaging pressure, speed, and temperature, and to depend upon deposited interfacial film for stability.

The rotating element of a brake system is usually a steel disc or drum, and the stationary element is usually a composition pad or shoe lining. The materials forming the composition element are the unpredictable variables that have the greatest affect

on the performance characteristics of the brake system.

Until recent years, the predominant material used in the manufacture of friction pads and discs for brakes, clutches and the like was asbestos. However, it was discovered that asbestos is a carcinogenic substance, and that such use released potentially harmful amounts of it into the environment. Extensive efforts have been put forth in an effort to find suitable environmentally safe materials having the desirable wear and heat resistant characteristics as asbestos.

Attempts to satisfy the need for long life, high friction heat resistant friction materials have included proposals to utilize various chopped fibers molded in a bonding matrix, such as a resin. The friction unit is formed by a molding process, with the fibers randomly oriented and placed in a binder, such as either a dry powder resin cured under heat and pressure, or placed in a liquid resin and cured.

However, friction units made by this method are expensive to manufacture and have not been satisfactory, because of their lack of uniformity in performance and durability. For example, units from the same batch may vary as much as 35% in performance characteristics. Thus, seemingly identical brake pads or shoes may vary as much as 35% in performance. The non-uniformity of results has been found to be caused largely by a non-uniformity of distribution and orientation of the fibers in the matrix. This not only creates expensive inspection and quality control problems, it can also create maintenance problems, and sometimes even hazardous conditions. For example,

pads that have been matched for performance at initial installation may vary over their useful life.

In my aforementioned application, I disclosed an improved method and composition for brake pads and linings. However, further improvements in both methods and compositions are desirable and have been developed as set forth herein.

Disclosure of the Invention

It is the primary object of the present invention to provide improved compositions for brake pads and linings and method of making same.

In accordance with a primary aspect of the present invention, a continuous process for the manufacture of friction units comprises the steps of impregnating a plurality of strands of reinforcing fibers with a phenolic resin material, pulling the impregnated strands of reinforcing fibers through a composite forming die for forming a body having at least a portion of the peripheral configuration of the friction units, and selectively cutting the body into a plurality of the friction units.

In accordance with another aspect of the invention, strands of reinforcing fibers are selectively oriented in molds and molded with compositions of phenolic resins.

Brief Description of Drawings

The above and other objects and advantages of the present invention will become apparent from the following description when read in conjunction with the accompanying drawings wherein:

Fig. 1 is a perspective view schematically illustrating an apparatus and a preferred method of carrying out the invention;

Fig. 2 is a detailed sectional view of a brake pad in accordance with the invention; and

Fig. 3 is a perspective view of a brake shoe lining in a drum type brake in accordance with the invention.

Best Mode for Carrying Out the Invention

Referring to Fig. 1 of the drawing, there is schematically illustrated an exemplary system for carrying out the process of the invention for making brake friction units in accordance with the invention. The system, designated generally by the numeral 10, comprises a plurality of creels 12 from which a plurality of strands 14 of an elongated continuous fiber are drawn and passed across suitable guide rollers or bars 16 to a thermoplastic bath 18. The fibers or strands 16 pass through the bath into or through a bath of a suitable resin contained within a reservoir 20 for impregnating the fibers or strands. The strands 14 are guided beneath suitable guide roller or means 22 and over the guide roller 24 and into a die 26 for imparting at least a part of the shape or configuration of the friction units.

The strands, particularly fiberglass may require a sizing treatment, i.e. application of a compound or chemical to insure a good bond between the fibers and matrix. A bulked roving (bunch of strands or fibers) may be used. Bulked roving is produced by a process in which a standard roving is fractured or splintered by forced cold air. This provides two useful properties, 1) increased diameter which assists in

providing fill to low glass content pultrusion, and 2) the "splinters" provide for good mechanical bonding with the resin matrix. More general, traditional rovings of properly size fibers is utilized.

The impregnated strands are passed through the die 26, where they are shaped into part of the desired configuration and at least partially cured. They emerge from the die in the form of a bar or block 28 having at least part of the peripheral configuration of the brake pad or other article being manufactured. The bar or block 28 is forced or pulled from the die 26 by suitable means, such as hydraulic pullers or the like, and positioned to be cut into individual brake pad units or pieces in the illustrated embodiment.

In the illustrated embodiment, a suitable cutting apparatus, such as a band saw 34 supported on its pulleys or rollers 36 and 38, is movable transverse to the axis or movement of the bar 28 for sawing the bar into a plurality of brake pads 40. Other suitable cutting apparatus may be utilized, such as water jets, laser, abrasive or other means. The cut surface represents the friction surface in this embodiment, and the fibers are preferably substantially normal or perpendicular to this surface. It may be desirable in some instances to provide a different angularity to the fibers in relation to the friction surface. This can be accomplished by cutting the friction units from the bar at the desired angle to the axis thereof.

The brake pads, upon being cut from the bar, fall onto a conveyer belt 42 and are moved into position held by a jig or fixture 44, 46 for operation of a punch or drill press 48 for forming mounting holes 50 and 52 on the brake pads. The pads are then accumulated in a suitable storage container or bin 54,

where they are then packaged and shipped. This provides a highly efficient and economical manufacturing process. In the case of bonded type pads, the drill and punch operation may be eliminated from the process.

The reinforcing fibers 14 for the brake pads or linings are preferably glass fiber, but may contain other materials and fibers or combinations thereof. In addition, other fibers may be woven or distributed in with the glass fibers in various selected distributions and proportions. For example, various fibers may be distributed in various concentrations throughout the unit for optimizing various parameters such as wear, fade, and cooling.

Many different fibers or strands and combinations may be utilized, including but not limited to glass, rock, ceramic, carbon, graphite, aramide, nomex, and fibers of other organic and inorganic materials. Various metallic fibers, such as copper and aluminum, may also be utilized in various proportions with non-metallic fibers.

The manufacturing system and process, as illustrated, provides for the controlled orientation of the fibers, as well as the controlled uniformity and density of the fibers within the resin matrix. For example, the composition of the friction device determines many of its characteristics, such as its durability, heat resistance, and friction resistance. With this process, the fibers may be controllably oriented uniformly at any suitable angle to the friction surface of the brake pad or friction device. Thus, the process and materials have the capability of providing superior, predictable and consistent performance.

The matrix material may be any suitable resin that is either a thermoplastic material or non-thermoplastic material, and it may require various forms of curing. It may be cured for example by cooling, or by the use of UV or other radiation or the like.

I have found a preferred material to be certain phenolic resins which are not thermoplastic. These have been found to have many desired characteristics for this manufacturing process and application. For example, one preferred phenolic resin is available from BP Chemicals under the trademark CELLOBOND and product designation J2041L. It is described as a high viscosity phenolic for use in heat cured pultrusion and press molding. It does not require any catalyst and will provide reasonably fast line speeds and cure cycles. This provides enhanced efficiency in production.

The matrix material will be formulated to include heat dissipation and/or friction modifiers, such as graphite and or non-ferrous metallic powders. For example, from about one to ten percent by weight of graphite powder and/or one or more non-ferrous metallic powders may be incorporated into the matrix material.

The glass or fiber to resin matrix may vary from about one part glass or fiber to two part resin, up to about three part fiber to one part resin. A preferred glass to matrix composition is from about 40 to 60% glass to 60 to 40% resin or matrix mix. The matrix preferably has from 5 to 10% by weight of one or more of graphite powder, copper powder and aluminum powder. In addition, aramide pulp and other synthetic

fiber pulps may be added or distributed throughout the matrix material.

Certain thermoplastic materials may be desirable for other specific applications. The thermoplastic material may, for example, be a suitable polyester and may also have components such as powders of graphite or other material to aid in friction control and the dissipation of heat. For example, a one to about ten percent by weight of graphite powder uniformly distributed through the thermoplastic material aids in the dissipation of heat. Alternate compositions may include small amounts of other materials, such as non-ferrous metallic powders, such as copper, aluminum or the like. For example, a one to ten percent by weight copper powder may also be utilized to enhance the dissipation of heat.

I have discovered that various proportions and compositions of materials can affect the performance characteristics of the brake pad and liner units. For example, the following ranges examples have been constructed and tested:

Glass content about 37 to 51% by volume (about 55 to 68% by weight), with a matrix of resin containing about 5 to 10% by weight of fine graphite and copper powder.

The best results were obtained from compositions within the range of from about 58 to about 59% by weight (41% volume) fiberglass in a matrix of phenolic resin, with about 5 to 10% by weight copper, and 5 to 10% by weight graphite. These samples more closely followed the temperature performance of asbestos control samples.

Referring to Fig. 2, a section view through a brake pad 40 is illustrating glass fibers 14 in a

matrix of thermoplastic material 19. The fibers 14 are shown substantially perpendicular to a friction surface 56 of the brake pad 40. Other friction devices, such as brake shoes and clutch pads, would preferably have similarly oriented strands or fibers. The density and mixture of fibers may be varied to suit the particular application.

While brake pads are illustrated in the process, it is apparent that clutch friction pads and brake shoe type of pads may also be manufactured by this process. The die is set to shape the emerging articles, such that the fibers are oriented uniformly at an angle preferably normal to the friction surface. However, in certain applications, an orientation parallel to the friction surface may be satisfactory or even preferred. For example, in a brake shoe and drum configuration as illustrated in Fig. 3, the fibers may preferably run parallel to the friction surface for ease of manufacturing. As illustrated, a typical brake drum 58 is illustrated having an inner friction surface 60 engaged by a brake shoe lining 62. The lining 62 is formed of fibers, the ends of which are shown at 64, with the fibers oriented parallel to the friction surfaces as indicated along arrow 66. This orientation of the fibers provides for an economical construction. Thin curved pultruded bars or slabs can be cut as in the Fig. 1 illustration to form the liner units.

The shoe linings may be formed by the pultrusion process in the form of a thin arcuate slab, and the linings cut to width as described above with respect to pads. This provides an economical technique for producing consistently uniform units. However, where orientation of the fibers normal to the friction is

desired, a rectangular slab may be cut along an arc to form the curved friction surfaces.

The articles may be cut from the pultruded bar by any suitable means, such as by laser, water or other means. The present method and process provides a highly efficient manufacturing process for the production of high quality friction units that are asbestos free and/or a controlled uniform composition and quality. The pultrusion process enables the careful control of fiber density, mixture, and orientation on a continuous basis.

While the pultrusion process is preferred, the articles may also be made by other similar or derivative processes including: filament winding process. By this process, strands or filaments are wound on or into compression mold cavities supported on a drum or circular rim, forming slabs which can then be cut into the friction units. Another derivative process would involve the placement of pre-preg fibers (usually manufactured by the pultrusion or filament winding processes) into mold cavities. While this process is more costly and labor intensive, because pre-preg fibers would have uniform orientation, friction unit characteristics would be similar to more preferred process technologies.

While I have illustrated and described my invention by means of specific embodiments, it should be understood that numerous changes and modifications may be made therein without departing from the spirit and scope of the invention, as defined in the appended claims.

CLAIMS

1. A continuous process for the manufacture of friction units comprising the steps of:

impregnating a plurality of strands of reinforcing fibers with a phenolic resin;

pulling said impregnated strands of reinforcing fibers into a composite forming die for forming a body having the peripheral configuration of said friction units; and

selectively cutting said body into a plurality of said friction units.

2. A continuous process according to claim 1 wherein said reinforcing fibers are a bulked roving of predominately fiberglass.

3. A continuous process according to claim 1 wherein said phenolic resin is a CELLOBOND resin.

4. A continuous process according to claim 1 wherein the ratio of fibers to resin is on the order of from about forty to sixty percent by weight.

5. A continuous process according to claim 1 wherein said reinforcing fibers are uniformly oriented predominately normal to the friction surface.

6. A continuous process according to claim 1 wherein said phenolic resin forms a matrix having about five to ten percent by weight of graphite powder.

7. A continuous process according to claim 1 wherein said phenolic resin forms a matrix having

about five to ten percent by weight of graphite powder and about five to ten percent by weight of copper powder.

8. A continuous process according to claim 1 wherein said friction unit is a brake pad having a friction surface and said fibers extend substantially normal to said surface.

9. A continuous process according to claim 1 wherein said friction unit is a brake shoe lining having a friction surface and said fibers extend substantially parallel to said surface.

10. A continuous process according to claim 1 wherein said friction unit is a brake pad having a friction surface and said fibers extend at a slight angle to said surface.

11. A method for the continuous manufacture of composite friction units comprising the steps of:

selecting and impregnating a plurality of elongated strands of reinforcing fibers with a phenolic resin material;

pulling said impregnated strands of reinforcing fibers in a predetermined alignment through a composite forming die for forming a body having the peripheral configuration of said friction units; and

selectively cutting said body at least along one friction surface into a plurality of said friction units.

12. A continuous process according to claim 11 wherein said reinforcing fibers are a bulked roving of predominately fiberglass.

13. A continuous process according to claim 12 wherein said reinforcing fibers is taken from the group consisting essentially of glass, rock, ceramic, carbon, graphite, aramide, and nomex.

14. A continuous process according to claim 13 wherein said phenolic resin is taken from the group consisting essentially of vinyl esters and epoxies and includes additives in the form of powders taken from the group consisting essentially of graphite, copper, brass, iron, and rubber in selected quantities.

15. A composite friction unit made by the continuous manufacturing process comprising the steps of:

selecting and impregnating a plurality of strands of reinforcing fibers with a resin material;

said step of selecting includes selecting and bulking a roving of fiberglass strands by the application of cold air thereto;

pulling said impregnated strands of reinforcing fibers in a predetermined alignment through a composite forming die for forming a body having the peripheral configuration of said friction units; and

selectively cutting said body into a plurality of said friction units.

16. A composite friction unit according to claim 15 wherein said reinforcing fibers are selected to be predominately fiberglass.

17. A composite friction unit according to claim 16 wherein said reinforcing fibers is taken from the group consisting essentially of glass, rock, ceramic, carbon, graphite, aramide, and nomex.

18. A composite friction unit according to claim 16 wherein said resin is a phenolic resin.

19. A composite friction unit according to claim 16 wherein said resin is a phenolic resin having about five percent by weight of graphite powder and about five percent by weight of copper powder.

20. A composite friction unit according to claim 19 wherein said friction unit is a brake shoe lining having a friction surface and said fibers extend substantially normal to said surface.

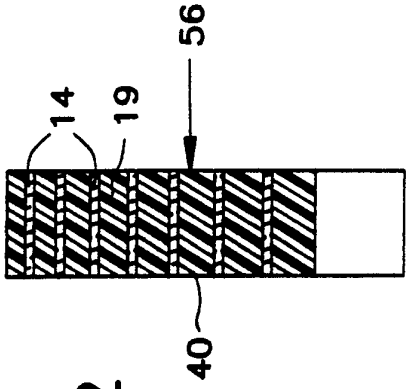

FIG. 2

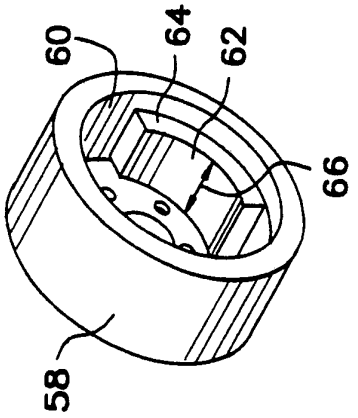

FIG. 3

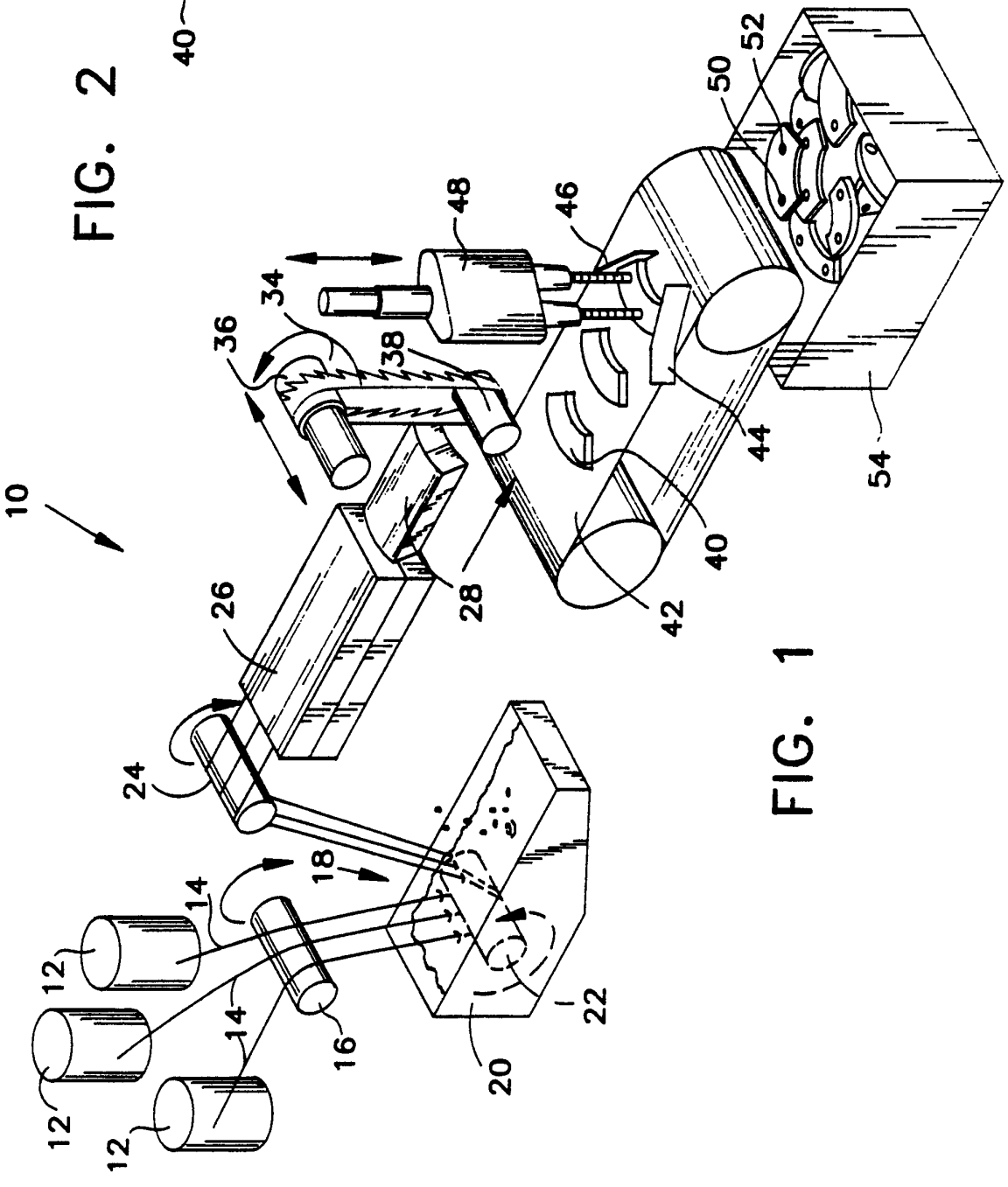

FIG. 1

INTERNATIONAL SEARCH REPORT

International Application No PCT/US92/00665

I. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): D04H 3/08; F16D 69/00

U.S. CL.: 156/180,181; 188/251A, 251R; 264/135,136,137

II. FIELDS SEARCHED

Minimum Documentation Searched

Classification System	Classification Symbols
US	188/251A, 251R 156/180, 181 264/135, 136, 137

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched

III. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X Y	US, A, 4,119,591 (Aldrich) 10 October 1978, See figure 25	15-20 1-14
X Y	US, A, 4,259,397 (Saito et al.) 31 March 1981. See column 1, lines 44-61	15-18,20 1-14,19
Y	US, A, 4,445,957 (Harvey) 01 May 1984 See figure 1.	1-14
Y	US, A, 4,892,600 (Baeuar) 09 January 1990. See figure 1.	1-14
Y	US, A, 5,026,447 (O'Conner) 25 June 1991	1-14

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
18 May 1992	12 JUN 1992
International Searching Authority	Signature of Authorized Officer
ISA/US	NGUYEN HOC-DO INTERNATIONAL EXAMINER Robert B. Davis

Form PCT/ISA/210 (second sheet) (Rev.11-87)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A, 4,432,922 (Kaufman et al.) 21 February 1984	1-20
A	US, A, 4,244,944 (Trainor et al.) 13 January 1981	1-20

V ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons.

1 ☐ Claim numbers because they relate to subject matter [2] not required to be searched by this Authority, namely:

2 ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [3], specifically:

3 ☐ Claim numbers_____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [3]

This International Searching Authority found multiple inventions in this international application as follows:

1 ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2 ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3 ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4 ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.