United States Patent [19]

Abplanalp

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[54] **DIAMOND DRILL BIT**

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[52] **U.S. Cl.** **175/329**

[51] **Int. Cl.** **E21b 9/36**

[58] **Field of Search** 175/329, 330

[56] **References Cited**

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Primary Examiner—David H. Brown

Attorney—Bernard Kriegel and Kendrick, Subkow & Kriegel

[57] **ABSTRACT**

A rotary bit having diamond cutting elements in its drilling face for drilling a bore hole, drilling fluid being pumped from the bit and into primary feeder waterways in the drilling face extending to the outer gauge portion of the bit. Jet passages receive drilling fluid from the interior of the bit, discharging such fluid into secondary waterways in the drilling face in the direction of rotation of the bit and toward the outer gauge portion, to create low pressure regions in the secondary waterways and cause fluid to flow from the relatively high pressure feeder waterways across the intervening bit faces toward the secondary waterways, effecting a cleaning action of the cuttings from the bottom of the hole, the bit faces and the diamonds embedded therein, such cuttings being flushed upwardly around the bit toward the top of the bore hole.

16 Claims, 3 Drawing Figures

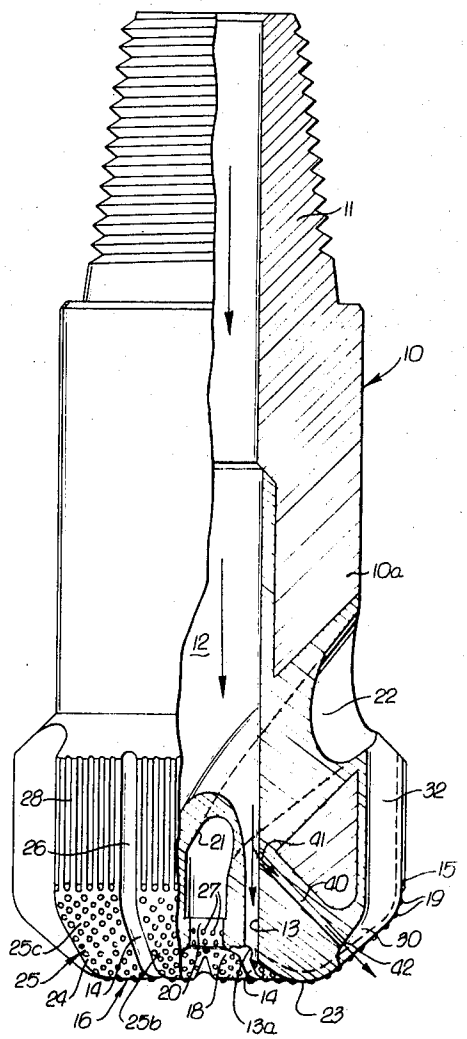


FIG. 1.

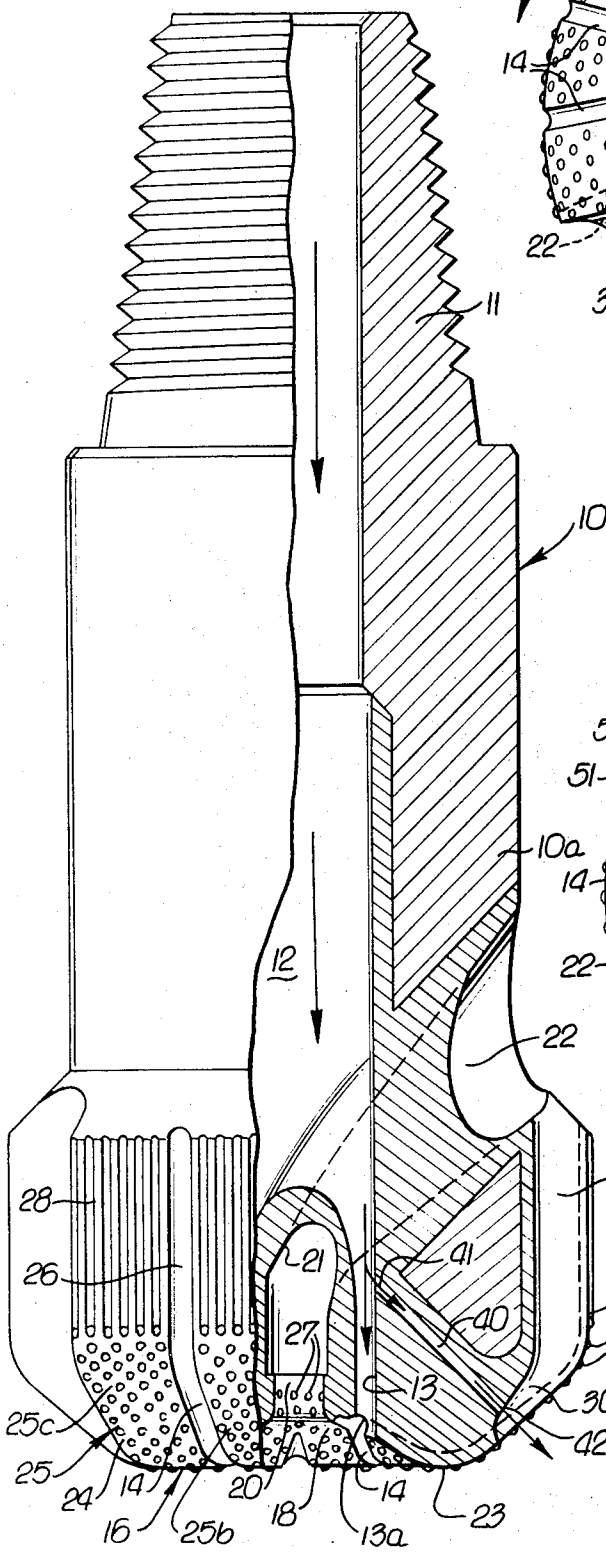


FIG. 2.

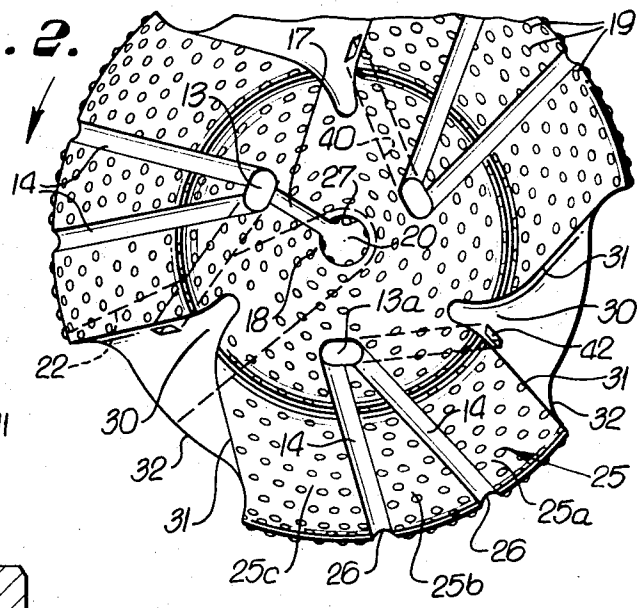
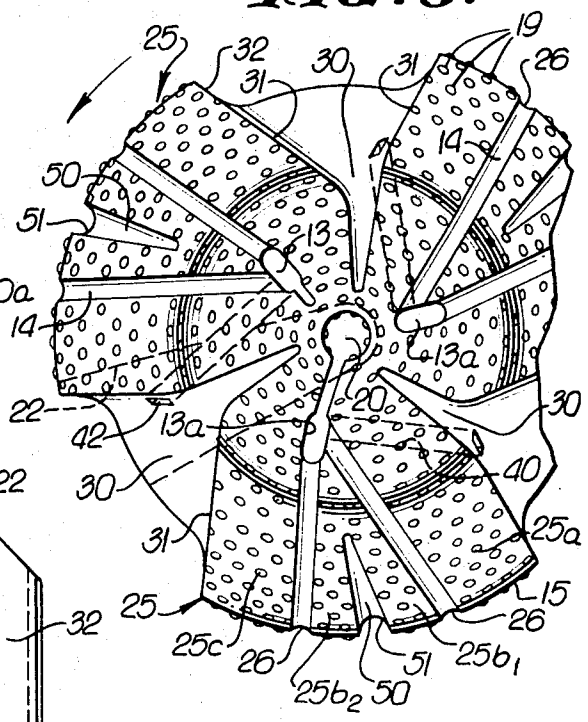


FIG. 3.



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DIAMOND DRILL BIT

The present invention relates to rotary drill bits, and more particularly to diamond bits used in the drilling of bore holes, such as oil and gas wells.

Diamond drill bits have been provided for drilling comparatively hard formations, such as sandstone. During the drilling operation, drilling mud or other drilling fluid is pumped down the drill string connected to the bit, discharging from the bit for the purpose of conveying the formation cuttings to the outer portions of the bit and thence upwardly therearound toward the top of the bore hole being drilled. In addition, the drilling fluid cleans and cools the bit of cuttings, insuring maximum penetration of the cutting elements into the formation.

Prior diamond bits that can drill hard formations effectively slow down upon entering a softer formation, such as shale. It is believed that the slower rate of drilling the softer formations is due to the inability of the drilling fluid to remove the cuttings effectively from the bit face and the bottom of the bore hole, thereby interfering with proper penetration of the diamond cutting elements into the softer formation.

By virtue of the present invention, a diamond drill bit has been provided which will drill hard formations efficiently, and which will also drill the softer formations more effectively than heretofore and at faster rates. This is accomplished by providing a rotary diamond drill bit which ensures the flow of the drilling fluid over its diamond set pads or lands. The drilling fluid is caused to discharge into primary waterways extending laterally outwardly across the bit face, such fluid being caused to flow from the water ways across the diamond set lands themselves into low pressure areas or waterways in the face of the bit on the opposite sides of the lands. The low pressure in these areas is produced by directing jets of fluid into such areas, the relatively high velocity of the fluid in the areas, which are preferably placed in advance of the bit lands or pads, reducing the pressure therein, thereby inducing the flow of fluid from the primary or feeder waterways across the pads or lands. Preferably, the primary waterways have a progressively reduced cross-section in the direction of the bit gauge to cause the pressure in such waterways to build up and thereby flow across the pads or lands to the low pressure secondary waterways that extend toward the gauge of the bit.

To enhance the cleaning action effected by the jets issuing from the bit, they are directed toward the bottom of the hole and inclined in a direction in advance of the lands, also being inclined toward the gauge portion of the bit. The jets are caused to discharge at different radial distances from the bit axis to collectively flush substantially the full bottom of the bore hole.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense.

Referring to the drawings:

FIG. 1 is a combined side elevation and longitudinal section of a rotary diamond bit embodying the invention;

FIG. 2 is a bottom plan view of the bit illustrated in FIG. 1; and

FIG. 3 is a view similar to FIG. 2 of a modified form of bit.

As disclosed in the drawings, a drill bit is provided for operation upon the bottom of a bore hole and to flush the cuttings from the bottom upwardly around the drill bit and a string of drill pipe (not shown), to which it is secured, to the top of the hole. The drill bit includes a body or shank **10** having an upper threaded pin **11** for threadedly attaching the bit to the string of drill pipe. Circulating drilling fluid pumped down through the drill pipe flows into a central or main passage **12** in the body of the tool, from where it will flow through a plurality of circumferentially spaced longitudinally extending ports or openings **13** against the bottom of the hole. The lower end of each distribution port **13** communicates with one or a plurality of generally radial primary waterways **14** extending toward the outer gauge portion **15** of the bit, the fluid flowing through such waterways and also across the cutting surface or face **16** of the bit, as described hereinbelow. A relatively short waterway **17** may extend inwardly from one port **13** across the inner portion **18** of the drilling face toward the axis of the bit.

The body of the bit has diamonds **19**, or similar cutting elements, secured in its formation contacting face **16** within a matrix (not shown separately) of a suitable type forming a portion of the bit body **10**. The central portion **18** of the bit illustrated is generally conical in shape, with the sides of the cone tapering in an upward and inward direction toward a central core tube portion **20** into which a relatively small diameter core, formed by the bit, will move during the drilling of the hole, the core moving upwardly until it engages a tapered core breaker face **21** that will break off the core. The broken core can discharge through an ejector passage **22** extending laterally to the outer portion of the bit body above the reaming face **15** of the bit. The arrangement for forming the core, breaking it off, and ejecting it through the lateral passage **22** is known in the art and forms no part of the present invention.

The generally conical central portion **18** of the bit merges into a lowermost bottom contacting portion **23**, which, in turn, merges into an upwardly diverging conical face **24** terminating at the generally cylindrical reaming face **15** of the bit.

The drilling portion of the bit is divided into a plurality of diamond set sections, lands, or pads **25** which extend outwardly from the region of the distribution ports **13**, and which are defined by the primary feeder waterways **14** extending from each port toward the gauge portion **15** of the bit. Thus, the waterways **14** extend from the outlets **13***a* of the distribution ports **13** generally radially along the inner conical face portion **18**, lowermost face portion **23**, and outer conical face portion **24**, merging into vertical waterways or grooves **26** in the reaming portion **15** of the bit body.

The inner conical portion **18** of the bit face has diamonds set therein for operation upon the central portion of the hole, the central vertical passage **20** having inner gauge stones or diamonds **27** therein for

cutting the small diameter core (not shown), which will be broken off by the core breaker face **21**, as described above. Similarly, diamonds **19** are set in a predetermined pattern in the faces of all of the lands, the diamonds **19** terminating at the lowermost end of the gauge region where vertical stabilizing ribs **28** are provided on the bit body, which may, if desired, have diamonds or other suitable cutting and stabilizing elements set therein.

As specifically disclosed in FIGS. **1** and **2**, circumferentially spaced low pressure recesses or secondary waterways **30** are formed in the drilling face, each of these recesses extending from an inner or intermediate portion of the lower drilling face, with its sides **31** diverging in a lateral outward direction, these low pressure waterways merging into junk slots **32** in the gauge portion of the bit through which cuttings can be flushed upwardly into the annular space around the smaller diameter bit shank portion **10***a* for conveyance by the drilling fluid upwardly around the string of drill pipe to the top of the bore hole. These low pressure recesses **30** actually divide the bit face into a plurality of sets of lands **25**, each set of lands being defined between the low pressure recesses or secondary waterways **30** and the primary feeder waterways **14**, as well as between adjacent primary waterways.

As specifically disclosed in FIG. **2**, each set of lands has three lands **25***a*, **25***b*, **25***c*, a leading land **25***a* being defined between a secondary waterway **30** and a primary feeder waterway **14**, an intermediate land **25***b* being b between a pair of adjacent waterways **14**, and a trailing land **25***c* being defined between a trailing primary waterway **14** and a secondary waterway **30**.

During rotation of the bit and the pumping of drilling fluid therethrough, for the purpose of drilling the bore hole and removing the cuttings, the pressure in the secondary waterways **30** is reduced by causing part of the drilling fluid to discharge through jet passages **40**, each passage having an upper entry **41** opening leading from one of the longitudinal distribution ports **13**, the passage inclining in a downward and outward direction toward the bottom of the bit and also being inclined toward a forward secondary waterway **30** into which its outlet **42** opens. Thus, the fluid discharging from each jet passageway **40** will issue at high velocity into a secondary waterway **30** and, because of such velocity, will reduce the pressure therein below the pressure in the primary feeder waterways **14**. As a result, the fluid flowing through such waterways **14** will be caused to flow transversely across the diamond studded lands or pads **25***a*, **25***c* and into the adjacent secondary waterways **30**, covering the full surface of the lands **25***a*, **25***c*. From the low pressure secondary waterways **30**, the cutting laden drilling fluid will pass outwardly toward the gauge of the bit and into the junk slots **32**, moving upwardly therethrough and around the bit body thereabove.

For the purpose of insuring transverse flow across the pads from the primary waterways **14** toward the low pressure secondary waterways **30**, the cross-sectional area of each primary waterway decreases in a direction toward the gauge of the bit, thereby imposing a restriction to direct generally radial outward flow of the fluid through the primary waterways **14** toward the gauge **15** and into the vertical waterways **26** with which they communicate. The progressively decreasing area of the primary waterways can be achieved, by way of example, by progressively decreasing the depth of each primary waterway in an outward direction, while maintaining the width of the primary waterway substantially uniform.

For the purpose of flushing substantially the full bottom of the bore hole, the outlets **42** of the inclined jets **40** are disposed at different distances from the bit axis, insuring a more thorough sweep of the flushing fluid around the bottom of the bore hole as the drill bit rotates.

In larger bit diameters, the diamond set lands **25** may become too wide for efficient cleaning and cooling when only the specific waterway arrangement disclosed in FIG. **2** is used. Accordingly, as illustrated in FIG. **3**, with a drill bit of a larger diameter, a relatively small secondary low pressure area **50** is provided between each set of primary waterways **14**, this relatively small secondary low pressure waterway **50** extending from an intermediate point in the bit face and extending to a smaller junk slot or vertical waterway **51**. With such design, four lands **25***a*, **25***b***1**, **25***b***2**, **25***c* are provided in each set, instead of the three lands shown in FIG. **2**, each land being narrower than would be the case if the small secondary waterway **50** were not provided. The drilling fluid flowing through the primary waterways **14** will not only flow transversely across the outer lands **25***a*, **25***c* toward the low pressure main secondary waterways **30**, but it will also flow from the primary waterways **14** transversely across the lands **25***b***1**, **25***b***2** toward the small secondary low pressure waterways **50**, insuring the effective cleaning and cooling of all areas of the drilling face of the drill bit.

With the drill bits illustrated and embodying the invention, hard formations have been drilled effectively, as well as the softer formations. Moreover, drilling has occurred at faster rates. The relatively high velocity jets **40** reduce the fluid pressure in the secondary waterways **30** and thereby cause the drilling fluid to flow from the primary waterways **14** transversely across the lands **25**, for the purpose of cooling and cleaning them of cuttings, as well as flushing the cuttings towards the outer portion of the drill bit and upwardly therearound and around the drill pipe to the top of the bore hole.

I claim:

1. In a rotary bit: a body having a cutting face for drilling a bore hole, said face comprising a plurality of spaced lands extending laterally from an inner portion of the face to the outer portion of the face, said cutting face having primary and secondary waterways defining said lands and separating said lands from each other, said body having first fluid passage means for feeding fluid from the interior of said body to said primary waterways, means for decreasing the fluid pressure in said secondary waterways below the fluid pressure in said primary waterways to induce flow of fluid from said primary waterways across the lands to said secondary waterways, comprising second fluid passage means communicating with the interior of said body and proportioned to discharge fluid into said secondary waterways at a substantially higher velocity than the velocity of the fluid flowing through said primary waterways, each of said second fluid passage means extending laterally outwardly of said body and being

inclined substantially to a radial plane passing through the axis of said body.

2. In a rotary bit as defined in claim 1; said body having an outer vertical face extending upwardly from said cutting face, said vertical face having vertical grooves therein communicating with and extending upwardly from the outer ends of said primary and secondary waterways.

3. In a rotary bit: a body having a cutting face for drilling a bore hole, said face comprising a plurality of spaced lands extending laterally from an inner portion of the face to the outer portion of the face, said cutting face having primary and secondary waterways defining said lands and separating said lands from each other, said body having first fluid passage means for feeding fluid from the interior of said body to said primary waterways, said body having second fluid passage means for jetting fluid from the interior of said body into said secondary waterways, whereby the jetting fluid decreases the fluid pressure in said secondary waterways below the fluid pressure in said primary waterways to induce flow of fluid from said primary waterways across the lands to said secondary waterways; and said second fluid passage means being inclined laterally outwardly and in the direction of rotation of the bit.

4. In a rotary bit as defined in claim 3, said second fluid passage means also being inclined downwardly of the bit.

5. In a rotary bit: a body having a cutting face for drilling a bore hole, said face comprising a plurality of spaced lands extending laterally from an inner portion of the face to the outer portion of the face, said cutting face having primary and secondary waterways defining said lands and separating said lands from each other, said body having first fluid passage means for feeding fluid from the interior of said body to said primary waterways, said body having second fluid passage means for jetting fluid from the interior of said body into said secondary waterways, whereby the jetting fluid decreases the fluid pressure in said secondary waterways below the fluid pressure in said primary waterways to induce flow of fluid from said primary waterways across the lands to said secondary waterways; said primary waterways being of progressively decreasing cross-sectional area in a direction laterally outwardly of the cutting face.

6. In a rotary bit as defined in claim 5; said second fluid passage means being inclined downwardly and laterally outwardly of the bit and also being inclined in the direction of rotation of the bit.

7. In a rotary bit as defined in claim 5; said body having an outer vertical face extending upwardly from said cutting face, said vertical face having vertical grooves therein communicating with and extending upwardly from the outer ends of said primary and secondary waterways, said second fluid passage means being inclined downwardly and laterally outwardly of the bit and also being inclined in the direction of rotation of the bit.

8. In a rotary bit: a body having a cutting face for drilling a bore hole, said face comprising a plurality of spaced lands extending laterally from an inner portion of the face to the outer portion of the face, said cutting face having primary and secondary waterways defining said lands and separating said lands from each other, said body having a main fluid passage for receiving fluid from a tubular drilling string to which the body is securable, said body having distribution ports for feeding fluid from said main fluid passage to the inner portions of said primary waterways, said body having jet passages communicating with said main fluid passage and opening into said secondary waterways for jetting fluid under high velocity into said secondary waterways to decrease the fluid pressure in said secondary waterways below the fluid pressure in said primary waterways, said jet passages being proportioned to discharge fluid into said secondary waterways at a substantially higher velocity than the velocity of the fluid flowing through said primary waterways, each of said jet passages extending laterally outwardly of said body and being inclined substantially to a radial plane passing through the axis of said body.

9. In a rotary bit as defined in claim 8; each of said distribution ports feeding fluid into a plurality of primary waterways, said primary waterways diverging from one another in a direction laterally outwardly of the body.

10. In a rotary bit as defined in claim 8; said body having an outer vertical face extending upwardly from said cutting face, said vertical face having vertical grooves therein communicating with and extending upwardly from the outer ends of said primary and secondary waterways.

11. In a rotary bit: a body having a cutting face for drilling a bore hole, said face comprising a plurality of spaced lands extending laterally from an inner portion of the face to the outer portion of the face, said cutting face having primary and second waterways defining said lands and separating said lands from each other, said body having a main fluid passage for receiving fluid from a tubular drilling string to which the body is securable, said body having distribution ports for feeding fluid from said main fluid passage to the inner portions of said primary waterways, said body having jet passages communicating with said main fluid passage and opening into said secondary waterways for jetting fluid under high velocity into said secondary waterways to decrease the fluid pressure in said secondary waterways below the fluid pressure in said primary waterways; each of said jet passages being inclined downwardly and laterally outwardly of the body and also being inclined in the direction of rotation of the bit.

12. In a rotary bit as defined in claim 11; said primary waterways being of progressively decreasing cross-sectional area in a direction laterally outwardly of the cutting face.

13. In a rotary bit as defined in claim 11; each of said distribution ports feeding fluid into a plurality of primary waterways which diverge from one another in a direction laterally outwardly of the body.

14. In a rotary bit as defined in claim 11; said primary waterways being of progressively decreasing cross-sectional area in a direction laterally outwardly of the cutting face, each of said distribution ports feeding fluid into a plurality of primary waterways which diverge from one another in a direction laterally outwardly of the body.

15. In a rotary bit as defined in claim 11; said body having an outer vertical face extending upwardly from said cutting face, said vertical face having vertical grooves therein communicating with and extending upwardly from the outer ends of said primary and secondary waterways, said primary waterways being of progressively decreasing cross-sectional area in a direction laterally outwardly of the cutting face.

16. In a rotary bit as defined in claim 11; said body having an outer vertical face extending upwardly from said cutting face, said vertical face having vertical grooves therein communicating with and extending upwardly from the outer ends of said primary and secondary waterways, said primary waterways being of progressively decreasing cross-sectional area in a direction laterally outwardly of the cutting face, each of said distribution ports feeding fluid into a plurality of primary waterways which diverge from one another in a direction laterally outwardly of the body.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,727,704 Dated April 17, 1973

Inventor(s) THOMAS L. ABPLANALP

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 31: "ensures" should be --insures--.

Column 3, line 32: "b" should be --defined--.

Column 6, line 36: "second" should be --secondary--.

Signed and sealed this 18th day of December 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents