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(71) Applicant 000002130
Sumitomo Electric Industries, Ltd.
4-5-33 Kitahama, Chuo-ku,
Osaka-shi, Osaka-fu

(74) Agent 110001416
Shin-Ei Patent Firm, P.C.

(72) Inventor Yutaka Hashimoto
c/o Sumitomo Electric Industries, Ltd.
4-5-33 Kitahama, Chuo-ku,
Osaka-shi, Osaka-fu

(72) Inventor Fumiaki Sato
c/o Sumitomo Electric Industries, Ltd.
4-5-33 Kitahama, Chuo-ku,
Osaka-shi, Osaka-fu

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(54) [Title of Invention] FIBER OPTIC CABLE

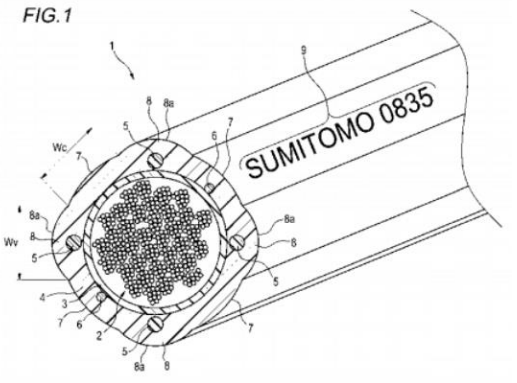
(57) [Abstract] (Revised)

[Problem] To provide a fiber optic cable wherein, when conducting pneumatic feeding within a duct, a pneumatic feeding distance can be extended, and an identification display applied to a cable outer cover is readily visible.

[Resolution Means] A fiber optic cable 1 having a plurality of a fiber optic core 2, and a cable outer cover 4 that contains the plurality of fiber optic cores and has a concave portion 7 on the surface, wherein an identification display 9 is applied only to the concave portion 7.

[Selected Drawing] FIG. 1

FIG.1



[Scope of Patent Claims]
[Claim 1]
A fiber optic cable, comprising:
a plurality of a fiber optic core; and
a cable outer cover that contains the plurality of fiber optic cores and has a concave portion on the surface, wherein an identification display is applied only to the concave portion.
[Claim 2]
The fiber optic cable according to claim 1, wherein the identification display is an identification display formed by an ink jet printer or a laser printer.
[Claim 3]
The fiber optic cable according to claim 1 or claim 2, wherein the cable outer cover comprises a plurality of the concave portion and a convex portion, and in the concave portion, a width of the cable outer cover in the circumferential direction is 3 mm or more, and a ratio of the width of the concave portion to the width of the convex portion is less than 2-to-1.
[Detailed Description of Invention]
[Technical Field]
[0001]
The present disclosure relates to a fiber optic cable provided with a plurality of a fiber optic core.
[Background Art]
[0002]
Patent document 1 describes a pneumatically fed cable wherein a fiber optic cable, in which a plurality of a fiber optic core are collectively covered, is laid within a duct (pipeline) via pneumatic feeding by compressed air.
Patent documents 2 and 3 teach a fiber optic cable having an identification display (marking) applied to the surface of the cable outer cover.
[Prior Art Documents]
[Patent Documents]
[0003]
[Patent Document 1] JP H3-128616 A
[Patent Document 2] JP 2012-032683 A
[Patent Document 3] JP 2013-020097 A
[Summary of Invention]
[Problem to Be Solved by Invention]
[0004]
For example, the pneumatically fed cable described in patent document 1 requires that pneumatic feeding be conducted over a large distance within a duct. However, friction arises between the surface of the cable outer cover and the inner surface of the duct during pneumatic feeding, and carries the risk of the pneumatic feeding distance being shortened.
In addition, for example, as in patent documents 2 and 3, the fiber optic cable may have an identification display (marking) applied to the surface of the cable outer cover. In terms of identification display content, while various cases are conceivable, information such as a number of fiber optic cores, product name, company name, year of manufacture, and length (position) is often included.
However, when a fiber optic cable such as a pneumatically fed cable has the identification display applied to the surface of the cable outer cover, the surface of the cable outer cover and the

inner surface of the duct are rubbed together during pneumatic feeding, and the identification display is scraped off, which carries the risk of visibility becoming difficult.

[0005]

An object of the present disclosure is to provide a fiber optic cable wherein, when conducting pneumatic feeding within a duct, a pneumatic feeding distance can be extended, and an identification display applied to a cable outer cover is readily visible.

[Means For Solving Problem]

[0006]

The fiber optic cable according to one embodiment of the present disclosure has a plurality of a fiber optic core, and a cable outer cover that contains the plurality of fiber optic cores and has a concave portion on the surface, wherein an identification display is applied only to the concave portion.

[Effect of Invention]

[0007]

According to the present disclosure, a fiber optic cable can be provided wherein, when conducting pneumatic feeding within a duct, a pneumatic feeding distance can be extended, and an identification display applied to a cable outer cover is readily visible.

[Brief Description of Drawings]

[0008]

[FIG. 1] A sectional view illustrating a configuration of the fiber optic cable according to the embodiment.

[FIG. 2] A schematic diagram illustrating a cable pneumatic feeding evaluation device.

[Embodiments of Invention]

[0009]

(Description of Embodiments of Present Disclosure)

First, the embodiments of the present disclosure will be described in a list.

A fiber optic unit according to one aspect of the present disclosure, having:

(1) a plurality of a fiber optic core, and

a cable outer cover that contains the plurality of fiber optic cores and has a concave portion on the surface, wherein an identification display is applied only to the concave portion.

According to a fiber optic cable having this configuration, because the concave portion and the inner surface of a duct carry a low risk of rubbing together during pneumatic feeding, the identification display applied only to the concave portion has a low risk of being scraped off. Therefore, the identification display applied to the cable outer cover is readily visible. In addition, because the surface is uneven due to the provision of the concave portion on the surface of the cable outer cover, an area of contact with the inner surface of the duct decreases, and friction between the surface of the cable outer cover and the inner surface of the duct during pneumatic feeding is reduced. As a result, a pneumatic feeding distance when conducting pneumatic feeding within a duct can be extended.

[0010]

(2) The identification display is an identification display formed by an ink jet printer or a laser printer.

According to a fiber optic cable having this configuration, numbers, characters, or the like of the identification display are printed by an inkjet printer or a laser printer, which are generally regarded as having a high printing speed. As a result, the time required for the process of forming the identification display can be shortened, so the manufacturing speed of the fiber optic cable can be

increased.

[0011]

(3) The cable outer cover has a plurality of the concave portion and a convex portion, and in the concave portions, a width of the cable outer cover in the circumferential direction is 3 mm or more, and a ratio of the width of the concave portions to the width of the convex portions may be less than 2-to-1.

According to a fiber optic cable having this configuration, because the width of the concave portions of the cable outer cover surface is 3 mm or more, the identification display of characters or numbers can be applied at 2 mm or more, which in general is readily visible with the naked eye. However, when the concave portion width is widened, the concave portions come into contact with the inner surface of the duct, and the friction between the surface of the cable outer cover and the inner surface of the duct increases, which also carries the risk of the identification display applied to the concave portions being scraped off. Because in the fiber optic cable having this configuration, the ratio of the concave portion width to the convex portion width is less than 2-to-1, the concave portion can be suppressed from making contact with the inner surface of the duct.

[0012]

(Details of Embodiments of Present Disclosure)

Specific examples of the fiber optic cable according to the embodiments of the present disclosure will be described below with reference to the drawings.

Note that the present invention is not limited to these examples, but is indicated by the Scope of Patent Claims and is intended to include all modifications within the meanings and scope equivalent to the Scope of Patent Claims.

[0013]

FIG. 1 is a sectional view illustrating a configuration of a fiber optic cable 1 according to the embodiment. As illustrated in FIG. 1, the fiber optic cable 1 is provided with a plurality of a fiber optic tape core 2, a water absorption tape 3 covering the circumference of the fiber optic tape cores 2, a cable outer cover 4 covering the circumference of the water absorption tape 3, and a tensioning body 5 and a tear string 6 provided inside the cable outer cover 4.

[0014]

The fiber optic tape cores 2 are housed, for example, in the fiber optic cable 1 in a rounded and aggregated state. Alternatively, the plurality of fiber optic tape cores 2 may be twisted together to form a unit, and a plurality of units may be housed in an aggregated state. In order to package the fiber optic tape cores 2 within the fiber optic cable 1 at a high density, the fiber optic tape cores 2 are preferably, for example, intermittently connected fiber optic tape cores. Note that the plurality of fiber optic tape cores 2 in the aggregated state may be bundled via a bundling material or the like, or may be bundled via a bundling material or the like by unit. In addition, although the fiber optic tape cores 2 are housed within the fiber optic cable 1 in the present example, such may be housed as-is as a fiber optic core without a taped form.

[0015]

The water absorption tape 3 is wound around the entirety of the plurality of fiber optic tape cores 2, for example, vertically or horizontally. The water absorption tape 3 is subjected to water absorbing treatment by adhering water absorbing powder to a base fabric made of, for example, polyester or the like.

[0016]

The cable outer cover 4 is formed of, for example, a resin such as polyethylene (PE). The resin of the cable outer cover 4 preferably has a Young's modulus of 500 Pa or more. The cable outer

cover 4 contains, for example, a silicon-based lubricant. The silicon-based lubricant is preferably contained, for example, at 2 wt% or more. The cable outer cover 4 is, for example, a thermoplastic resin and is formed by extrusion molding a resin on the plurality of fiber optic tape cores 2 having the water absorption tape 3 wound thereon.

[0017]

The tensioning body 5 is provided so as to be embedded inside the cable outer cover 4. The tensioning body 5 is formed, for example, of a fiber reinforced plastic (FRP), and is, for example, an aramid FRP, a glass FRP, a carbon FRP, or the like. The tensioning body 5 is formed in a circular shape in a cross-sectional view. A plurality (four in the present example) of the tensioning body 5 is provided. The four respective tensioning bodies 5 are provided as two pairs of two paired tensioning bodies 5 at opposing positions across the center of the fiber optic cable 1 in a cross-sectional view of the fiber optic cable 1. The positions of the four tensioning bodies 5 in the cross-sectional view are such that two straight lines connecting each of the two paired tensioning bodies 5 are orthogonal. The respective tensioning bodies 5 are provided within the cable outer cover 4 along the longitudinal direction of the fiber optic cable 1.

[0018]

The tear string 6 is for tearing the cable outer cover 4 and is embedded within the cable outer cover 4 in the longitudinal direction of the fiber optic cable 1. In the present example, two of the tear string 6 are provided. The two tear strings 6 are provided opposite each other at approximately the center position of adjacent tensioning bodies 5. The cable outer cover 4 is torn in the longitudinal direction by pulling out the tear strings 6, which allows the fiber optic tape cores 2 to be pulled out. The tear strings 6 are formed, for example, of a plastic material (for example, polyester) that has a high tensile strength.

[0019]

Next, a configuration of the cable outer cover 4 will be described in detail.

The cable outer cover 4 has the concave portions 7 on the surface thereof. The convex portions 8 are provided on the surface of the cable outer cover 4 other than that of the concave portions 7. The concave portions 7 and the convex portions 8 are alternately provided on the surface of the cable outer cover 4 so as to be adjacent in a cross-sectional view of the fiber optic cable 1. In the present example, four each of the concave portion 7 and the convex portion 8 are provided in a cross-sectional view. The four concave portions 7 and convex portions 8 are provided at substantially equal intervals on the surface of the cable outer cover 4 in a cross-sectional view. Note that the number of the concave portion 7 and the convex portion 8 are not limited to four.

[0020]

The concave portions 7 are parts, in a cross-sectional view of the cable outer cover 4, having a smaller fiber optic cable 1 diameter than that of the convex portions 8. The concave portions 7 are provided continuously along the longitudinal direction of the fiber optic cable 1 in a straight line. The convex portions 8 are also provided along the longitudinal direction of the fiber optic cable 1, however, the convex portions 8 may be provided continuously or discontinuously along the longitudinal direction.

In addition, the concave portions 7 and the convex portions 8 may be provided in a straight line or in a spiral along the longitudinal direction of the fiber optic cable 1. The concave portions 7 and the convex portions 8 of the present example are provided continuously along the longitudinal direction of the fiber optic cable 1 in a straight line. The concave portions 7 and the convex portions 8 are, for example, integrally formed by extrusion molding. Note that in the example in FIG. 1, although the convex portions 8 are formed such that an end surface 8a, whose direction is that in

which the convex portions 8 protrude, forms a curved surface of a constant curvature, the invention is not limited thereto. For example, curved surfaces of different curvatures or flat surfaces may also be incorporated. In addition, the concave portions 7 may likewise have a surface other than a curved, arc-shaped surface, for example, curved surfaces of different curvatures or flat surfaces may also be incorporated.

[0021]

A width Wc of the concave portions 7 in the circumferential direction of the cable outer cover 4, and a width Wv of the convex portions 8 in the circumferential direction of the cable outer cover 4 are formed such that the ratio thereof is less than 2-to-1. That is, the width Wc of the concave portions 7 and the width Wv of the convex portions 8 are formed so as to satisfy the relationship: $Wc < 2Wv$.

In addition, the width Wc of the concave portions 7 is formed to be 3 mm or more. The width Wc may be changed, for example, according to an outer diameter of the fiber optic cable 1.

[0022]

In addition, the surface of the cable outer cover 4 has the identification display (marking) 9 for identifying the fiber optic cable 1 applied thereto. The identification display 9 is only applied to the concave portions 7 of the cable outer cover 4. The identification display 9 contains information such as a product name, company name, number of fiber optic cores housed within the fiber optic cable 1, cable length (position), and year of manufacture. A size of the characters, numbers, and the like included in the identification display 9 is, for example 2 mm or more, as far as the size in the vertical direction. The size of the identification display 9 can be varied according to the size of the width Wc of the concave portions 7. The identification display 9 is printed, for example, by spraying ink on the concave portions 7 using an inkjet printer. Alternatively, the identification display 9 is printed by transferring a toner onto the concave portions 7 using a laser printer.

[0023]

In addition, the identification display 9 may be formed, for example, via a hot stamping method in which a stamp is pressed onto the concave portions 7, and characters, numbers, and the like are engraved.

In addition, the identification display 9 may, for example, be a colored band that extends along the surface of the concave portions 7 in the longitudinal direction of the cable. In addition, the colored band may be provided along with the characters, numbers, and the like. The colored band is formed, for example, by simultaneously pressing a material of a different color than that of the outer cover main body part during the pressure extrusion of the cable outer cover 4.

[0024]

In the fiber optic cable 1 described above, the outer diameter of the fiber optic cable 1 is, for example, 16 mm or less when the inner diameter of a micro-duct through which the fiber optic cable 1 is pneumatically fed is 20 mm or less. In addition, for example, when the inner diameter of a micro-duct through which the fiber optic cable 1 is pneumatically fed is 14 mm or less, the outer diameter of the fiber optic cable 1 is 11 mm or less.

[0025]

In addition, it is preferable that a core density obtained by dividing the total number of fiber optic cores constituting the plurality of fiber optic tape cores 2 by the cable cross-sectional area of the fiber optic cable 1 be 5.0 cores/mm^2 or more. For example, when the outer diameter of the fiber optic cable 1 is 10 mm, the thickness of the cable outer cover 4 is 1.0 mm, and the outer diameter of the fiber optic core is 200 μm, if the number of the 12-core fiber optic tape cores 2 housed within the cable outer cover 4 of the fiber optic cable 1 is 36, the total number of fiber optic cores at that time is 432, making for a core density of 5.5 cores/mm^2. In addition, it is preferable that a bending rigidity of

the fiber optic cable 1 in the radial direction be 0.35 $N \cdot m^2$ or more and 1.3 $N \cdot m^2$ or less in the full circumferential direction. In addition, in the case that the tensioning body 5 is formed of four aramid FRP, when, for example, the outer diameter of the fiber optic cable 1 is 10 mm and the thickness of the cable outer cover 4 is 1.0 mm, the outer diameter of the aramid FRP is preferably 0.5 mm or more.
[0026]

As described above, the fiber optic cable 1 according to the present embodiment is provided with the plurality of fiber optic tape cores 2, as well as the cable outer cover 4 that contains these fiber optic tape cores 2 and has the concave portions 7 on the surface. Furthermore, the identification display 9 is applied only to the concave portion 7. According to this configuration, when the fiber optic cable 1 is pneumatically fed, the concave portions 7 do not readily make contact with the inner surface of the duct, which carries little risk of the identification display 9 applied to the concave portions 7 being scraped off by rubbing against the inner surface of the duct. Therefore, the identification display applied 9 to the cable outer cover 4 can maintain a high visibility. In addition, because the surface has an uneven structure due to the provision of the concave portions 7 on the surface of the cable outer cover 4, an area of contact between the fiber optic cable 1 and the inner surface of the duct decreases, and friction between the surface of the cable outer cover 4 and the inner surface of the duct during pneumatic feeding is reduced. As a result, a pneumatic feeding distance when conducting pneumatic feeding of the fiber optic cable 1 within a duct can be extended. In addition, because the identification display 9 is applied only to the concave portions 7 of the surface of the cable outer cover 4, the identification display 9 does not overlap a boundary of the concave portions 7 and the convex portions 8, which allows for favorable visibility of the characters, numbers, and the like included in the identification display 9.
[0027]

In addition, the fiber optic cable 1 has the numbers, characters, and the like of the identification display 9 printed by an inkjet printer or a laser printer, which are generally regarded as having a high printing speed. Thus, the time required for the process of forming the identification display 9 can be shortened, so the manufacturing efficiency of the fiber optic cable 1 can be increased.
[0028]

In addition, the fiber optic cable 1 is formed such that the width Wc of the concave portions 7 on the surface of the cable outer cover 4 is 3 mm or more. As such, the identification display 9 of characters and numbers of 2 mm or more, which in general is readily visible with the naked eye, can be applied to the concave portions 7 of the cable outer cover 4. Therefore, this allows for favorable visibility of the identification display 9 in the fiber optic cable 1.
[0029]

However, when the concave portion 7 width Wc is overly widened, the concave portions 7 come into contact with the inner surface of the duct, which carries the risk of the identification display 9 applied to the concave portions 7 being scraped off. In addition, when the concave portions 7 come into contact with the inner surface of the duct, friction between the surface of the cable outer cover 4 and the inner surface of the duct increases. In contrast, according to the fiber optic cable 1, the ratio between the concave portion 7 width Wc and the convex portion 8 width Wv is formed so as to be smaller than two-to-one. This allows for contact between the concave portions 7 and the inner surface of the duct to be suppressed, and allows for scraping off of the identification display 9 to be suppressed. In addition, because the convex portions 8 can be made to contact the inner surface of the duct, friction between the surface of the cable outer cover 4 and the inner surface of the duct can be suppressed from increasing, and can ensure a sufficiently long pneumatic feeding distance.
[0030]

(Embodiments)

In the fiber optic cable according to the present embodiment, visibility of the identification display as well as pneumatic feeding distance were evaluated for a plurality of samples in which the ratio of the concave portion width to the convex portion width was different. The evaluation results are shown in Table 1.

[0031]

[Table 1]

Table 1

Sample No.	1	2	3	4	5	6	7
Concave portion width (convex portion width) [mm]	2.5 (5.3)	3.0 (4.8)	3.5 (4.3)	4.0 (3.8)	4.5 (3.3)	5.0 (2.8)	5.5 (2.3)
Visibility of identification display	B	A	A	A	A	A	A
Pneumatic feeding distance [m]	A	A	A	A	A	A	B

[0032]

In Table 1, the outer diameter of the fiber optic cable is 10 mm. The number of concave portions (convex portions) of the cable outer cover was the same as the number of concave portions (convex portions) of the fiber optic cable 1 illustrated in FIG. 1, which was four. The identification display of the cable outer cover had 2 mm characters and numbers printed on the concave portions using an ink jet printer.

[0033]

The visibility of the identification display in terms of whether the printed characters and numbers were visible, and whether such might be identified as other characters and numbers (for example, whether a printed number could be identified as an “8” or a “0”) was determined visually.

For the pneumatic feeding distance, a micro duct pneumatic feeding test in compliance with IEC was performed using the pneumatic feeding device illustrated in FIG. 2. A pipe 20 was 1,000 m long and was folded back every 100 m. Bending (R) of the pipe 20 was 40 times the outer diameter of the pipe, and the inner diameter of the pipe 20 was 14 mm. An opening 21 is a entry feed port for air and a fiber optic cable, and an opening 22 is an exit feed port for air and a fiber optic cable. The air pressure was 1.3 MPa to 1.5 MPa.

[0034]

Evaluation of the visibility of the identification display was as such: those for which visibility was favorable were given an evaluation A, those which were visible were given an evaluation B, and those for which visibility was difficult were given an evaluation C.

For evaluation of the pneumatic feeding distance, those for which the pneumatic feeding distance was 1,000 m or more were given an evaluation A, those for which the pneumatic feeding distance was 600 m or more and less than 1,000 m were given an evaluation B, and those for which the pneumatic feeding distance was less than 600 m were given an evaluation C.

[0035]

According to the evaluation results in Table 1, the samples having favorable visibility in the visibility of the identification display (evaluation A samples) were nos. 2 to 7. In addition, the sample which was visible (evaluation B sample) was no. 1. Thereby, it was understood that when the concave portion width was 3 mm or more, visibility of the identification display was favorable. Meanwhile, it was understood that when the concave portion width was 2.5 mm, although printing of 2 mm

characters and the like within the concave portions was possible, the identification display overlapped a boundary of the concave portion and the convex portion due to variations in manufacturing. Thus in this case, despite being visible, visibility could not be said to be favorable.

[0036]

In addition, the samples for which the pneumatic feeding distance was 1,000 m or more (evaluation A samples) were nos. 1 to 6. In addition, the sample for which the pneumatic feeding distance was 600 m or more and less than 1,000 m (evaluation B sample) was no. 7. Accordingly, it was understood that when the ratio of the concave portion width to the convex portion width is less than 2-to-1 in the fiber optic cable, the pneumatic feeding distance is favorable.

[0037]

So far, the present invention has been described in detail with reference to specific embodiments, but it is clear to a person skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the present invention. Furthermore, the number, position, shape, and the like of the constituent members described above are not limited to the embodiments described above, and the number, position, shape, and the like can be changed as appropriate in implementing the present invention.

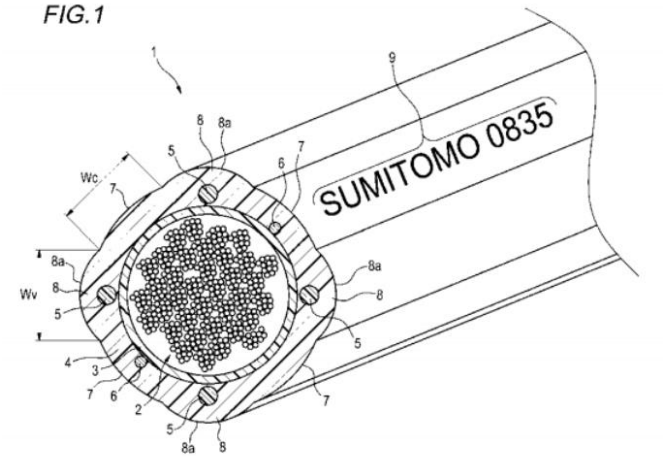
[Description of Reference Numerals]

[0038]

1: Fiber optic cable
2: Fiber optic tape core
3: Water absorption tape
4: Cable outer cover
5: Tensioning body
6: Tear string
7: Concave portion
8: Convex portion
8a: End surface
9: Identification display
20: Pipe
21, 22: Opening
Wc: Concave portion width
Wv: Convex portion width

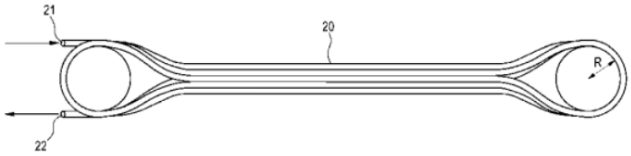
[FIG. 1]

FIG.1



[FIG. 2]

FIG.2



CERTIFICATE OF TRANSLATION

I, Nicholas Abraham, hereby certify that the document identified below, translated from Japanese into English, is true and accurate to the best of my knowledge and belief.

Reference: JP 2021-18338 A 2021.2.15

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Nicholas Abraham

Signature

Nicholas Abraham

Printed Name

State of Florida, County of Palm Beach

Sworn to before me this

31 day of October, 2024 by Nicholas Troy Abraham.

He/She/They is/are __ Personally Known OR _X_ Produced _DRIVER'S LICENSE, as identification.

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