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(54) **APPARATUS AND METHOD FOR DRAWING METAL TUBE**

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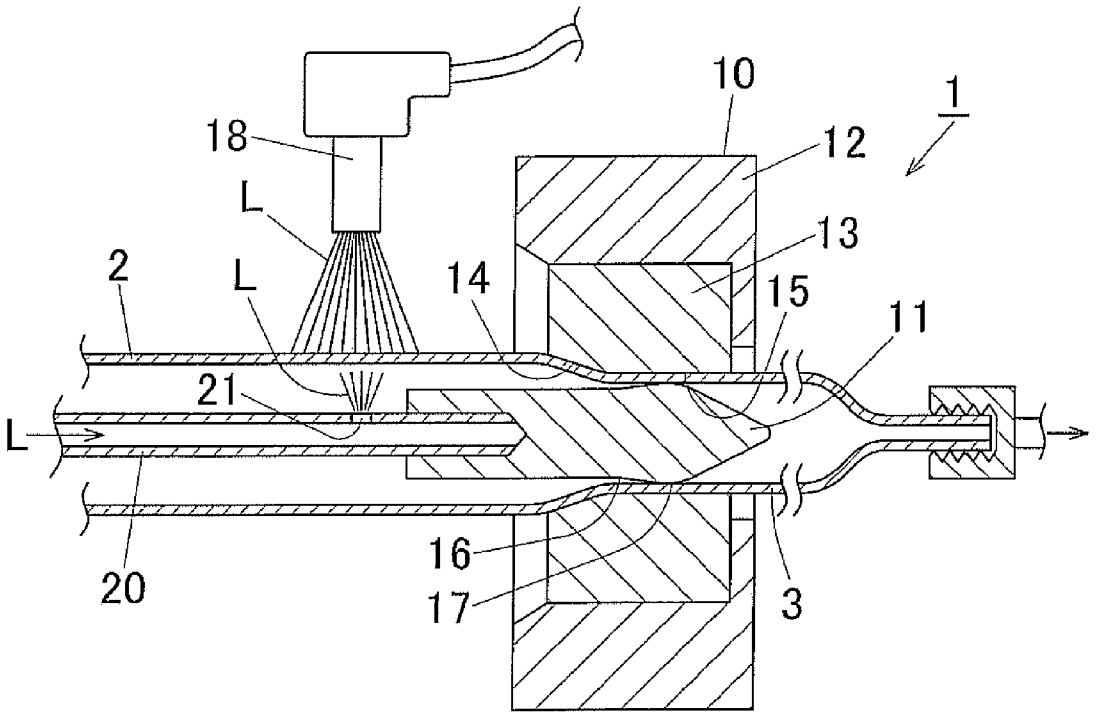
(57) **ABSTRACT**

In an apparatus for drawing a metal tube in which lubrication oil is ejected from an ejecting opening formed in a hollow rod supporting a plug to apply the lubrication oil onto an inner surface of a raw tube, the lubrication oil ejection responsiveness when a discontinuous lubrication oil supply is performed is enhanced. In the drawing apparatus in which a metal raw tube (**2**) is processed by passing the same between a die (**10**) for forming an outer surface and a plug (**11**) for forming an inner surface, an ejecting opening (**21**) from which lubrication oil (L) is ejected opens into an outer peripheral surface of a hollow rod (**20**) supporting the plug (**11**). The ejecting opening (**21**) is provided only in a region of the rod (**20**) higher than the center thereof in the up-and-down direction.



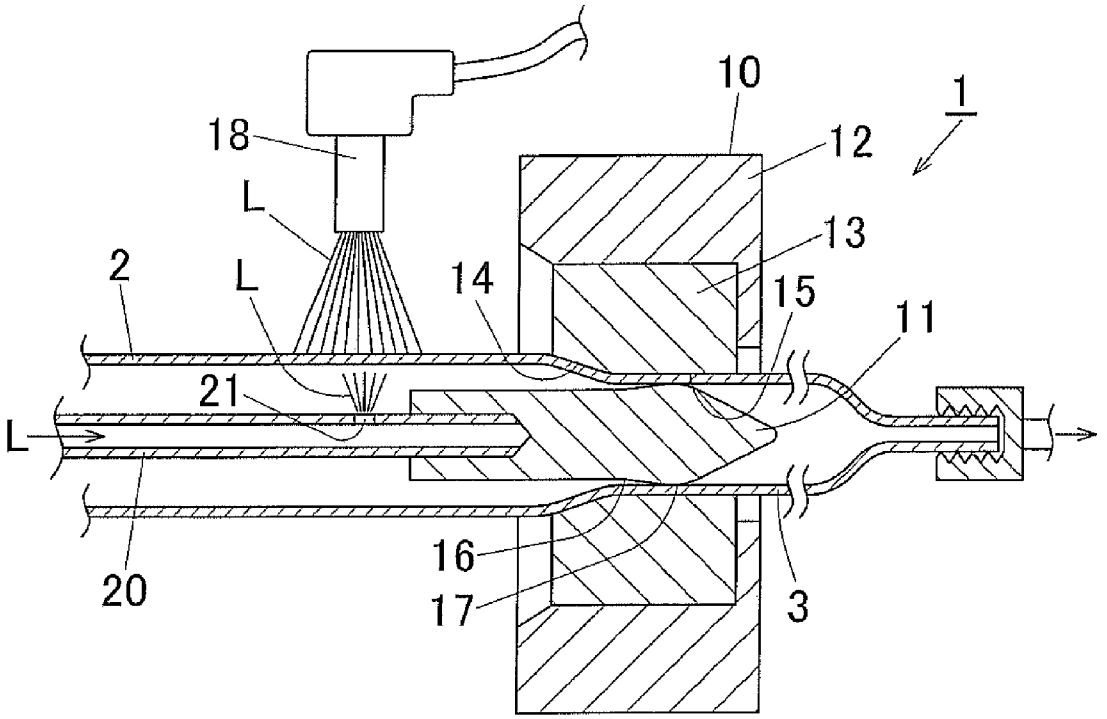


FIG.1

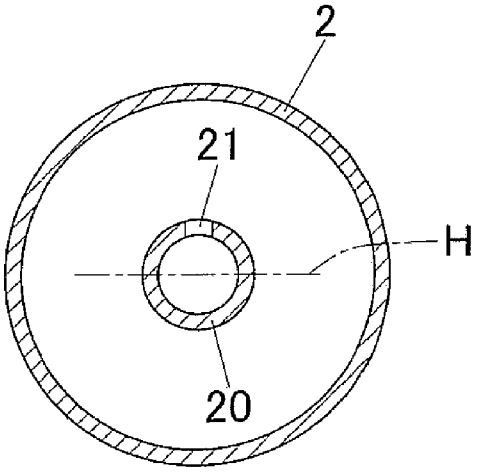


FIG.2

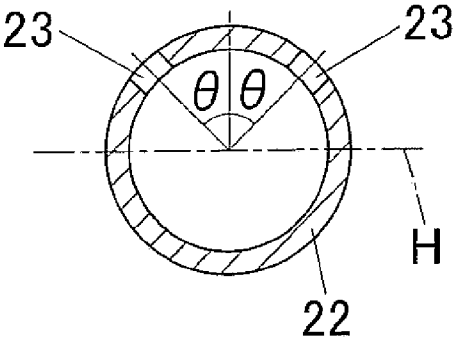


FIG.3

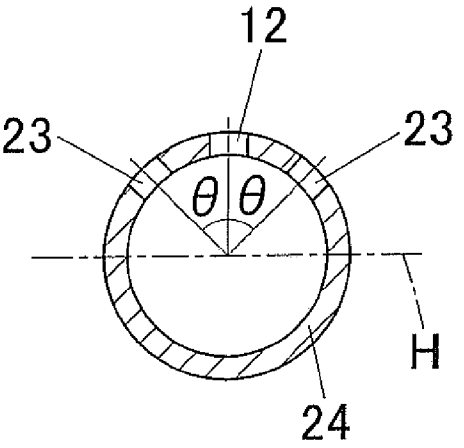


FIG.4

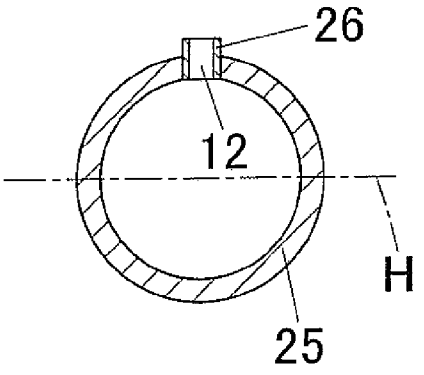


FIG.5

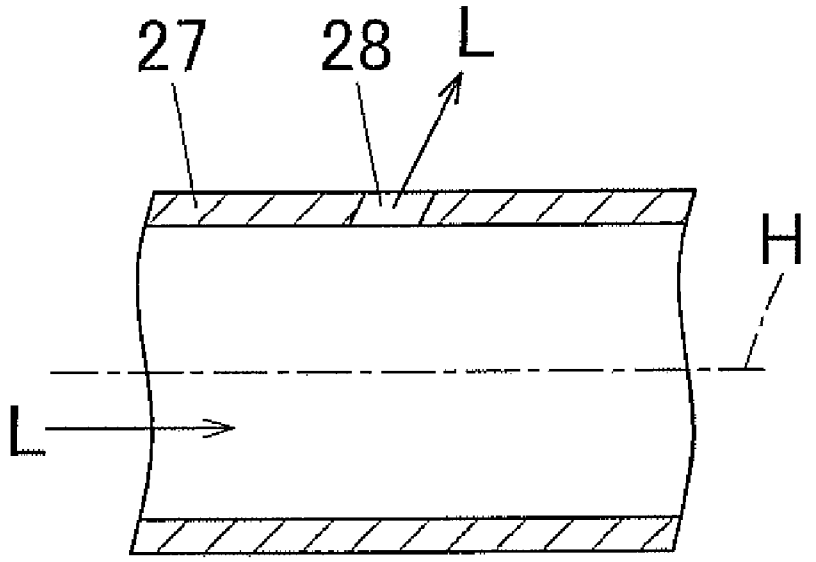


FIG.6

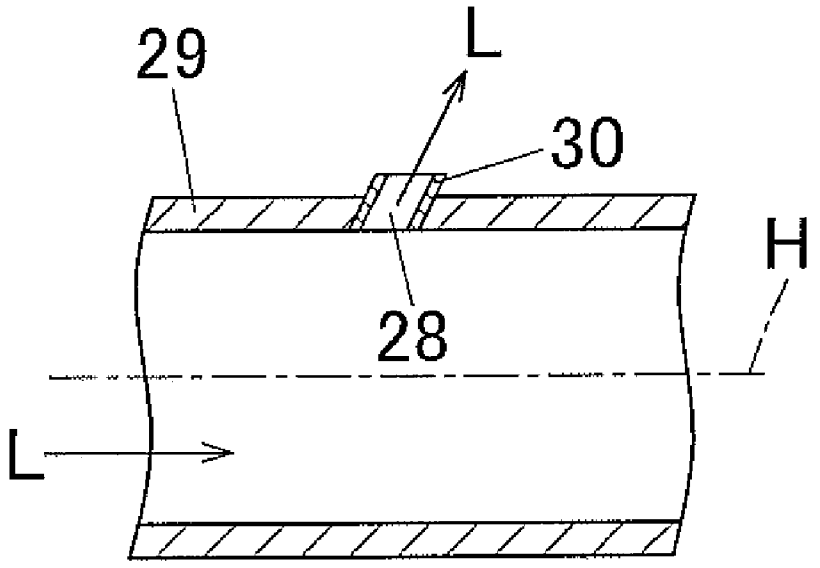


FIG.7

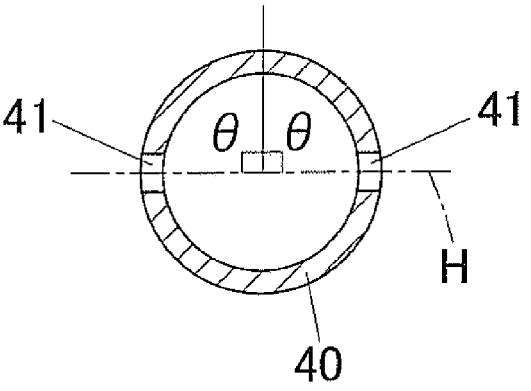


FIG.8

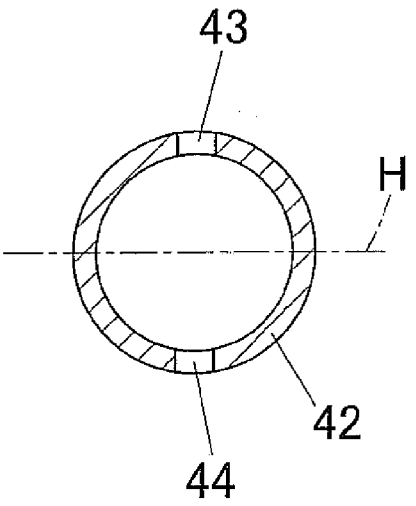


FIG.9

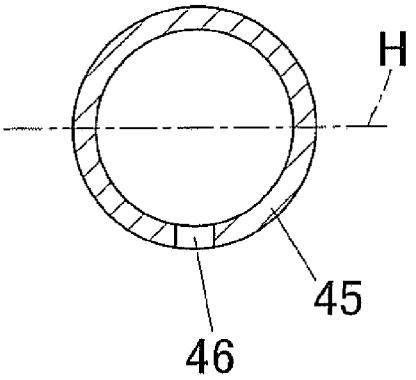


FIG.10

APPARATUS AND METHOD FOR DRAWING METAL TUBE

TECHNICAL FIELD

[0001] The present invention relates to an apparatus for drawing a metal tube capable of producing a dawn tube excellent in dimensional accuracy, which can be preferably used as an OPC photoconductive drum substrate for electro-photographic apparatus, such as, e.g., copying machines, laser beam printers, and facsimile apparatus, and also relates to a drawing method using the apparatus for drawing a metal tube. In the description of this specification, the wording "rear/rearward" used with reference to a drawing apparatus and a drawing method denotes a direction toward a raw tube with respect to a drawn tube, and "front/frontward" denotes a direction toward a drawn tube with respect to a raw tube.

BACKGROUND TECHNIQUE

[0002] In recent years, as an OPC photoconductive drum substrate for electro-photographic apparatus, such as, e.g., copying machines, laserbeam printers, or facsimile machines, a non-cut tube suitable for mass production has been widely used. One of such non-cut tubes is a so-called ED tube obtained by drawing an aluminum extruded raw tube, which is suitable for mass production in that a plurality of product tubes can be manufactured by a single drawing process. The production method is now getting an attention as a production method which complies with mass consumption accompanied by market expansion.

[0003] Such ED tube is produced by initially obtaining an aluminum extruded raw tube by extruding an aluminum billet, and then cutting the extruded raw tube into a predetermined length. Thereafter, the cut tube is subjected to one pass or two or more passes of drawing processing using a die and a plug to obtain an aluminum tube having a predetermined configuration (i.e., predetermined outer diameter, inner diameter, wall thickness), and further subjected to a cutting process, a chamfering process for chamfering an end portion, a washing process, and an inspection process for inspecting dimensions and appearance to thereby obtain an ED tube.

[0004] In such a drawing process for an aluminum tube for a photoconductive drum substrate, supplying lubrication oil onto an outer surface of a tube can be easily performed by previously applying lubrication oil on the outer surface or supplying lubrication oil so as to flow down on the outer surface during the drawing process. However, when supplying lubrication oil onto an inner surface of a tube, especially in the case of an ED tube in which a raw tube is subjected to two or more passes of continuous drawing processes at a high speed, it was difficult to previously supply lubrication oil onto an inner surface of a tube. For this reason, there was no choice but to perform a drawing process in a state in which a plug with lubrication oil applied thereon is inserted in a tube. In contrast to an outer surface of a tube to which lubrication oil can be supplied as needed, in the case of an inner surface, lubrication oil may sometimes become insufficient during the drawing process, resulting in burning of the inner surface, which deteriorates the run-out accuracy of the drawn tube.

[0005] To cope with such a problem, the present applicant has proposed a drawing apparatus capable of supplying lubrication oil onto an inner surface of a raw tube as needed in which an opening is formed in a peripheral wall of a hollow rod supporting a plug to discharge the lubrication oil supplied into the inner space of the hollow rod from the rear end portion thereof. In such a drawing apparatus, in order to evenly spread the lubrication oil adhering the inner surface of the tube of the plug, a core is attached to the rod (see Patent Documents 1 and 2).

PRIOR ART

Patent Document

[0006] Patent Document 1: Unexamined Laid-open Japanese Patent Application Publication No. 2009-22982 (JP-A-2009-22982)

[0007] Patent Document 2: Unexamined Laid-open Japanese Patent Application Publication No. 2009-45663 (JP-A-2009-45663)

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0008] According to the step for sequentially drawing a plurality of extruded raw tubes using the aforementioned drawing apparatus, after completion of a drawing process of a single extruded raw tube, the drawn tube is taken out from the apparatus while suspending the supply of lubrication oil, and then a subsequent extruded raw tube is set to the apparatus and supplying of lubrication oil is resumed at the time of initiating the subsequent drawing process. According to such a step in which lubrication oil is supplied discontinuously, suspending the supply of lubrication oil causes outflow of the lubrication oil accumulated in the rod through the opening. Furthermore, since the inner space of the rod is not filled with lubrication oil, even if lubrication oil supply is resumed, it takes a time until a certain amount of lubrication oil is ejected from the opening formed in the vicinity of the plug, resulting in poor responsiveness of lubrication oil ejection. For this reason, if a drawing process is performed in a state in which lubrication oil is not sufficiently ejected, burning may occur at the drawing initiation portion. If a drawing process is performed after waiting for recovery of ejection amount, the processing efficiency deteriorates.

Means for Solving the Problems

[0009] In view of the aforementioned technical background, the present invention aims to enhance the responsiveness of lubrication oil ejection in the case of discontinuously supplying lubrication oil in a drawing apparatus for a metal tube in which lubrication oil is ejected through an opening formed in a hollow rod supporting a plug to adhere the lubrication oil to an inner surface of a raw tube.

[0010] A drawing apparatus and a drawing method according to the present invention have the following structure [1] to [10].

[0011] [1] A drawing apparatus for a metal tube for processing a metal raw tube bypassing a metal raw tube between a die for forming an outer surface and a plug for forming an inner surface, characterized in that an ejecting opening for ejecting lubrication oil opens into an outer peripheral surface of a hollow rod supporting the plug, wherein the ejecting opening is provided only at a region above a center of the rod in an up-and-down direction.

[0012] [2] The drawing apparatus for a metal tube as recited in the aforementioned item **1**, wherein a distance between the ejecting opening and a bearing portion of the plug in a drawing direction is 20 cm or less.

[0013] [3] The drawing apparatus for a metal tube as recited in the aforementioned item **1**, wherein a nozzle protruded from the outer peripheral surface of the rod is provided at the ejecting opening.

[0014] [4] The drawing apparatus for a metal tube as recited in the aforementioned item **2**, wherein a nozzle protruded from the outer peripheral surface of the rod is provided at the ejecting opening.

[0015] [5] The drawing apparatus for a metal tube as recited in the aforementioned item **1**, wherein the ejecting opening opens toward a front side of the apparatus.

[0016] [6] The drawing apparatus for a metal tube as recited in the aforementioned item **2**, wherein the ejecting opening opens toward a front side of the apparatus.

[0017] [7] The drawing apparatus for a metal tube as recited in the aforementioned item **3**, wherein the ejecting opening opens toward a front side of the apparatus.

[0018] [8] The drawing apparatus for a metal tube as recited in the aforementioned item **4**, wherein the ejecting opening opens toward a front side of the apparatus.

[0019] [9] The drawing apparatus for a metal tube as recited in one of the aforementioned items **1** to **8**, wherein the ejecting opening is provided within an angle range of 60° or less from an apex of the rod with respect a center of the rod.

[0020] [10] A drawing method for a metal tube for sequentially drawing a plurality of metal raw tubes by repeating the following steps (i) to (v) using the drawing apparatus as recited in any one of the aforementioned items **1** to **9**:

[0021] (i) a step of drawing a raw tube while supplying lubrication oil onto an inner surface of the raw tube by ejecting the lubrication oil supplied to an inside of a hollow rod supporting a plug;

[0022] (ii) a step of suspending supply of the lubrication oil after completion of drawing the raw tube;

[0023] (iii) a step of taking out the drawn tube from the drawing apparatus and setting a subsequent raw tube to the drawing apparatus;

[0024] (iv) a step of resuming supply of the lubrication oil; and

[0025] (v) a step of returning to the step (i).

Effects of the Invention

[0026] According to the invention as recited in the aforementioned item[1], since the ejecting opening for lubrication oil is provided only within an upper region of the rod, even when supply of lubrication oil is suspended, the lubrication oil filled within a rod does not flow out through the election opening. Even if the lubrication oil flows out, the flow amount is insignificant. During the suspension of the supply of lubrication oil, the inside of the rod is in a state in which the inside is completely or almost filled with lubrication oil. For this reason, even if the supply of lubrication oil is suspended after completion of a drawing process of one raw tube until the drawn tube is taken out and a subsequent raw tube is set to the apparatus, the inside of the rod is filled, or almost filled, with lubrication oil. Therefore, it is possible to cause ejection of lubrication oil immediately, or within a very short period of time, after resuming the supply of lubrication oil. Thus, in performing a sequential drawing process of a plurality of raw tubes in which intermittent lubrication oil supply is performed, or lubrication oil supply is suspended at the time of replacing a raw tube with a subsequent one, it becomes possible to cause assured adherence of lubrication oil from the initiation of the drawing process for each raw tube, which in turn can prevent burning. Furthermore, since it is not required to wait for recovery of the ejection amount after resuming the supply of lubrication oil, the processing can be performed efficiently.

[0027] According to the invention as recited in the aforementioned item [2], since the distance from the lubrication oil ejection position to the bearing portion of the plug is short, it becomes possible to adhere lubrication oil assuredly to the upper region of the raw tube in which lubrication oil tends to become insufficient.

[0028] According to the invention as recited in the aforementioned items [3] and [4], since the nozzle is protruded from the outer peripheral surface of the rod, the ejection position of lubrication oil can be approached to the raw tube. Therefore, even in cases where an inner diameter of the raw tube is large with respect to an outer diameter of the rod, or the ejection amount of lubrication oil is relatively small, it becomes possible to adhere lubrication oil to a predetermined position. Furthermore, the nozzle functions as a dam at the time of resuming the supply of lubrication oil, which prevents an outflow of the lubrication oil from the ejecting opening provided at a position other than the apex of the rod.

[0029] According to the invention as recited in the aforementioned items [5], [6], [7], and [8], lubrication oil can be sprayed forward than the position of the ejecting opening, and the distance from the sprayed position of lubrication oil to the bearing portion of the plug becomes short. This enables assured adhesion of lubrication oil at the upper region of the raw tube where lubrication oil tends to become insufficient at the bearing portion.

[0030] According to the invention as recited in the aforementioned item [9], the amount of lubrication oil flowing out of the ejecting opening during the suspension of supplying lubrication oil is small, and therefore the response sensitivity at the time of resuming supply of lubrication oil is excellent.

[0031] According to the invention as recited in the aforementioned item [10], since the drawing apparatus as recited in any one of the aforementioned items [1] to [9] is used, in a sequential drawing process for a plurality of raw tubes, when lubrication oil is discontinuously supplied for replacing raw tubes, it becomes possible to cause assured adhesion of lubrication oil from the initiation of drawing each raw tube to prevent occurrence of burning. Furthermore, since it is not required to wait for recovery of the ejection amount after resuming the supply of lubrication oil, a plurality of raw tubes can be processed efficiently.

BRIEF EXPLANATION OF THE DRAWINGS

[0032] FIG. **1** is a vertical cross-sectional view showing an example of a drawing apparatus for carrying out a drawing method for a metal tube according to the present invention.

[0033] FIG. **2** is a cross-sectional view of a raw tube and a rod in a drawing apparatus shown in FIG. **1**.

[0034] FIG. **3** is a cross-sectional view showing another embodiment of a rod of a drawing apparatus according to the present invention.

[0035] FIG. **4** is a cross-sectional view showing a still another embodiment of a rod of a drawing apparatus according to the present invention.

[0036] FIG. **5** is a cross-sectional view showing a still yet another embodiment of a rod of a drawing apparatus according to the present invention.

[0037] FIG. **6** is a cross-sectional view showing a still yet another embodiment of a rod of a drawing apparatus according to the present invention.

[0038] FIG. **7** is a cross-sectional view showing still yet another embodiment of a rod of a drawing apparatus according to the present invention.

[0039] FIG. **8** is a cross-sectional view showing a rod of Comparative Example 1 used in a drawing test.

[0040] FIG. **9** is a cross-sectional view showing a rod of Comparative Example 2 used in a drawing test.

[0041] FIG. **10** is a cross-sectional view of a rod of Comparative Example 3 used in a drawing test.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0042] FIG. **1** shows an example of a drawing apparatus for carrying out a drawing method for a metal tube according to the present invention. This drawing apparatus **1** is equipped with a drawing tool and a lubrication oil supplying portion for supplying lubrication oil onto an outer surface and an inner surface of a raw tube **2**.

[0043] The drawing apparatus includes a drawing die **10** and a plug **11**. The drawing die **10** is provided with a die main body **13** fitted in a die case **12**. The die main body **13** has an approach portion **14** formed around a center die hole and a bearing portion **15** continued from the approach portion. The plug **11** is attached to a tip end of a rod **20** formed by a hollow tube and supported by the tube, and has an approach portion **16** and a bearing portion **17** continued from the approach portion **16**. By drawing a raw tube **2** by passing through between the drawing die **10** and the plug **11**, an outer surface of the tube is formed by the bearing portion **15** of the die main body **13** and an inner surface thereof is formed by the bearing portion **17** of the plug **11**. Thus, a drawn tube **3** is produced.

[0044] As a lubrication oil supplying portion for supplying lubrication oil onto an outer surface of a raw tube, a nozzle **18** is arranged above the raw tube and rearward of the drawing die **10**. The lubrication oil L supplied from a tank (not illustrated) is ejected from the nozzle **18** toward the raw tube **2**, and the lubrication oil L adhered to the upper portion of the raw tube **2** travels on the outer surface of the raw tube to be supplied to the entire surface of the raw tube. The excessive lubrication oil L runs down. The raw tube **2** is introduced into the drawing tool with the lubrication oil L adhering to the outer surface of the raw tube.

[0045] As a lubrication oil supplying portion for supplying lubrication oil onto an inner surface of a raw tube, a lubrication oil ejecting opening **21** is formed in the rod **20**. The rod **20** is a hollow tube and is utilized as a supplying passage for lubrication oil L. By drilling the peripheral wall of the tube, an ejecting opening **21** communicating with the supplying passage is formed. In this embodiment, a single ejecting opening **21** is formed at the apex (i.e., the highest position in the up-and-down direction) of the rod **20** so as to face straight upward. The lubrication oil L introduced into the inner space of the rod **20** via the rear portion thereof from a tank (not illustrated) is sprayed onto the inner upper wall surface of the raw tube **2** to be adhered thereto, and then travels on the wall surface to be spread in the peripheral direction. When the raw tube **2** is drawn while supplying the lubrication oil L onto the inner surface of the raw tube **2**, the raw tube **2** is introduced into the drawing tool with the lubrication oil L adhering to the entire inner surface of the raw tube. Continuously ejecting the lubrication oil L from the ejecting opening **21** during the drawing process enables adhesion of lubrication oil L by a required amount regardless of the length of the raw tube **2**.

[0046] In the case of sequentially drawing a plurality of raw tubes **2** with the drawing apparatus **1**, the drawing process and the lubrication oil supply to the inner surface of the raw tube are performed by repeating the following steps:

[0047] (i): a step of drawing the raw tube **2** while spraying lubrication oil L onto the inner surface of the raw tube **2** by supplying the lubrication oil L into the rod L;

[0048] (ii): a step of suspending the supply of lubrication oil L after completion of the drawing process for the single raw tube **2**;

[0049] (iii): a step of taking out the drawn tube from the drawing apparatus **1** and setting a subsequent raw tube to the drawing apparatus;

[0050] (iv): a step of resuming supply of lubrication oil L;

[0051] (v): a step of supplying lubrication oil L until an ejection amount becomes stable;

[0052] (vi): a step of returning to Step (i).

[0053] During the drawing step (i), lubrication oil L is continuously supplied, and therefore the inner side of the rod **20** is filled with lubrication oil L. At Step (ii), when the supply of lubrication oil L is suspended, the lubrication oil L in the rod **20** flows out until the liquid level goes down to the height of the ejecting opening **21**. For example, in the case of the rod **20** shown in FIGS. **1** and **2**, since the ejecting opening **21** is formed at the apex, the lubrication oil L will not flow out. However, in the case of the rod **22** shown in FIG. **3**, since the ejecting opening **23** of the rod is formed at a position lower than the apex, the lubrication oil L flows out until the liquid level goes down to the height of the ejecting opening **23**. Further, like the rods **40**, **42**, and **45** shown in FIGS. **8** to **10**, as the position of the ejecting opening **41**, **44** and **46** become lower, the discharge amount increases. Even if the supply of lubrication oil L is resumed at Step (iv), lubrication oil will not be ejected until the discharged amount is compensated. When the inside of the rod **22** is filled with lubrication oil L via Step (v), ejection of lubrication oil L will be resumed. After establishing the stable ejection of lubrication oil, the step proceeds to Step (vi). Step (v) is a waiting time for waiting for the recovery of the discharged amount by compensating the discharged lubrication oil. As the discharged amount becomes smaller, the waiting time can be shortened and the lubrication oil ejection responsiveness improves. If drawing of the subsequent raw tube **2** is executed by omitting Step (v), lubrication oil shortage occurs at the drawing initiation portion of the raw tube.

[0054] In the present invention, the ejecting opening should be provided only at the region above the center of the rod in the up-and-down direction, and should not be provided at the region equal to or below the center of the rod. By providing the ejecting opening only at the region above the center, the discharged amount of the lubrication oil to be discharged during the period of suspending the supply of lubrication oil can be reduced to assuredly supply lubrication oil to the inner surface of the raw tube from the initiation of the drawing, and that the waiting time can be reduced as much as possible to thereby shorten the time required for continuously drawing a plurality of raw tubes.

[0055] The number and/or position of the ejecting opening is not limited as long as the ejecting opening is provided only at the region above the center of the rod in the up-and-down direction. The present invention covers the cases in which a

plurality of ejecting openings are formed so as to extend in the peripheral direction or in the drawing direction.

[0056] In the cross-sectional views of various rods shown in FIGS. **2** to **7**, "H" denotes a horizontal plane passing through the center of each of the rods **20**, **22**, **24**, **25**, and **29**. The region of the rod above the horizontal plane His a region in which an electing opening can be formed. If it is within this region, the number and position of the ejecting opening can be arbitrarily set. In the present invention, the position of the ejecting opening in the circumference direction is defined by an angle θ from the apex of the rod with respect to the center of the rod. In the present invention, the condition of the angle θ is 0<90° (degree), and if it is within this range, the angle can be arbitrarily set depending on the inner diameter of the raw tube, the spraying area from the ejecting opening, the ejection amount, etc.

[0057] FIGS. **1** and **2** show an example in which a single ejecting opening **21** is provided at a position of 0=0° (degree).

[0058] FIG. **3** shows an example of a rod **22** in which two ejecting openings **23** and **23** are provided at positions downwardly apart from the apex in the circumference direction, or positions satisfying 0°<θ<90°. For the purpose of reducing the amount of lubrication oil flowing out of the ejecting opening **23** during the suspension of lubrication oil supply, it is preferable to provide the ejecting opening **23** so that the angle θ falls within the range of 60° (including 60°), more preferably within the range below 40° (including 40°) because of the following reasons. As the angle θ becomes larger, the position of the ejecting opening **23** becomes lower, increasing the flow amount of the lubrication oil during the suspension of lubrication oil supply, which in turn deteriorates the responsiveness at the time of resuming the supply of lubrication oil.

[0059] Further, lubrication oil sprayed onto the inner surface of the raw tube **2** would not flow to a portion higher than the position to which the lubrication oil was sprayed. Therefore, in the case of spraying lubrication oil obliquely upward in the rod **22** shown in FIG. **3**, shortage of lubrication oil might occur at the portion of the raw tube immediately above the rod **22** or the vicinity thereof. Such a problem can be easily solved by adding an ejecting opening at the apex of the rod or the vicinity thereof. The rod **24** shown in FIG. **4** is an example in which ejecting openings are provided by adding the ejecting opening **21** (arranged at the position of θ=0° shown FIG. **2** to two ejecting openings **23** and **23** (arranged at the position of 0°<θ<90° shown FIG. **3**.

[0060] Further, as shown in FIG. **5**, it is also preferable to attach a nozzle **26** to the periphery of an ejecting opening **21** formed in a peripheral wall of the rod **25** so as to protrude from the outer peripheral surface of the rod **25**. Providing the nozzle **26** results in a closer election position of the lubrication oil with respect to the raw tube **2**. Therefore, even in cases where the inner diameter of the raw tube **2** is large with respect to the diameter of the rod **25** and/or the ejection amount of lubrication oil is small, it becomes possible to assuredly adhere lubrication oil to a predetermined position. Furthermore, the nozzle **26** functions as a dam during the suspension of lubrication oil supply, which prevents the lubrication oil from flowing out of the ejecting opening provided at a position other than the position of 0=0°.

[0061] Further, it is preferable that the ejecting opening is provided at a position closer to the bearing portion of the plug in a drawing direction. Since the ejecting opening **21** is provided at the upper region of the rod **20**, lubrication oil L is sprayed to the upper region of the raw tube **2** to be adhered, and flows downward during which the raw tube **2** is moved from the position of the ejecting opening **21** to the position of the bearing portion **17** of the plug **11**. The lubrication oil L, except for the lubrication oil drawn together with the drawn tube **3**, is sequentially moved rearward of the raw tube **2** and downward, which easily causes occurrence of lubrication oil shortage at the upper region of the raw tube **2**. By approaching the position of the ejecting opening **21** to the bearing portion **17** with respect to the flow of lubrication oil L to thereby shorten the distance from the position of spraying lubrication oil L to the bearing portion **17**, it becomes possible to assuredly adhere lubrication oil L to the upper region of the bearing portion **17** where shortage of lubrication oil L tends to occur and efficiently adhere lubrication oil L to the inner surface of the raw tube **2**. From this point of view, it is preferable to provide the ejecting opening **21** at a position within 20 cm (including 20 cm) from the bearing portion **17**, more preferably within 10 cm (including 10 cm) from the bearing portion **17**. In the structure in which the tip end portion of the rod **20** is inserted into and secured to the plug **11** as shown in FIG. **1**, it should be noted that the present invention covers the case in which the ejecting opening is provided at a portion where the tip end portion of the rod **20** and the plug **11** are overlapped.

[0062] Furthermore, it is also preferable to eject lubrication oil from the ejecting opening toward the front side. As mentioned above, although the spraying position can be approached to the bearing portion **17** by providing the ejecting opening **21** at the location near the bearing portion **17**, the spraying position can be further approached to the bearing portion by ejecting lubrication oil toward the front side from the position where the ejecting opening is provided. As a means for setting the ejection direction of lubrication oil, the structures shown in FIGS. **6** and **7** can be exemplified. In the rod **27** shown in FIG. **6**, the peripheral wall is drilled obliquely so that the ejecting opening **28** faces toward the front side. In the rod **29** shown in FIG. **7**, the nozzle **30** is attached to the ejecting opening **28** formed in the peripheral wall of the rod so as to face toward the front side.

[0063] Supply of lubrication oil to the outer surface of the raw tube can be performed by any well-known method, such as a method in which the aforementioned lubrication oil ejecting opening **18** is provided rearward of the drawing apparatus. It is not always required to supply lubrication oil while drawing the raw tube, and it can be accepted to previously apply lubrication oil on the entire outer surface of the raw tube before conducting the drawing process.

[0064] With respect to the outer surface, there is no positional limitation like in the inner surface. Therefore, lubrication oil can be supplied either during or before the drawing process, and therefore drawing can be performed without causing lubrication oil shortage.

[0065] In supplying lubrication oil onto the inner surface of the metal raw tube in the drawing apparatus according to the present invention, since the ejecting opening of lubrication oil is provided only at the upper region of the rod, even if lubrication oil supply is suspended, the lubrication oil filled in the rod would not flow out through the ejecting opening or the amount of lubrication oil is little even if it flows out. In other words, even during the suspension of lubrication oil supply, the inner side of the rod is filled with or almost filled with the lubrication oil. For this reason, at the step of continuously drawing a plurality of raw tubes, after completion of drawing a single raw tube, even if lubrication oil supply is suspended

after taking out the drawn tube from the drawing apparatus until setting a subsequent raw tube to the drawing apparatus, the inside of the rod is filled with or almost filled with lubrication oil. Therefore, when lubrication oil supply is resumed, it is possible to eject lubrication oil from the ejecting opening immediately or in a very short time. In other words, when resuming the lubrication oil supply, it is extremely excellent in responsiveness until lubrication oil ejection is resumed to the level before suspension of lubrication oil supply. Therefore, in a sequential drawing process of a plurality of raw tubes, when discontinuous lubrication oil supply in which lubrication oil supply is suspended at the time of changing raw tubes is performed, assured adhesion of lubrication oil from the initiation of drawing of each raw tube can be attained to prevent occurrence of burning. Furthermore, it is not necessary to wait for the recovery of the ejection amount after resuming lubrication oil supply, which enables efficient processing of a plurality of raw tubes.

[0066] The present invention does not limit a length of a raw tube. In the case of a short raw tube, the lubrication of the inner surface of the raw tube can be secured even by applying lubrication oil to a plug before the drawing processing. Therefore, in the case of drawing a long tube, remarkable effects can be exerted. Thus, the present invention is suitably used in the case of drawing a long raw tube. Specifically, when a raw tube is 2 m or longer, more preferably 2.5 m or longer, remarkable effects can be expected.

[0067] The drawing method of a metal tube according to the present invention is not limited by a type of metal, and can be widely applied to a method for drawing a raw tube of, e.g., aluminum, iron, copper or alloys thereof. Remarkable effects can be exerted when drawing a long raw tube, and therefore the drawing method of the present invention is suitable for manufacturing an aluminum tube for a photoconductive drum substrate. In manufacturing an aluminum tube for a photoconductive drum substrate, there is a tendency to use a long raw tube to manufacture a number of product tubes by a single drawing process. Therefore, by applying the drawing method of the present invention, high quality aluminum tubes small in deflection can be manufactured efficiently. Furthermore, even in the case of performing a continuous drawing of two or more passes in which a raw tube is drawn twice or more for the purpose of enhancing the dimensional precision, it is not required to perform any operation for supplying lubrication oil between passes, resulting in quick continuous drawing. Furthermore, as a material of an aluminum tube for use in photoconductive drum substrates, Al—Mn series alloy, Al—Mg series alloy, Al—Mg—Si series alloy, and pure aluminum can be exemplified.

EXAMPLES

[0068] Using the drawing apparatus **1** shown in FIG. **1**, drawing tests were performed while changing positions of the ejecting openings for lubrication oil in the rod. Used in the tests were rods **20**, **22**, **24**, **25**, **29**, **40**, **42** and **45** shown FIGS. **2-5**, and **7-10**.

[0069] In the drawing apparatus **1**, in the die main body **13** of the drawing die **10**, the approach angle of the approach portion **14** was 15°, and the bearing length of the bearing portion **15** was 15 mm. The approach angle of the approach portion **16** of the plug **11** was 7°, and the bearing length of the bearing portion was 2 mm.

[0070] In the drawing apparatus **1**, a nozzle **18** as a common lubrication oil supplying portion for supplying lubrication oil to an outer surface was arranged rearward of the drawing die **10** on the upper side of the raw tube. During the drawing processing, lubrication oil L supplied to a tank (not illustrated) was ejected from the nozzle **18** to be supplied to the upper surface side of the raw tube **2** and then to the entire periphery of the raw tube **2** while being travelled on the outer surface of the raw tube.

[0071] Supply of lubrication oil onto the inner surface of the raw tube **2** was performed by ejecting lubrication oil L introduced into the inside of the rod from the rear end thereof from each ejecting opening to be sprayed onto the inner surface of the raw tube **2**.

[0072] As the lubrication oil L for the inner and outer surfaces of the raw tube, Strol ES150 (viscosity: 1.4×10^{-4} m^2/s) made by Kyoei Yuka Kabushiki Kaisha was used.

[0073] In the rod used in each Example, the position of the ejecting opening in the peripheral direction and the number of the ejecting openings were set as shown in Table 1. In the explanation of each Example, the position of the ejecting opening in the peripheral direction is shown by an angle θ from the apex of the rod with respect to the center of the rod. The position of the ejecting opening in the longitudinal direction of the rod was 10 cm rearward of the bearing portion **17** of the plug **11**, which was common in each Example.

Example 1

[0074] As shown in FIG. **2**, a single ejecting opening **21** was provided at the position of θ=0°.

Example 2

[0075] As shown in FIG. **3**, two ejecting openings **23** were provided at the positions of θ=40°.

Example 3

[0076] As shown in FIG. **4**, a single ejecting opening **21** was provided at the position of θ=0°, and two ejecting openings **23** were provided at the positions of θ=40°.

Example 4

[0077] As shown in FIG. **5**, a nozzle **26** was attached to the peripheral edge of the ejecting opening **21** provided at the position of θ=0°.

Example 5

[0078] As shown in FIG. **7**, an ejecting opening **28** opening obliquely forward at the position of θ=0°, and a nozzle **30** was attached to the peripheral edge of the ejecting opening **28** in a forwardly inclined manner.

Comparative Example 1

[0079] As shown in FIG. **8**, two ejecting openings **41** opening just right besides were provided at the positions of θ=90°.

Comparative Example 2

[0080] As shown in FIG. **9**, ejecting openings **43** and **44** were provided at the positions of θ=0° and θ=180°. These ejecting openings were opened right above and right below, respectively.

Comparative Example 3

[0081] As shown in FIG. **10**, an ejecting opening **46** opening right below was provided at the positions of θ=180°.

[0082] In each drawing test, a billet of aluminum alloy (consisting of Mn: 1.12 mass %, Si: 0.11 mass %, Fe: 0.39 mass %, Cu: 0.16 mass %, Zn: 0.01 mass %, Mg: 0.02 mass %, and the balance being aluminum and inevitable impurities) was extruded under the conditions of extrusion temperature: 520° C., and extrusion rate: 5 m/min into a cylindrical tube having an outer diameter of 32 mm and a wall thickness of 1.5 mm. Then, the extruded tube was cut into 2.2 m in length and used as a test raw tube **2**.

[0083] Drawing processing was performed at the drawing rate: m/min, the outer diameter reduction rate: 16% and the cross-sectional area reduction rate: 32% while supplying lubrication oil onto the outer and inner surfaces of the raw tube **2**. A plurality of raw tubes were sequentially processed. In sequentially drawing a plurality of raw tubes, after completion of drawing a single raw tube, supplying lubrication oil to the inner and outer surfaces of the raw tube was immediately suspended, the drawn tube was taken out from the drawing apparatus and the subsequent raw tube was set to the drawing apparatus. Immediately thereafter, subsequent drawing and lubrication oil supply were initiated. In other words, in the sequential drawing process for a plurality of raw tubes, the processing suspended time was minimized.

[0084] The drawn tube **3** processed in each Example was transferred to a transferring conveyer from the drawing apparatus **1** and cooled down to a room temperature, and cut into a length of 260 mm. On each 260 mm length tube, burning of the inner surface was evaluated by the following criteria through visual inspection. The evaluation results are shown in Table 1.

[0085] ○: no burning occurred

[0086] Δ: burning occurred at the drawing initiation portion

[0087] x: burning occurred at the entire region along the longitudinal direction

TABLE 1

		Ejecting opening						
		Angle θ	Number	Total number	Nozzle	Forward inclination	Ref. drawing	Burning
Example	1	0°	1	1	No	Nil	FIG. 2	○
	2	40°	2	2	No	Nil	FIG. 3	○
	3	0°	1	3	No	Nil	FIG. 4	○
		40°	2		No	Nil		
	4	0°	1	1	Attached	Nil	FIG. 5	○
	5	0°	1	1	Attached	Inclined forwardly	FIG. 7	○
Comparative Example	1	90°	2	2	No	Nil	FIG. 8	x
	2	0°	1	2	No	Nil	FIG. 9	Δ
		180°	1		No	Nil		
	3	180°	1	1	No	Nil	FIG. 10	x

[0088] From the results shown in Table 1, it was confirmed that when an ejecting opening was provided only in a region above the center of the rod, the responsiveness at the time of resuming lubrication oil supply is good, and even if drawing processing is initiated together with resuming lubrication oil supply, lubrication oil can be assuredly supplied to the inner surface of the raw tube to prevent occurrence of burning.

[0089] This application claims priority to Japanese Patent Application No. 2009-188827 filed on Aug. 18, 2009, and the entire disclosure of which is incorporated herein by reference in its entirety.

[0090] It should be understood that the terms and expressions used herein are used for explanation and have no intention to be used to construe in a limited manner, do not eliminate any equivalents of features shown and mentioned herein, and allow various modifications falling within the claimed scope of the present invention.

INDUSTRIAL APPLICABILITY

[0091] According to the drawing method for a metal tube of the present invention, lubrication oil can be assuredly and effectively applied to an inner surface of a raw tube, and therefore the method is suited for mass production of aluminum tubes for photoconductive drum substrates.

DESCRIPTION OF THE REFERENCE NUMERALS

[0092] **1** . . . drawing apparatus

[0093] **2** . . . raw tube

[0094] **3** . . . drawn tube

[0095] **10** . . . drawing die

[0096] **11** . . . plug

[0097] **20**, **22**, **24**, **25**, **27**, **29** . . . rod

[0098] **21**, **23**, **28** . . . ejecting opening

[0099] **26**, **30** . . . nozzle

[0100] L . . . lubrication oil

1-10. (canceled)

11. A drawing apparatus for a metal tube for processing a metal raw tube by passing a metal raw tube between a die for forming an outer surface and a plug for forming an inner surface, characterized in that an ejecting opening for ejecting lubrication oil opens into an outer peripheral surface of a hollow rod supporting the plug, wherein the ejecting opening is provided only at a region above a center of the rod in an up-and-down direction.

12. The drawing apparatus for a metal tube as recited in claim **11**, wherein a distance between the ejecting opening and a bearing portion of the plug in a drawing direction is 20 cm or less.

13. The drawing apparatus for a metal tube as recited in claim **11**, wherein a nozzle protruded from the outer peripheral surface of the rod is provided at the ejecting opening.

14. The drawing apparatus for a metal tube as recited in claim **12**, wherein a nozzle protruded from the outer peripheral surface of the rod is provided at the ejecting opening.

15. The drawing apparatus for a metal tube as recited in claim **11**, wherein the ejecting opening opens toward a front side of the apparatus.

16. The drawing apparatus for a metal tube as recited in claim **12**, wherein the ejecting opening opens toward a front side of the apparatus.

17. The drawing apparatus for a metal tube as recited in claim **13**, wherein the ejecting opening opens toward a front side of the apparatus.

18. The drawing apparatus for a metal tube as recited in claim **14**, wherein the ejecting opening opens toward a front side of the apparatus.

19. The drawing apparatus for a metal tube as recited in claim **11**, wherein the ejecting opening is provided within an angle range of 60° or less from an apex of the rod with respect the center of the rod.

20. A drawing method for a metal tube for sequentially drawing a plurality of metal raw tubes using the drawing apparatus as recited in claim **11**.

21. A drawing method for a metal tube for sequentially drawing a plurality of metal raw tubes by repeating the following steps (i) to (v) using the drawing apparatus as recited in claim **11**:

(i) a step of drawing a raw tube while supplying lubrication oil onto an inner surface of the raw tube by ejecting the lubrication oil supplied to an inside of a hollow rod supporting a plug;

(ii) a step of suspending supply of the lubrication oil after completion of drawing the raw tube;

(iii) a step of taking out the drawn tube from the drawing apparatus and setting a subsequent raw tube to the drawing apparatus;

(iv) a step of resuming supply of the lubrication oil; and

(v) a step of returning to the step (i).

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