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METHOD FOR COATING THE INNER SURFACE OF METAL PIPES

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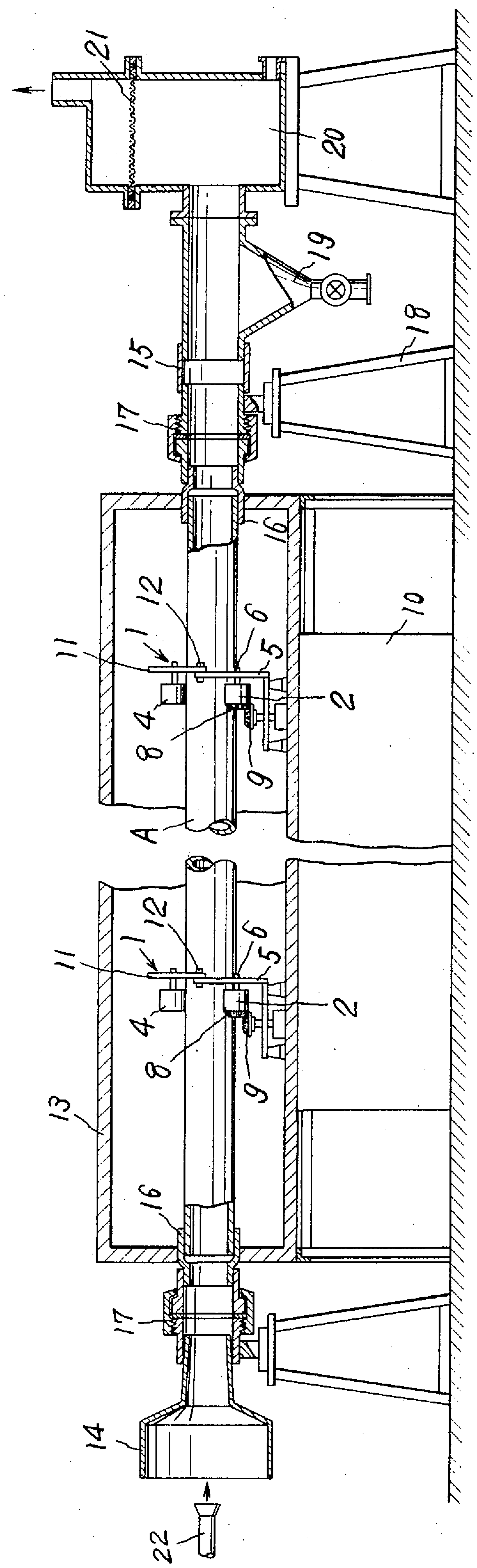
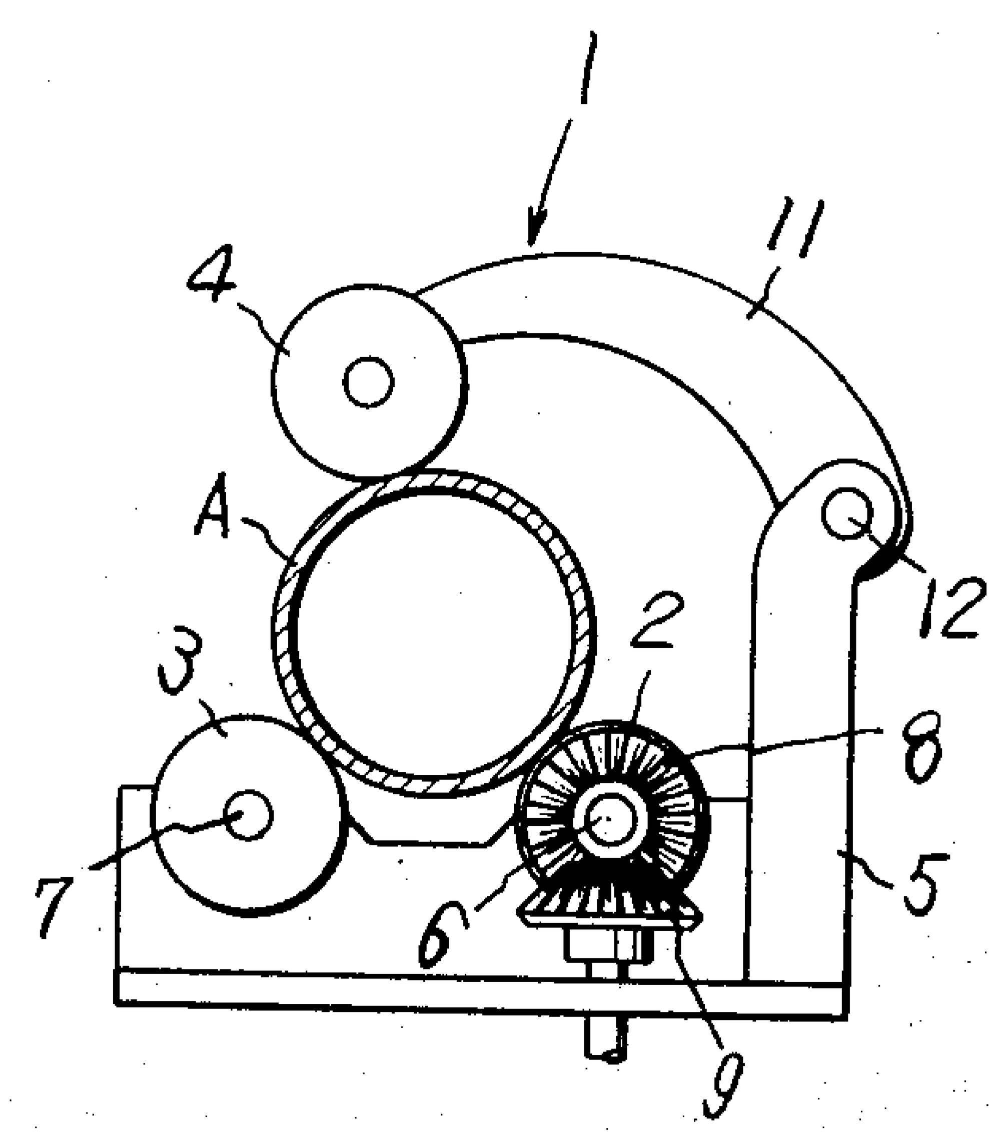


FIG. 1.

FIG. 2



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METHOD FOR COATING THE INNER SURFACE OF METAL PIPES

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Int. Cl. B05b *5/02;* B44d *1/094*
U.S. Cl. 117—17 3 Claims

ABSTRACT OF THE DISCLOSURE

A method for coating the inner surface of a metal pipe having an inner diameter of 2 to 15 cm. is characterized by heating said metal pipe electrically grounded at a temperature of from a softening point of a coating composition to below a melting point thereof, feeding negatively charged dry particles of a coating composition into the interior of said metal pipe from one end of the pipe and sucking air at the same time from the other end of the metal pipe so as to form an air stream carrying the particles and to allow the particles to deposit electrostatically on the inner surface of the pipe.

The present application is a continuation-in-part of our copending application Ser. No. 863,537, filed Oct. 3, 1969, (now abandoned) and entitled "Method for Coating the Inner Surface of Metal Pipes."

This invention relates to a method for coating the inner surface of a metal pipe, more particularly to a method for forming continuous film on the inner surface of a metal pipe having a relatively small inner diameter by electrostatic powder coating.

To protect a metal pipe from corrosion due to water, steam, chemicals, etc. flowing in the pipe it is required to coat the inner surface of the pipe with a continuous resin film, and dry powder of coating compositions has been used for this purpose. In one of the known methods dry powder of a thermoplastic resin is fluidized in an air stream, in which a metal pipe heated to a temperature higher than the melting point of the resin is immersed to form a resin film on the inner and outer surface of the pipe. According to this method, however, it is difficult to form a uniform pinhole-free coating on the inner surface of a pipe having an inner diameter smaller than 15 cm., since resin particles cannot be fluidized evenly in the interior of the pipe of such a smaller diameter. Further when a long pipe is treated in the above manner, it has to be dipped in a fluidized bed of resin particles on a large-scale apparatus, and it is impossible to fluidize the resin particles uniformly in the interior of the pipe in the lengthwise direction thereof, with the result that an uneven film having numerous pinholes is formed. Since not only the inner surface but also the outer surface of the pipe are coated simultaneously, this method has another disadvantage that it is practically impossible to provide the resin coating only on the inner surface of the pipe.

It is also known in the art to form a resin film on the inner surface of a pipe by electrostatic coating, using clear or pigmented dry powder of resins. This method employs an electrostatic powder spraying gun, so-called "pole gun," which is provided with a slidably extendable barrel and the coating is conducted by inserting the barrel of the gun into the interior of a metal pipe electrically grounded, spraying charged particles through the barrel to electrostatically deposit them on the inner surface of the pipe, and heating the pipe to produce a continuous coating film. However, this method is not suitable for coating the interior of a metal pipe of a small inner diameter, because spark discharged frequently occurs between the high voltage electrode at the head of the gun barrel and the inner wall of the metal pipe, making it difficult to ensure uniform deposition of the charged particles. In fact, when a metal pipe having an inner diameter smaller than 15 cm., particularly below 10 cm., is coated by this method, the resultant coating film formed on the inner surface of the pipe is uneven in thickness and has numerous pinholes throughout the film.

One object of the invention is accordingly to provide a method for coating the interior of a metal pipe, which is capable of forming a uniform pinhole-free coating on the inner surface of the pipe having such a small inner diameter as 2 to 15 cm.

Another object of the invention is to provide a method for coating the inner surface of a metal pipe in a continuous manner, whereby coating composition can be uniformly deposited over entire inner surface of the pipe to form continuous film extended uniformly in thickness from the inlet of the pipe to the outlet thereof regardless of the length of the pipe.

Another object of the invention is to provide a method for coating the inner surface of a metal pipe, which is capable of producing a coating film having excellent flexibility and high order of water-proof and chemical-resistant properties.

These and other objects of the invention will be apparent from the following description.

The method of the invention to be applied in coating the inner surface of a metal pipe having such a small inner diameter as 2 to 15 cm. comprises heating said metal pipe electrically grounded at a temperature of from a softening point of a coating composition to below a melting point thereof, feeding negatively charged dry particles of a coating composition into the interior of said metal pipe from one end of the pipe, sucking air at the same time from the other end of the metal pipe so as to form an air stream carrying the particles and flowing in the interior of the pipe at a rate of 4 to 20 m./sec. and to allow the particles to deposit electrostatically on the inner surface of the pipe, and fusing the deposited particles to form a continuous film on the inner surface of the pipe.

Throughout the specification and claims "softening point" shows a value measured in accordance with ASTM D 1525–58 T, and "melting point" shows a value determined in accordance with ASTM D 1238–57 T, using a load of 2160 g. at a flow rate of 10±1 g./10 min.

According to the present invention, uniform film coating free of pinhole can be produced on the inner surface of a metal pipe having such a small inner diameter that it has been diffifficult or impossible to form such a uniform pinhole-free film on the inner surface thereof by the conventional methods. In fact, the inner surface of a metal pipe having an inner diameter smaller than 15 cm., particularly 2 to 10 cm., can be effectively coated by the method of the invention. Particularly, according to the present method, uniform deposition can be effected over the entire inner surface of the pipe, resulting in the production of a coating film having relatively even thickness from the inlet portion of the pipe to the outlet portion thereof. Moreover, the coating film obtained in accordance with the present invention has good flexibility and high order of corrosion resistant property to water and chemicals.

The metal pipe which can be coated by the invention includes those having an inner diameter of 2 to 15 cm.

and made of steel, stainless-steel, aluminium, copper and like metals.

Various dry coating compositions heretofore used for electrostatic coating may be used in the invention. For example, polyvinyl chloride, polyethylene, polypropylene, polyamide, polyester, chlorinated polyether, epoxy resin, phenol resin, fluorine resin and like thermoplastic or uncured thermosetting resins may be used as a coating composition in the invention in the form of dry powder, to which may be added, as required, plasticizers, coloring agents and like additives. Preferably particle size of the coating composition is in the range of 2 to 500μ.

As the machine for giving electrostatic charge to the particles of the coating composition may be used various dry electrostatic coating machines available under trade marks such as "REP Gun" sold by Ransberg Japan Ltd., "Stajet" and "Stafluid" by Société Anonyme de Machines Electrostatiques, France, etc.

According to the process of the present invention, a metal pipe to be coated is electrically grounded and heated at a temperature of from a softening point of the coating composition to below a melting point thereof. According to the researches of the present inventors it has been found that, when the metal pipe is previously heated at a temperature of from a softening point to below a melting point of the coating composition, uniform deposition of the coating composition over the entire inner surface of the pipe can be more efficiently ensured than in the case in which the metal pipe is heated at a temperature of the melting point or higher than that of the coating composition. It is noted that when the pipe is heated at a temperature of melting point of the coating composition or higher, the particles of the composition fed into the interior of the pipe are liable to stick to one another during their passing the pipe to form lumps which may be deposited on the inner surface of the pipe to produce rugged coating film, whereas when the pipe is heated below the melting point of the coating composition the formation of such lumps can be effectively prevented with the result that more uniform coating film can be produced throughout the entire inner surface of the pipe. The coating film obtained in accordance with the present invention has good flexibility and excellent water-proof and chemical-resistant properties due to the uniformity thereof and substantial absence of undesired pin-holes therein. However, if the pipe is not heated or if it is heated at a temperature lower than the softening point of the coating composition, the powder having deposited on the inner surface of the pipe is liable to come off and down the inner surface by slight shock or impact which may be given during its conveying to the subsequent heating step for fusing the deposited powder resulting in the production of uneven film. Preferable heating temperature of the pipe is in the range of from a softening point of the coating composition to a temperature of about 5° C. lower than a melting point thereof. The metal pipe is preferably positioned horizontally, though it may be positioned vertically or in any direction desired.

According to the invention negatively charged dry powder of a coating composition is fed continuously into the interior of the pipe thus heated from one end thereof by a suitable dry electrostatic coating machine. At the same time air is sucked from the other end of the pipe by a suitable sucking device, such as sucking pump, sucking fan, etc., whereby an air stream is produced in the interior of the pipe. The dry powder fed from one end, while being carried by such air stream, is deposited electrostatically on the inner surface of the grounded pipe, resulting in uniform deposition of the powder on the entire inner surface of the pipe. To ensure uniform deposition, it is essential to control the flow rate of the air stream flowing in the interior of the pipe in the range of 4 to 20 m./sec. A flow rate lower than 4 m./sec. not only renders the process inefficient but also causes the powder to be deposited mainly on a portion near the inlet of the pipe, and at a higher flow rate of 20 m./sec. almost all powder particles will be carried away with air and effective deposition can no longer be achieved. Particularly preferable flow rate is in the range of 5 to 18 m./sec.

To achieve more uniform deposition of the powder, it is preferable to rotate the metal pipe at least one r.p.m. during the electrostatic coating. The preferable rotation rate may be 5 to 50 r.p.m. though it may be increased to such a high rate as 200 r.p.m.

The powder thus deposited on the inner surface of the pipe is then heated at a temperature ranging from a melting point of the powder to below a decomposing temperature thereof to fuse it into a continuous film. Various heating apparatuses may be used for the purpose, such as air oven, induction heating machine, etc.

The thickness of the film thus obtained may vary in a wide range in accordance with the kinds of the coating compositions used and the time for coating but usually it is in the range of 100 to 1000μ.

For a better understanding of the invention, examples are given below in which the apparatus shown in the attached drawings is used.

FIG. 1 shows a side view partially in section of one preferred apparatus for carrying out the method of the invention; and

FIG. 2 is a front view of rotating means shown in FIG. 1.

Referring now to the drawings, designated at **1** is a couple of rotating means for a metal pipe to be coated, each of which comprises a driving roll **2**, idle roll **3**, set roll **4** and supporting means **5** for these rolls. The driving roll **2** and idle roll **3** are rotatably supported on shafts **6** and **7** on the supporting means **5**, and the driving roll **2** is driven by bevel gears **8** and **9** which are driven through a reduction gear (not shown) by a motor (not shown), these reduction gear and motor being disposed in a case **10**. The set roll **4** is rotatably supported on an arm **11** fixed to supporting means **5** with a screw **12**.

A metal pipe A, the inner surface of which is to be coated, is electrically grounded and mounted horizontally on a couple of rotating means **1** and held in position by the set roll **4** so as to be rotated by means of the driving rolls **2**. Designated at **13** is a heating furnace for the pipe A. The metal pipe A is airtightly connected to a baffle **14** at the front end and to a rubber pipe **15** at the back end by means of socket and spigot joints **16** and union joints **17** respectively. Each union joint is supported by a frame **18**. The rubber pipe **15** is connected to a powder recovery hopper **19**, and is further connected to air-sucking means (not shown) with a powder recovery box **20** disposed therebetween. The box is provided with a bag filter or screen **21** to prevent escape of the powder. Designated at **22** is a barrel head of a dry electrostatic coating machine (not shown).

EXAMPLE 1

The inner surface of a steel pipe, 5.5 m. in length and 2.5 cm. in inner diameter, was coated in the following manner on the apparatus shown in attached drawings.

The pipe mounted on the rotating means 1 and electrically grounded was rotated at 5 r.p.m. and heated at 110° C. Dry powder of an epoxy resin coating composition containing epoxy resin, curing agent and pigment and having particle size of 20 to 150μ, softening point of 90° C. and melting point of 120° C. was charged negatively to a voltage of —90 kv. and blown through the electrostatic gun head **22**, "REP Gun" (trademark), into the baffle **14** at the rate of 300 g./min. At the same time air was sucked by means of a sucking pump, whereby air stream flowing through the interior of the pipe at a flow rate of 10 m./sec. was produced. The dry powder blown in was carried by the air stream and deposited electrostatically on the inner surface of the pipe. This procedure was continued for 2 minutes. Thereafter the pipe was disengaged from the apparatus and heated in an air oven at 200° C.

for 20 minutes, whereby continuous film of a thickness of 200μ covering the entire inner surface of the pipe was obtained.

The pipe coated as above was sawn in the longitudinal direction, and inspected by naked eye and the condition of the surface of the film was found to be uniform and free of pinholes.

Further the coating film displays excellent flexibility and high order of water-proof and chemical resistant properties as shown in appended Table 1.

EXAMPLE 2

Electrostatic coating was conducted in the same manner as in Example 1, except that the flow rate of the air stream was 5 m./sec.

The resultant film was uniform free of pinholes and had a thickness of 350μ. The test results on the flexibility and water-proof and chemical resistant properties of the resultant film are shown in Table 1.

EXAMPLE 3

Electrostatic coating was conducted in the same manner as in Example 1, except that the flow rate of the air stream was 18 m./sec.

The resultant film was uniform free of pinholes and had a thickness of 220μ. The test results on the flexibility and water-proof and chemical resistant properties of the resultant film are shown in Table 1.

For comparison, electrostatic coating in Example 1 was carried out at the flow rate of 2 m./sec. and 22 m./sec. In the former case dry powder was deposited only on the front part of the pipe with almost no deposition on the back part, failing to produce uniform film, and in the latter case almost no deposition of the dry powder was observed.

The following tests were performed on the coated pipes obtained in Examples 1 to 3 with the results shown in Table 1 below:

1. Water-proof property

The coated pipe, 15 cm. in length, was dipped in distilled water at room temperature for 30 days and thereafter dried at room temperature. The pipe thus treated was sawn in longitudinal direction and the condition of the surface of the film was inspected by naked eye.

2. Alkali resistance

The test of alkali resistance was performed in the same manner as in the above test except that 5 weight percent aqueous solution of sodium hydroxide was used in the place of distilled water.

3. Flexibility

The coated pipe, 50 cm. in length, was bended at an angle of 90° in 2 seconds. Then the pipe was sawn in the longitudinal direction and the condition of the film was inspected by naked eye.

TABLE 1

Example No.	Water-proof property	Alkali Resistance	Flexibility
1	No change was observed.	No change was observed.	No crack was observe.
2	do	do	Do.
3	do	do	Do.

EXAMPLE 4

The inner surfaces of the steel pipes having different inner diameters were electrostatically coated in the same manner as in Example 1, with the results shown in Table 2 below, in which the surface conditions of the resultant film, flexibility, waterproof property and alkali resistance were inspected in the same manner as in Examples 1 to 3.

TABLE 2

No.	Inner dia. of pipe (mm.)	Thickness of film (μ)	Surface conditions of film	Water-proof property	Alkali resistance	Flexibility
1	21	630	Uniform, free of pinhole	No change was observed	No change was observed	No crack was observed.
2	30	430	do	do	do	Do.
3	150	120	do	do	do	Do.

EXAMPLE 5

The inner surface of a steep pipe, 5.5 m. in length and 2.5 cm. in inner diameter, was electrostatically coated in the same manner as in Example 1, in which various dry coating composition of a particle size of 20–200μ shown in Table 3 below were used and the pipe was heated at temperatures shown in Table 3 below during electrostatic coating. The same tests as in Example 1 were performed on the resultant pipe with the results shown in Table 3 below.

TABLE 3

No.	Coating comp.	Softening point (° C.)	Melting point (° C.)	Temperature applied (° C.)	Average thickness of film (μ)	Surface conditions of film	Water-proof property	Alkali resistance	Flexibility
4	Polyamide	150	200	170	390	Uniform, free of pinhole.	No change was observed.	No change was observed.	No crack was observed.
5	Polyethylene	110	170	140	350	do	do	do	Do.
6	Polyester	85	120	95	320	do	do	do	Do.
7	Phenol resin	80	120	90	330	do	do	do	Do.
8	Chlorinated polyether.	170	220	195	350	do	do	do	Do.
9	Fluorine resin	250	300	280	280	do	do	do	Do.

What we claim is:

1. A method for coating the inner surface of a metal pipe having an inner diameter of 2 to 15 cm. with a dry coating composition, which comprises the steps of:
   (a) rotating said metal pipe electrically grounded at a rate of at least one r.p.m.,
   (b) preheating said metal pipe at a temperature of from a softening point of said coating composition to a temperature of 5° C. lower than a melting point thereof,
   (c) feeding negatively charged dry particles of a coating composition into the interior of said metal pipe from one end of the pipe,
   (d) sucking air at the same time from the other end of the metal pipe so as to form an air stream carrying the particles and flowing in the interior of the pipe

at a flow rate of 4 to 20 m./sec. and to allow the particles to deposit electrostatically on the inner surface of the pipe, and

(e) fusing the deposited particles to form a continuous film on the inner surface of the pipe.

2. The method for coating the inner surface of a metal pipe according to claim **1**, in which said flow rate of air stream is in the range of 5 to 18 m./sec.

3. The method for coating the inner surface of a metal pipe according to claim **2**, in which said pipe is rotated at the rate of 5 to 50 r.p.m.

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