Sept. 21, 1971 N. M. STEELE 3,606,974

MATERIAL TREATING APPARATUS

Filed April 4, 1969 2 Sheets-Sheet 1

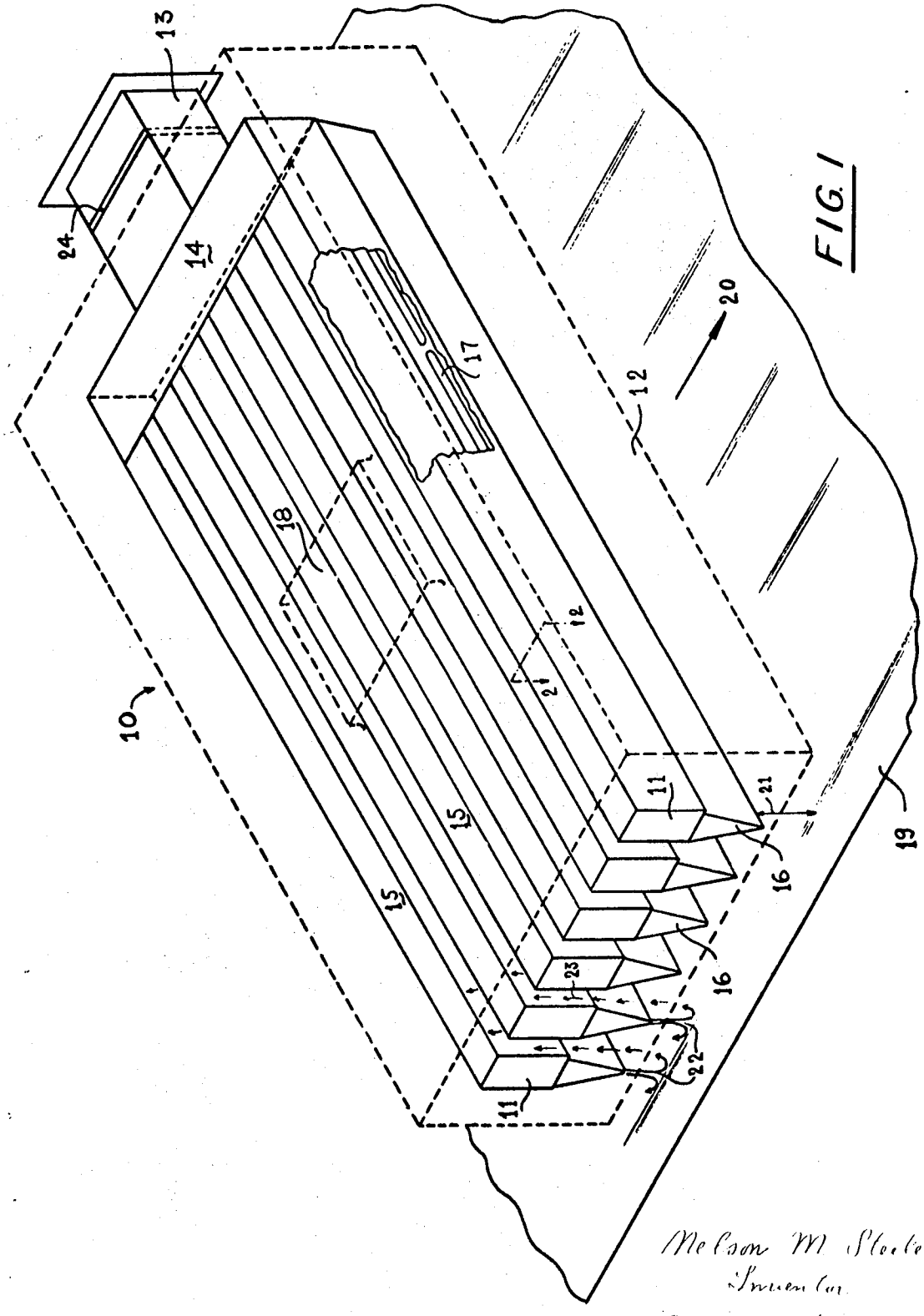


FIG. 1

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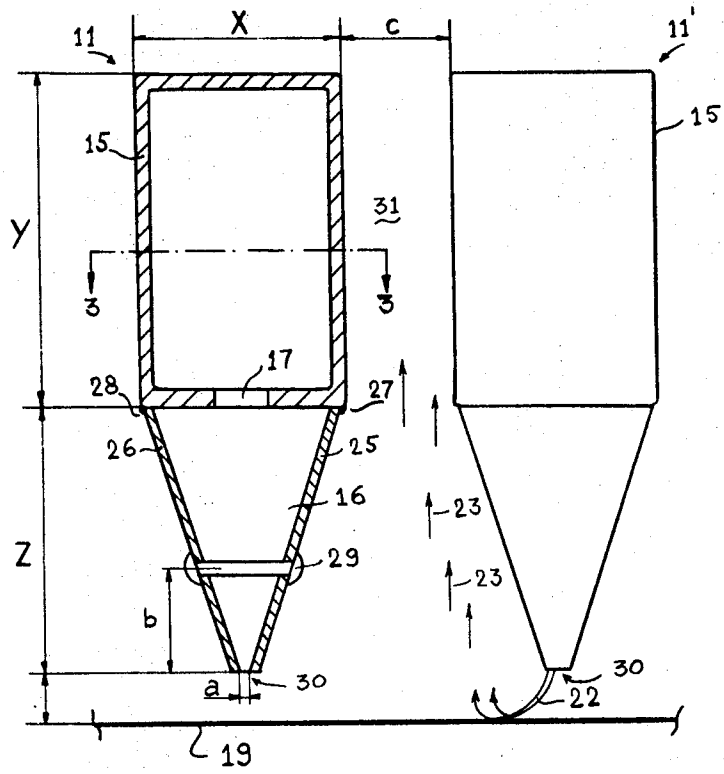


FIG 2

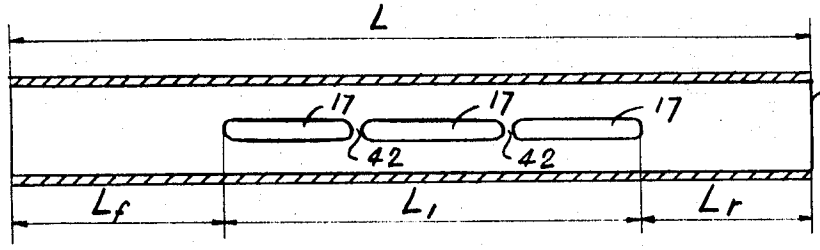


FIG 3

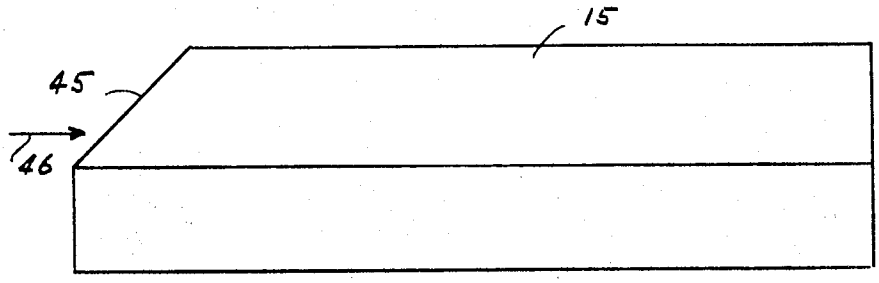


FIG 4

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3,606,974

MATERIAL TREATING APPARATUS

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Int. Cl. A62c 31/10
U.S. Cl. 239—568 5 Claims

ABSTRACT OF THE DISCLOSURE

A nozzle assembly for treating materials by impingement of a high velocity gaseous medium comprising a plenum chamber and a generally triangularly shaped nozzle attached to said plenum chamber and communicating therewith.

The present invention relates to material treatment apparatus and more particularly to a nozzle assembly therefor for the projection of high velocity streams of gaseous medium onto the material to be treated. The invention further relates to methods of manufacturing such nozzle assemblies.

It is well known to utilize high velocity streams of gaseous medium issuing from nozzles for drying and other purposes and it is also well known to utilize comparatively large exhaust openings between the nozzles for withdrawing spent gaseous medium from the surface of the material to be treated.

Many arrangements and designs of nozzles and exhaust openings are lacking in two important aspects. First of all, the designs are not "clean" from an aerodynamic viewpoint thereby resulting in inefficient operation, and secondly, the designs are costly to manufacture.

It will be appreciated to those skilled in the art that the cost of heating a gaseous medium is rising rapidly and that the need for utmost economy in utilizing the heated medium is becoming more and more acute. The need for reduction in cost of this type of equipment has always been present but difficult to achieve.

It is accordingly an important object of the present invention to provide for a simple, economic and efficient nozzle design.

Another object of the present invention is to provide for a nozzle and exhaust opening assembly or arrangement of optimum aerodynamic design.

A further object of the invention is to provide for a novel and simple method of economically constructing nozzle assemblies which may be arranged in any desired configuration in order to accommodate the particular path through which the material to be treated travels.

These and other objects of the invention will appear from time to time as the following specification proceeds and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a nozzle assembly in accordance with the principles of the invention;

FIG. 2 is a cross-sectional view of a nozzle assembly constructed in accordance with the principles of the present invention, and taken along the lines 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view taken along the lines 3—3 of FIG. 2; and

FIG. 4 is a side elevational view of a nozzle assembly in accordance with the principles of the invention.

In FIG. 1 of the drawings a drying apparatus **10** is shown in perspective view. The drying apparatus essentially comprises a plurality of nozzle assemblies **11** mounted in generally parallel relationship to each other and within an exhaust hood assembly **12** which, for purposes of clarity, is shown in dotted lines. The nozzle assemblies **11** are suitably mounted in spaced apart relationship to the interior of the exhaust hood assembly **12**. A gaseous medium supply duct **13** is mounted to the rear of the nozzle assemblies and is in open communication with a chamber **14**. The chamber **14** is in open communication with the upper, generally rectangularly shaped portions of each of the nozzle assemblies **11**. The plenum chambers **15** are in open communication with the nozzle portions **16** by means of longitudinal openings **17**. The exhaust hood assembly **12** completely surrounds the nozzle assemblies but is open at the bottom so as to permit the high velocity gaseous medium to exit from the nozzle portions **16** onto the objects to be treated. An exhaust opening **18** is provided in the top of the exhaust hood assembly **12**.

The material to be treated by the gaseous medium issuing from the nozzles **16** is represented by a web **19** moving in the direction of the arrow **20**. It should, however, be understood that the present invention is not restricted to the drying of weblike materials but may equally be utilized for the drying of other objects such as painted pottery, corn cobs, and the like. For purposes of simplicity, however, the invention will be primarily described in connection with the drying of a weblike material such as represented by the numeral **19**.

As shown in FIG. 1, the nozzle assemblies **11** are spaced a predetermined distance **21** above the web **19**. In operation, hot gaseous medium is introduced into the supply duct **13** and enters the plenum chambers **15** of the nozzle assemblies **11** via chamber **14**. From the plenum chambers **15** the gaseous medium enters the nozzle portion **16** through openings **17** located in the bottom wall of the plenum chamber. The gaseous medium then exits from the bottom of the nozzles **16** and impinges upon the web **19** substantially as shown by the arrows **22**. The spent gaseous medium after impingement on the web **19** is forced to enter into the spaces between the nozzle assemblies **11** as shown by the arrows **23** and is removed from the exhaust hood assembly **12** through exhaust opening **18**. The spent gaseous medium from the exhaust opening **18** may, if desired, be dehumidified and reused in order to improve overall efficiency. A suitable damper mechanism, indicated by the numeral **24** may be utilized in connection with the air supply duct **13** in order to regulate the volume of air supplied to the nozzle assemblies **11**.

Referring now to FIG. 2 of the drawings, the nozzle assembly **11** is shown in cross-sectional view substantially along the lines 2—2 of FIG. 1. The nozzle assembly **11** comprises a plenum chamber **15** and a nozzle portion **16**. The plenum chamber **15** is in open communication with the nozzle portion **16** by means of openings **17**. The plenum chamber **15** is of generally rectangular cross-sectional area and may be manufactured from a suitable material such as for example sheet metal or heat resistant plastic.

The cross-sectional area of the plenum chamber **15** has a width generally indicated by X and a height generally indicated by Y. In order to obtain good air flow through the plenum chamber **15** the ratio $X:Y$ is preferably in the neighborhood of 1:1.75. In a typical form of the apparatus of the present invention the width of the plenum chamber X may be two inches while the height Y would be in the order of 3.5 inches.

The nozzle portion **16** of the nozzle assembly **11** comprises two flat plate members **25** and **26** welded to the bottom wall of the plenum chambers **15** at **27** and **28**. A spacer member **29** is mounted a predetermined distance above the tip **30** of the nozzle **16**. The spacer member **29** may be in the form of a simple bolt or rivet mounted in such a manner as to maintain a predetermined distance *a* between the lower portions of the plate **25** and **26** thereby forming a relatively narrow continuous slot at the tip **30** of the nozzle **16**.

The location and use of the spacer element **29** is an important part of the present invention. In the prior art it has been common practice to construct nozzles of the type described by spot welding the plates **25** and **26** together at the opening **30**. The spot welds are spaced at predetermined intervals and sufficient welds are used to insure adequate strength. Spot welds of the aforementioned type are distinctly disadvantageous in that they cause the nozzle opening **30** to warp appreciably, but more importantly, the spot welds at the opening **30** create obstructions to the air flow and cause air flow disturbances which greatly impede the efficiency of the nozzle. Such air flow disturbances at the location of the aforementioned spot welds impede the efficiency of the air flow to such an extent that substantially reduced drying of the material is obtained immediately below the spot weld thus causing severe localized moisture variations with obvious unsatisfactory end results. In order to maintain the construction of the nozzles as economic as possible it has been found desirable to maintain spacer elements at spaced intervals along the length of the nozzle. Elimination of the spacer elements would require substantial reinforcement of the plate members **25** and **26** and greatly increase the cost.

It has been found, however, that an obstruction to the air flow at a point above the nozzle opening **30** does not result in undesirable irregularities in air flow out of the nozzle opening **30** since the air or other medium is given ample opportunity to "reform" or, in other words, the flow disturbance created by the spacer elements is given ample opportunity to dissipate. It has been established that the spacer elements **29** should be located a distance *b* above the nozzle opening **30** which is at least ten (10) times the width *a* of the nozzle opening **30**.

It has further been found that the triangular shape nozzle **16** can be optimized from the standpoint of flow efficiency by making the ratio of the base X of the triangle to the height Z within the range of from 1 to 1.75.

FIG. 2 also shows an additional nozzle assembly **11'** mounted in predetermined spaced apart relation from the nozzle assembly **11**. As shown with respect to the nozzle assembly **11'** the gaseous medium exits from the nozzle opening **30** as indicated by the arrows **22** onto the surface of the article **19**. The spent gaseous medium travels upwardly between the space provided between the nozzle assemblies **11** and **11'** as indicated by the arrows **23**. It has been found that optimum exhaust of spent gaseous medium may be obtained when the spacing *c* between the plenum chambers **15** of the nozzle assemblies is within the range of ⅛ inch to 5/16 inch each and preferably approximately 3/16". In accordance with the present invention the exhaust openings **31** between the nozzle assembly **11** is unobstructed throughout the full width of the nozzle.

FIG. 3 shows a cross-sectional view taken along the lines **3—3** of FIG. 2 and for purposes of simplicity FIG. 3 has been drawn on a reduced scale. FIG. 3 shows the location of the openings **17** which permit the gaseous medium to flow from the plenum chamber **15** into the nozzle **16**. As previously indicated with respect to FIG. 1 the gaseous medium is introduced into the plenum chamber **15** from one end thereof. The feed end of the plenum chamber is indicated in FIG. 3 by the numeral **40**. In order to obtain equal flow of gaseous medium from the plenum chamber **15** into the nozzle **16** the spacing and location of the openings **17** is extremely important. As previously indicated, in order to obtain equal drying rates across the

width of material to be treated it is essential to obtain equal velocity flow out of the nozzle opening **30**. With a uniform cross section plenum chamber to which gaseous medium is supplied from one end only the spacing of the openings **17** and their relative size is of critical importance. At the same time, it will be apparent to those skilled in the art that substantial economy of design will be realized with the aforementioned constant cross section design.

As shown in FIG. 3 the total length of the nozzle assembly **11** is indicated by L. The total axial length of the openings **17** is represented by L_1. The portion of the plenum chamber ahead of the openings **17** is represented by *Lf* while the portion of the plenum chamber immediately following the openings **17** is represented by *Lr*.

It has been found that if the length *Lr* immediately following the openings **17** is made too large a dead space will be created immediately ahead of the rear wall **41** of the plenum chamber **15**. This dead space will result in substantially impeded airflow out of the nozzle opening **30** at a location below the dead space in the plenum chamber. In order to compensate for this dead space it has been found that the entire group of openings **17** must be shifted towards the rear wall **41** by a distance which has within the range of from 1 to 1.5 inches. In other words, the group of openings **17** whose axial length is represented by L_1 must be positioned with respect to the overall length L of the plenum chamber so that the following equation is satisfied:

$$Lf - Lr = 1 \text{ to } 1.5 \text{ inches}$$

It has further been found that equal flow of gaseous medium through the entire length of the nozzle opening **30** is obtained when the total length L_1 of the nozzle openings **17** is approximately ½ of the total length L of the plenum chamber. The land areas **42** between the slots **17** are preferably approximately ¼ inch long. The length of the slots or openings **17** are equal with the exception that the central slot is approximately 1 inch longer than the remaining slots. This is desirable in order to obtain proper pressure distribution in the nozzle **16**.

FIG. 4 shows an elevational view of the nozzle assembly **11**. It will be noted that the front portion or front wall **45** of the plenum chamber **15** has been beveled at an angle of approximately 45° in order to facilitate the entry of air into the plenum chamber in the direction of the arrow **46**.

What is claimed is:

1. A nozzle assembly for treating materials by impingement of a high velocity gaseous medium comprising in combination:

(a) walls, including a bottom wall, defining a plenum chamber;

(b) a nozzle attached to said bottom wall, said nozzle comprising two plates converging towards each other in a direction away from said bottom wall, said plates defining a narrow elongate slot of predetermined width at the converging end of said nozzle;

(c) a plurality of elongate openings in said bottom wall of said plenum chamber, said openings providing open communication between said plenum chamber and said nozzle; and

(d) spacer means located a predetermined distance from said elongate slot and attached to each said plates for maintaining a predetermined distance between said plates thereby maintaining the width of said slot constant.

2. The structure of claim **1** wherein said plenum chamber has a uniform rectangular cross-sectional area.

3. The structure of claim **2** wherein the ratio of the base of said triangle to the height of said triangle is within the range of from 1 to 1.75.

4. The structure of claim **1** wherein said distance of said spacer means to said slot is at least ten times the width of said slot.

5. The structure of claim 1 wherein the axial length of said elongate opening is approximately ½ of the axial length of said plenum chamber.

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U.S. Cl. X.R.

239—594, 597, 599