June 25, 1968 R. S. CAUGHMAN ETAL 3,390,039

METHOD AND APPARATUS FOR MAKING ADDITIVE FILTERS

Filed Sept. 22, 1965 2 Sheets-Sheet 1

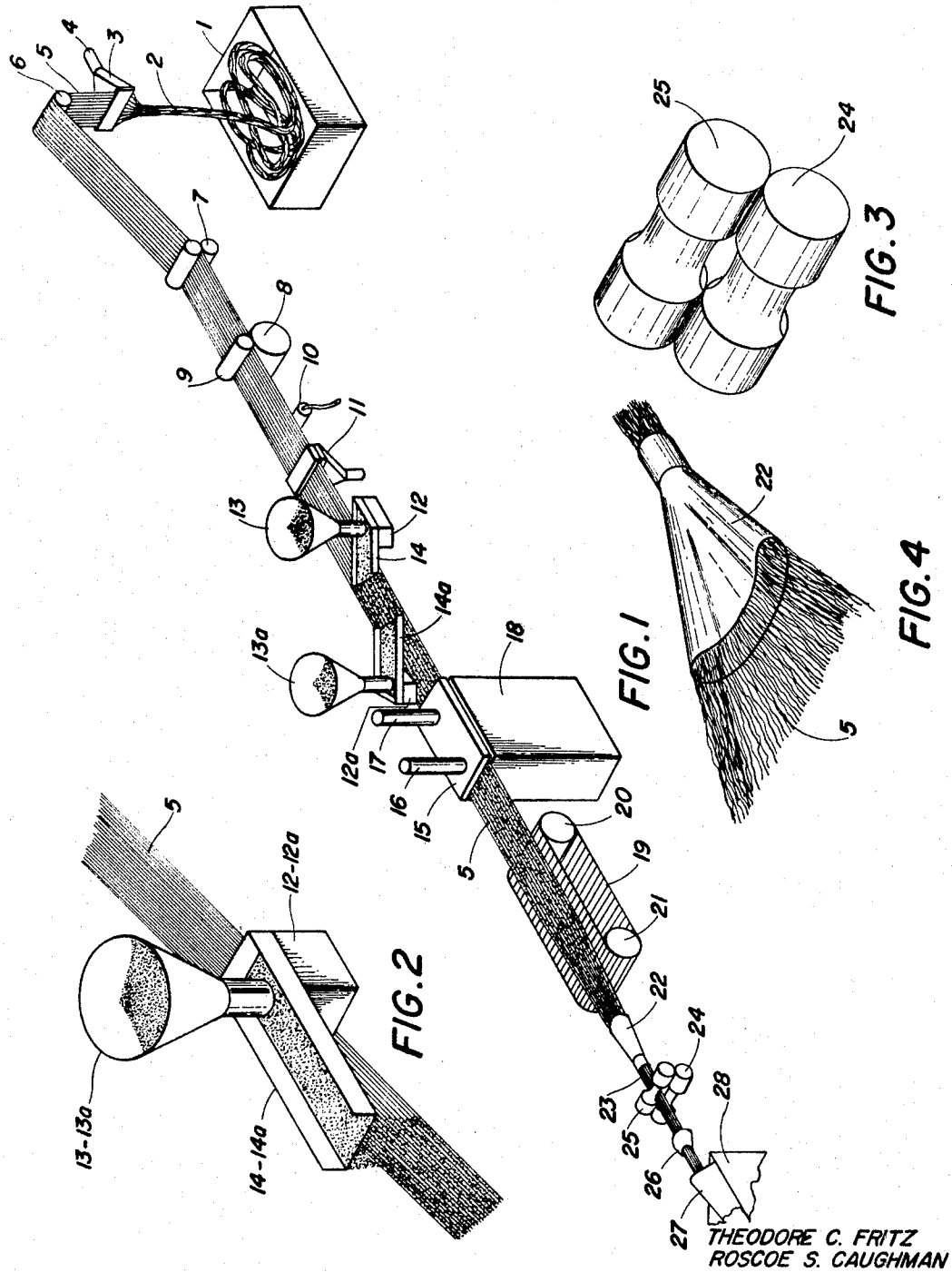

FIG. 1

FIG. 2

FIG. 3

FIG. 4

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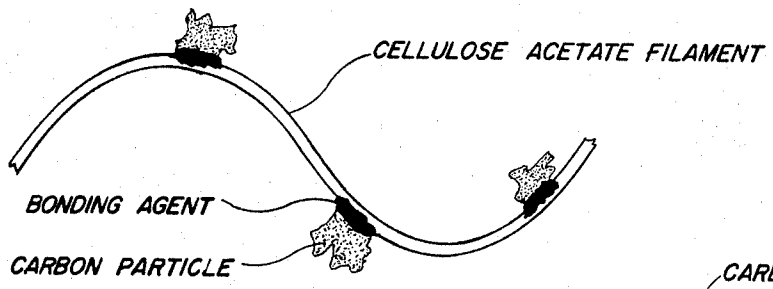

FIG. 5

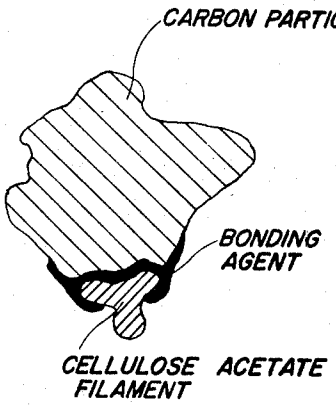

FIG. 6

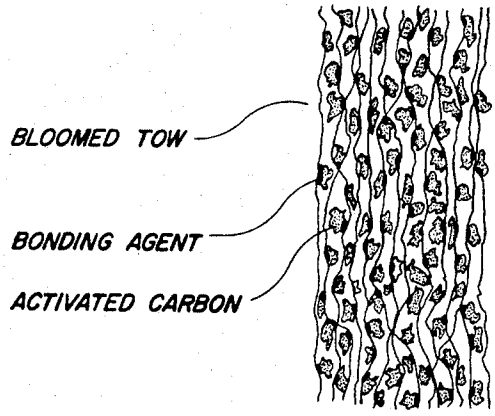

FIG. 7

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3,390,039
METHOD AND APPARATUS FOR MAKING ADDITIVE FILTERS

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Continuation-in-part of application Ser. No. 402,772, Oct. 9, 1964. This application Sept. 22, 1965, Ser. No. 489,328

14 Claims. (Cl. 156—166)

ABSTRACT OF THE DISCLOSURE

A process and apparatus for forming an additive containing tobacco smoke filter element by depositing predetermined amounts of a particulate additive and bonding agent onto a filter tow after which the bonding agent is softened by heating to secure the particulate additive to the tow.

This application is a continuation-in-part of their copending application Ser. No. 402,772, filed Oct. 9, 1964 now abandoned and entitled, "Apparatus and Method for Producing Carbon Containing Filter Rods."

This invention relates to a method and apparatus for the production of filamentary tobacco smoke filters containing relatively large solid particulate additives of various kinds which enhance the filter's ability to remove certain undesirable components from tobacco smoke. More specifically, the invention relates to a method and apparatus for securing the particles of the solid additive material, such as activated carbon, to the individual filaments of the filter by means of a heat sensitive solid particulate bonding agent.

Numerous expedients for the securing of various additives to filamentary cigarette filter tow in the manufacture of tobacco smoke filters have been suggested. For example, it has been suggested to distribute various particulate materials such as activated carbon, rice starch, calcium carbonate, cellulose acetate floc and even tobacco itself among the individual filaments of a filamentary filter tow and to secure such materials within the body of the filter rod by a variety of means. One such means is by simple mechanical entrapment by which the finely divided particles are merely distributed at random among the interlaced crimped filaments of the tow as it passes in a fluffed or randomly opened condition from one point in the rod making apparatus to another. This method depends upon simple mechanical interlocking of the fibers along the length of the rod, as it is shaped into a cylindrical form, to hold the particles within the filamentary mass. Such a method has the obvious disadvantage that it is difficult to control because any finely divided or particulate material by its very nature has a marked tendency to escape from the filamentary mass and to contaminate the machinery and the atmosphere in the immediate vicinity of the filter making operation. This method has the additional disadvantage that the additive particles, being only loosely mechanically held, have a tendency to shake loose from both the tow and the finished filter rod and to fall out during the final cigarette filter assembling operation with the result that an imperfect cigarette product is obtained.

Another well known expedient to lock the particulate additive material into the filter rod undergoing formation is to spray a liquid plasticizer or other agent onto the opened crimped tow as it passes to the rod making operation. A plasticizer such as triacetin, for example, has a solvating or softening action on certain types of filaments

as, for example, those composed of cellulose acetate. This solvating action causes the filaments to become fused at random points of contact throughout the filamentary mass and, as a result, produces an interlaced labryinthine filamentary network which, as in the expedient described in the preceding paragraph, merely mechanically traps the additive particles and suffers from the same disadvantages.

A still further expedient is to treat the opened crimped tow with an emulsified resin as, for example, an aqueous emulsion of polyvinyl acetate, after which the emulsion-treated material is heated to remove the water component of the emulsion and to cause the resin particles to coalesce and thereby function as a bonding agent to secure previously deposited particles of additive to the filamentary material. Such a method has the disadvantage from the manufacturing standpoint that it requires relatively cumbersome controls and a heating step. This method is also disadvantageous in that the application of water to any crimped filament tow inevitably reduces the angle of crimp and causes the filaments to flatten out, thereby reducing the amount of filament surface available for impingement and removal of particulate components, such as tars, from tobacco smoke which may pass therethrough.

It is an object of the present invention to provide a commercial method and apparatus for the preparation of a new and improved filamentary tobacco smoke filter of the type in which relatively large particles of additive are firmly attached within the filter structure for the more effective removal of gaseous and particulate components of tobacco smoke.

Another object is to provide a commercial method and apparatus for the preparation of a novel filamentary cigarette filter in which relatively large particles of granular activated carbon are held within the filter structure by means of a heat sensitive thermoplastic solid particulate bonding agent. The carbon particles are firmly attached to the filaments of the filter by a process which prevents their mechanical loss during their manufacture or in their subsequent use as a cigarette filter and still provides for sufficient exposure of the porous surface of the carbon particles for the effective removal of gaseous and particulate components from tobacco smoke.

A further object is to provide a unique and efficient commercial apparatus for depositing on and securing to the filaments of the cigarette filter tow a solid particulate additive, such as activated carbon, in a manner which results in a minimum of dust and loose particles.

Further objects will be apparent hereinafter.

In accordance with the present invention there is provided a continuous method for the preparation of a structurally unitary fibrous tobacco smoke filter containing a solid particulate additive which removes gaseous and particulate components from tobacco smoke, comprising the steps of conditioning a continuous horizontally moving crimped filament tow by separating the individual filaments one from another to give the band of tow and opened or fluffed appearance and increased bulk, depositing a predetermined amount of solid particulate additive on the upper surface of the horizontally moving tow in which the filaments are in an opened or fluffed condition, immediately thereafter depositing a predetermined amount of a heat-sensitive solid particulate bonding agent on the upper surface of the horizontally moving band of filter tow so that it commingles with the previously deposited additive particles, passing the thus prepared filter tow through a heating zone which is controlled to heat the bonding agent particles to cause them to soften and create a bonding condition by firmly attaching the additive particles to the filaments of the tow

which they are in contact, passing the tow through a cooling step at room temperature to harden the bonding agent particles after which the tow is caused to assume a substantially cylindrical form during the rod-forming operation by the inward folding of the tow on itself to lock in the additive particles.

According to the present invention there is also provided an apparatus for making tobacco smoke filtering elements, such apparatus comprising a plurality of operating means positioned successively along and all forming a horizontal path for the filter tow to travel and including a filament separation means disposed to withdraw crimped tow from a source of supply and acting to give the band of tow an open or fluffed appearance and increased bulk, means adjacent the separating means for depositing a predetermined amount of solid particulate additive and a heat-sensitive solid particulate bonding agent on the upper surface of the horizontally moving separated tow, said deposited particles may be deposited from separate vibrating hoppers located above the moving tow or by means of a controlled mixture from a single hopper. The filter is then passed through a heating zone for purposes of activating the particles of heat sensitive bonding agent to cause them to firmly attach the additive particles to the filaments of the tow. More specifically, the temperature of the heating zone is dependent mainly on the softening temperature of the polyolefin bonding agent being used, the speed of travel of the filter tow and the type of heating unit employed. The maximum temperature is preferably well below the softening temperature or charring temperature of the filaments of the tow; however, sufficient heat must be applied to cause the particles of the bonding agent to soften and in this condition acts to grip both the filament and the particle of solid additive in a manner which firmly attaches one to the other. Horizontal conveyor means in the same plane as the traveling filter tow provides for the cooling of the heat treated tow at room temperature prior to conveying the filter tow to the shaping means for forming the filamentary mass into a substantially rod-like or cylindrical form from where the rod is fed directly to the garniture of a filter rod making mechanism for further wrapping, sizing and cutting to length.

The invention will be described herein in terms of a process which can be conducted with any suitable continuous filamentary material such as tow composed of crimped filaments of regenerated cellulose, cellulose acetate, polyolefins (polyethylene, polypropylene, polybutylene and copolymers thereof), polyamides, polyesters, polyacrylonitriles and the like. One of the most satisfactory materials for this purpose is a tow made of 6,000 to 10,000 crimped continuous filaments of 3 to 8 denier per filament having 8 to 16 crimp per inch of filament length. In preparing the tow for firmly attaching the solid particulate additive, the tow will be usually removed from a bale or other package thereof and subjected to a "blooming" operation which as referred to above as a mechanical separation treatment well know in the art of cigarette filter manufacturing in which the individual filaments of the tow are opened or fluffed in a manner to partially deparallelize the individual filaments and give the tow increased bulk. The material is then in condition for the application on its upper surface of solid particulate additives of the type capable of removing gaseous and/or particulate components from tobacco smoke. Examples of such additives are activated carbon, rice starch, cellulose acetate floc, calcium carbonate or other suitable material. If activated carbon is employed, it may be derived from a number of different materials such as wood, petroleum, coconut shell, coal, blood, bone and other materials. Our process is also particularly unique in that it provides a highly efficient, clean and dust free filamentary tobacco smoke filter in which relatively large particles of an additive, such as activated carbon in large quantities are firmly attached to the filaments of the filter element to an extent not previously possibly by known adhesive means. We have found that larger and a greater quantity of additive particles per standard length of filter tip can ge firmly attached and contained within the filter element by means of a heat sensitive, finely divided, solid, particulate bonding agent. Such a bonding agent is preferably a polyolefin having a relatively low softening temperature range, such as polyethylene, polypropylene, polybutylene or copolymers of ethylene, propylene or butylene. Furthermore such a bonding material will soften, and to a certain extent become tacky, at a relatively moderate temperature, for example within the range of about 50–180° C., or in any case well below the softening temperature or charring temperature of the filaments of the tow.

Typical of polyolefin and copolymers having properties and softening temperature ranges which give them particular value in practicing our invention are the following:

Polymer:	Softening point, ° C.
Polyethylene	70–160
Polypropylene	90–180
Ethylene-propylene copolymer	80–170
Propylene-butylene copolymer	50–100

When the solid additive particles and the particles of bonding agent are intimately mixed or commingled with the filaments of the opened filter tow they are subjected to a heat treatment which softens but does not melt or cause the bonding agent to flow. The softened bonding agent particle acts to grip both the filament and the particle of solid additive in a manner which firmly attaches one to the other. This phenomenon repeats itself innumerable times at random points over the upper surface of the filter tow. A properly heated bonding agent softens only to the extent necessary to firmly attach the additive particles to the filaments. Therefore it is important to note that the amount of heat employed in the heating step is dependent upon the physical properties of the heat-sensitive, low-melting bonding agent being used. It is necessary that the particles of bonding agent merely soften to give its unique fastening characteristic. It is further to be noted that a properly heated bonding agent of the type described when given its unique fastening qualities adheres to only a small portion of the total surface area of the additive, thus leaving the major portion of its porous surface exposed to adsorb and remove the gaseous components from the tobacco smoke.

Instead of depositing the additive particles and the bonding agent particles separately as described above they may be uniformly mixed in any desired proportions and the mixture deposited on the tow from a single vibratory distributor. Such a mixture may contain, for example, 70–95 percent by weight of activated carbon particles of the desired particle size, the balance being particles of a dry bonding agent such as polyethylene polymer of low softening range and of appropriate particle size. A preferred mix for producing a cigarette filter rod 10 mm. in length and 25 mm. in circumference and containing 100 mg. of activated carbon, for example, may contain 85 percent by weight of 20 x 50 mesh activated carbon particles and 15 percent by weight of 50 mesh particles of low density polyethylene having a softening range of 90–110° C. It will be understood that the actual amounts or proportions of both the additive and the bonding agent will be determined by the type of filter rod being produced. For example, some cigarette producers may prefer a filter of 10 mm. standard length and 25 mm. circumference to contain 100 mg. of activated carbon while others may prefer to have a greater or less amount of carbon present and the amount of carbon or other solid additive deposited thus will vary in accordance with the requirements of any given user.

As to the matter of particle size of both the additive and the bonding material this is measured, as indicated

above, in terms of "mesh." By this is meant the size of particle which will pass through the square openings between the wires of a wire mesh screen or sieve of standard construction as to the number of openings per inch and as to the diameter of wire employed. For example, a 12 mesh particle will just pass through the .0661 inch opening in a screen or sieve having 12 openings per inch formed between wires each having a diameter of .0272 inch on the U.S. Standard Sieve Series; likewise, a 100 mesh particle will just pass through the .0059 inch opening in a screen having 100 openings per inch formed between wires each having a diameter of .0040 on this standard and so on. When reference is made to a range of particle sizes, as for example, 20 by 50 mesh, this includes all particles which have a mesh size falling within this range. Thus this range would exclude all particles too coarse to pass through a 20 mesh and particles no larger than those which would just pass a 50 mesh screen.

In accordance with the invention the solid particulate additive, such as activated carbon, can have a particle size ranging from as large as 12 x 30 to as small as 100 x 200 mesh. In other words, if it is desired to deposit relatively coarse particles the particle size will fall within the range of 12 x 30 mesh. For finer material the range will fall within the range of 100 x 200 mesh with a preferred range of 20 x 50 mesh.

As to the bonding agent it has been found that the coarsest particle size should in general not be greater than about 10 mesh and the smallest particle size should not be finer than about 300 mesh, with a preferred range for most practical purposes of 40–120 mesh. In general, the particle size of the bonding agent will be selected with reference to the particle size of the solid particulate additive it is desired to employ. In other words, if one employs a solid additive having relatively large particles, the particle size of the bonding agent will be proportionately large. On the other hand, if one employs a fine particle size additive, the particle size of the bonding agent will be proportionately small.

In order that the invention may be clearly understood and readily practiced a preferred construction of apparatus or machine suitable for forming a cigarette filter rod in accordance with the invention will be described by reference to the accompanying drawing in which:

FIGURE 1 is a schematic perspective view, in the nature of a flow sheet, of a preferred form of filter rod making apparatus in accordance with the invention.

FIGURE 2 is an enlarged detail view of the vibratory feeder mechanism of FIGURE 1 for distribution of solid particulative additive and bonding agent on the tow.

FIGURE 3 is an enlarged detail view of the delivery rolls of FIGURE 1.

FIGURE 4 is an enlarged view of the forming trumpet of FIGURE 1 and illustrating its action in causing the outer edges of the tow to be folded inwardly and thus to form the tow into a substantially cylindrical filter element.

FIGURE 5 is an enlarged segment of a single filament of a tobacco smoke filter produced in accordance with the invention, illustrating the manner in which solid additive particles are firmly bound to the filament by means of a heat-sensitive thermoplastic solid particulate bonding agent.

FIGURE 6 is an enlarged view of a typical cross sectional configuration of a filament. It should be realized that this invention is equally effective with all types of filaments having varying cross sectional configurations and this illustration should not be taken as limiting this invention to a particular type of cross sectional filament.

FIGURE 7 is a highly magnified section of a small portion of a cigarette filter tow produced in accordance with the invention and illustrating distribution of relatively large activated carbon particles in the filamentary network.

Describing the invention in somewhat more detail, if desired, one may start with a bale of crimped tow composed of any suitable multifilamentary tow such as cellulose acetate or polypropylene and carry this tow through an opening or fluffing operation which is generally referred to as "blooming." This step deparallelizes the individual filaments and gives the tow increased bulk. The first step in this operation is to pass the tow, as it comes off the bale or other package, through a device known in the art as a banding jet which causes the rope or bundle of crimped filamentary material to become flattened out into the form of a band or ribbon as it is conveyed through the device by a blast of air. The band of filaments thus produced may then be passed through a set of pretensioning rolls which serve to debundlize or "bloom" the filamentary material, that is, to separate the individual filaments one from another, deparallelize them and give the band increased bulk. The material is then in condition for employment in the process herein described.

Alternatively, one may start with a previously "bloomed" tow and introduce it directly into the process of the invention. As will be more fully set forth hereinafter, the band or ribbon of tow passes through the entire process in a horizontal plane and in a flattened but open condition until it reaches the ultimate step in which the material is caused to assume a substantially cylindrical form as a filter plug.

The first step of the process after the tow is "bloomed" is to deposit the desired particulate additive material, such as finely divided activated carbon particles onto the band of tow as it moves in a horizontal direction. These particles are thus spread somewhat evenly over the upper surface of the filamentary material. This is followed immediately by depositing over the same area of the tow a particulate dry bonding agent the particles of which thus become thoroughly distributed among or intermingled with the particles of the previously deposited additive materials.

The tow is then carried into the immediate vicinity of a heating element, as for example an infrared heater, the heat from which, controlled at an appropriate temperature, substantially instantaneously softens or causes the particles of the solid bonding agent in contact with the solid additive particles to become tacky and thereby causes the additive particles to be firmly attached to the filaments with which they are in contact. The tow is cooled at room temperature in passing from the heating area to a forming or shaping operation and the bonding material is thus hardened to firmly fasten the solid additive particles to the filaments. In the final step of the operation the band of treated tow is carried through a forming trumpet as previously described and this causes the outer edges of the tow to curl inwardly upon themselves. As the shaping operation progresses, the entire band of treated tow finally assumes a substantially cylindrical form as it passes out of the circular delivery orifice of the trumpet. From this point the rod passes continuously to the garniture of a conventional cigarette filter rod making machine where it is further sized to the exact diameter desired and then wrapped in an appropriate paper wrap.

It is to be particularly noted that the employment of a solid particulate bonding agent in accordance with the invention and in the manner just described and the shaping and forming of the rod by passing it through a forming trumpet enables all of the added particulate material, both additive per se and bonding agent, to be completely locked within the filter rod body and preclude the escape therefrom of any loose particles of any kind to give rise to housekeeping and other problems of manufacture. It will also be evident that the outside of the filter plug as thus formed is made up entirely of filamentary material which completely encloses and thus shows no evidence of the inclusion therein of the additive or bonding agent.

Referring to FIGURE 1 of the drawing, numeral **1** designates a bale of crimped cellulose acetate cigarette

filter tow **2** of appropriate denier per filament and total denier, the selection of which will depend, among other considerations, upon the amount of carbon (expressed as milligrams of carbon per 10 millimeter length of filter rod of 25 mm. circumference) is desired in the finished filter product. Tow **2** is drawn through banding jet **3** which is supplied with air under a moderate pressure of the order of 3–4 p.s.i. through conduit **4**. The stream of air passing through the jet escapes in a plane parallel to the body of filaments being treated and serves to spread the filamentary mass and form it into a relatively flat band or ribbon **5**. The band of filaments **5** thus formed passes over cylindrical rod or guide **6** and then between the pinch of a set of pneumatically loaded tensioning rolls **7**, then to "blooming" rolls **8** and **9**, the surface of the latter being indented with a plurality of parallel circumferential grooves of rectangular or square cross-section. These rolls serve to "bloom" or open or fluff the tow in such manner as to deparallelize or place the individual filaments out of registration one with another and give the tow increased bulk as previously described. After being thus "bloomed" or opened, tow **5** passes over static eliminator bar **10** and thence through a second banding jet **11** which serves to control the width of the tow as it is readied for reception of the particulate material.

The operations referred to in the preceding paragraph are more or less conventional tow preparation steps employed in the commercial manufacture of tobacco smoke filters while forming no part of the present invention are described to illustrate a practical method of preparing a tow for treatment in accordance with the invention. Alternatively, one could of course start with a previously "bloomed" or opened tow since the invention is directed only to the apparatus for and process of depositing and securing additive material to the tow and the formation of cigarette filter rods therefrom.

Upon leaving banding jet **11**, tow **5** passes underneath a vibratory feeder **12** having a flat slightly inclined tray **14** from which it is supplied with activated carbon particles (or any other solid particulate additive it is desired to employ) of the desired particle size from hopper **13** positioned above and connected to it by a feed conduit as shown. The carbon particles under the influence of vibration are metered whereby a predetermined amount of the carbon particles flow from tray **14** and fall by gravity onto the tow **5** moving horizontally below it. The solid particulate bonding agent is supplied from a similar vibratory feeder **12***a* supplied from hopper **13***a*; the particles of bonding agent passing through tray **14***a* are also metered to cause a predetermined amount of the bonding agent particles to fall by gravity onto tow **5** which has already received the carbon particles from tray **14**.

If desired, only one vibratory feeder may be employed for depositing in one step both the carbon particles and the particles of the bonding agent in an appropriate mixture and amount. The two-feeder method has the advantage that it provides a means of more or less exact control of the amount of each kind of particle which is deposited on the tow. The single feeder method has the advantage that premixed particles are already in close association one with another when dropped on the moving tow and are thus deposited on the tow in this condition. Another advantage of the use of the single feeder is that it makes possible a somewhat speedier operation since it tends to facilitate bonding in the heating step.

Whether employing one feeder or two, the tow **5** treated as described above and carrying on the surface thereof the mixture of solid particulate bonding agent and carbon particle additive material, passes beneath infrared heater unit **15** which is provided through conduits **16** and **17** with a supply of cooling water to enable the temperature to be appropriately controlled and maintained without overheating the unit itself or adversely affecting the filaments of the tow. During the heating step the particles of bonding agent in contact with the carbon or other additive particles and with the filaments are softened to bind or cement the additive particles to the filaments of the tow in the manner previously described and more specifically illustrated in FIGURES 5, 6 and 7. A cabinet **18** may be disposed beneath the heating unit to receive any small amount of particulate material which may accidentally escape from the tow during the heating step.

It is important that the temperature within the heating zone be maintained and controlled within those temperature ranges which are required to produce the gripping action of the particular polyolefin bonding agent being used. The heating apparatus must therefore be sufficiently flexible to perform the heating step for the variety of bonding agents discussed above which vary in their softening point from 50–180° C. In addition to the physical properties of the bonding agent other factors that must be considered during the heating operation are the speed of the prepared filter tow passing through the heating zone and the intensity of heat that can be brought to bear upon the traveling tow. It is essential that heat be applied only to soften the bonding agent, yet remain well below the softening or charring temperature of the filaments of the tow.

Tow **5** emerges from heater **15** and continuing in its horizontal path is carried over an open grid type endless belt conveyor **19** supported by rolls **20** and **21**, the latter being driven by appropriate means not shown. As the tow passes from conveyor **19** it is drawn into forming trumpet **22** which serves to roll the tow inwardly on itself from its outer edges, thus giving it a substantially cylindrical form. Upon emerging from circular orifice **23** of the forming trumpet the tow passes through grooved delivery rolls **24** and **25**, both of which are driven by appropriate means not shown, thence to trumpet **26** and finally into tongue **27** of a garniture attached to a standard cigarette filter rod making machine **28**.

The apparatus of the invention is a novel, highly effiicient and flexible device for practicing the process herein described and has certain unique features distinguishing it from similar tow treating machines known to the art. One of the most important of such features is the fact that the machine is an in-line horizontal plane apparatus for the manufacture of cigarette filter rods comprising, in series, means for removing a crimped cigarette filter tow from a suitable source thereof, means for maintaining the tow in relatively flat ribbon-like yet opened condition and means for successively applying to the moving tow carbon or other additive particles and particles of a solid particulate binder, or for adding a mixture of such particles from a single source, and a heating means for substantially instantaneously activating the particles of bonding agent to cause them to bond the carbon or other additive particles to the filaments at points of contact and means for cooling the thus treated filaments and conveying them to an element to shape the filamentary mass into a substantially rod-like or cylindrical form in which the rod can be fed directly to the garniture of a filter rod making mechanism for further wrapping, sizing and cutting to length. This additive depositing apparatus is particularly characterized by the fact that all of its elements are disposed in a horizontal position which enables the deposited material to be handled in the most effective manner, minimizes the possibility of escape of loose particles and enables the material to be heat treated in a most efficient manner. Another feature is that the apparatus lends itself readily to tying in with other processes such as those of banding and blooming or other preparative steps of treating the two. In addition, the apparatus is particularly adapted for the efficient distribution on the moving tow of various types of particulate materials and even to the spraying or rolling on of liquid material if such a step were desired for any reason.

In the following examples will be illustrated the practice of the process of preferred embodiments of our invention by means of the novel apparatus as shown in FIGURES 1 through 4 of the drawing.

Example I

A tow composed of cellulose acetate filaments of 5 denier per filament and having a total denier of 30,000 is continuously withdrawn from a bale and formed into a flat band of filaments by carrying it through the banding jet 3 of FIGURE 1 as described above. The band of filaments is then bloomed to open, fluff and deparallelize the filaments by continuously passing the band through pretensioning rolls 7 and blooming rolls 8 and 9, thence through a second banding jet 11. Shortly after leaving the second banding jet a predetermined amount of activated carbon particles of 20 x 50 mesh are distributed over the upper surface of the filaments by means of vibratory feeder 12 as the tow moves horizontally at a linear speed of 150 feet per minute. In the same manner, a predetermined amount of a 50 mesh solid particulate bonding material composed of low density polyethylene having a softening range of 90–110° C. is then distributed on the carbon laden tow. The tow then passes beneath infrared heater unit 15; the radiant heat is controlled at a temperature sufficient to immediately soften the particles of bonding agent as they pass under the heating unit at the indicated linear speed. Numerous particles of the bonding agent, being in a more or less tacky or a pliable condition and at the same time in contact with carbon particles and with the filaments, act to stick the carbon particles to the filamentary material. Simultaneously a certain amount of sticking together of individual filaments one to another may occur at random points throughout the filamentary mass where the softened bonding agent particles are simultaneously in contact with two or more filaments. The tow passes from the heating unit onto conveyor 19 where it is cooled by the surrounding air sufficiently to cause the polyethylene particles to form solid bonds between the carbon particles and the filaments and between some of the filaments themselves.

The band of treated tow is then cotninuously drawn from conveyor 19 by delivery rolls 24–25, passing then through forming trumpet 22, where it assumes a substantially cylindrical rod-like shape by virtue of the outer edges of the band folding inwardly on itself. The rod thus formed then passes to the tongue 27 of a garniture of the filter rod making machine 28 where it is continuously wrapped in an appropriate paper wrap, exactly sized to a circumference of 25 millimeters and cut to the desired length. The filter rod product produced as described above is found to have a carbon particle content of 134 milligrams per 10 millimeters of length.

When the filter rods of this invention are employed in the manufacture of cigarettes and such cigarettes subjected to known analysis procedures for determining the removal of both gaseous phase and particulate material from tobacco smoke the following results, expressed as weight percentage removal of the total weight of materials present in unfiltered smoke, are obtained:

Removals—Gaseous phase:	Percent
Acetaldehyde	76
Isoprene	93
Acetone	89
Acrolein	100
Particulate removals:	
Tar	13.9

Example II

The procedure of Example I is repeated exactly except that the solid particulate bonding agent is a polyethylene wax having a softening range of 100 to 125° C. and the linear speed of the moving tow is 175 feet per minute. The resultant filter rod product thus produced has a carbon particle content of 120.3 milligrams per 10 millimeter length.

The removal efficiency of such filter rods when subjected to the same tests as referred to in Example I are as follows:

Removals—Gaseous phase:	Percent
Acetaldehyde	89
Isoprene	97
Acetone	97
Acrolein	98
Particulate removals:	
Tar	20

Example III

The procedure of Example I is repeated exactly except that the solid particulate bonding agent is a copolymer of propylene and butylene containing 40 percent by weight of butylene and having a softening of 90 to 130° C. and the linear speed at which the tow moves is 200 feet per minute. The resultant filter rod product thus produced has a carbon particle content of 118 milligrams per 10 millimeters of filter rod length.

The removal efficiency of such filter rods when subjected to the same tests as referred to in Example I are as follows:

Removals—Gaseous phase:	Percent
Acetaldehyde	84
Isoprene	95
Acetone	94
Acrolein	100
Particulate removals:	
Tar	28

The method of the invention herein described has, among the many other advantages described in detail above, the outstanding advantage that, since the particulate bonding agent is in a dry condition when applied, it can be simply mixed with or otherwise associated with the additive particles in any desired proportion and upon a proper application of heat, bonding of the additive particles to the tow can be accomplished with a minimum of treating steps or other controls. A tobacco smoke filter produced in accordance with the invention is an element readily pervious to the passage of vaporized or gaseous materials but still able, when employed in a composite cigarette filter structure or as a pipe or cigar filter element, to filter out gaseous and particulate matter such as tars from tobacco smoke with the high degree of efficiency demanded by the tobacco industry.

The apparatus of the invention, being designed for deposition of the solid particulate additive and the solid particulate bonding agent while the band of opened or bloomed cigarette filter tow is moving rapidly in a horizontal direction, has the great advantage that the deposited particles tend to remain on the tow and not migrate into the atmosphere surrounding the filter making operation as is the case in machines or apparatus in which additive material is deposited on a tow being conveyed from point to point in a vertical or inclined direction. An outstanding advantage of the apparatus of the invention is the fact that it readily lends itself to being combined with other machine structures involved in filter tow pretreating or preparative steps or processes such as banding, blooming and the like and the further advantage that it can readily be made a part of an overall cigarette filter rod manufacturing operation by simple adjustments or adaptations well known to those skilled in the art.

Although the invention has been described in considerable detail with particular reference to certain preferred embodiments thereof, variations and modifications can be effected within the spirit and scope of the invention as described hereinabove, and as defined in the appended claims.

We claim:

1. A continuous process for the production of tobacco smoke filters containing a particulate additive which will

remove gaseous and particulate components from tobacco smoke which comprises:

(a) depositing a predetermined amount of particulate additive and at least one heat sensitive particulate bonding agent on the upper surface of a horizontally moving band of crimped filament cigarette filter tow in which the filaments are spaced relatively parallel to one another in an open or fluffed condition so that substantially all of the deposited particulate additive and bonding agent are retained thereon;

(b) heating the bonding agent particles to their softening point to cause the bonding particles to soften and firmly fasten the additive particles to those filaments of the tow with which they are in contact:

(c) permitting the bonding agent particles to cool as the tow moves in a substantially horizontal direction so as to cause hardening of the bonding agent particles; and

(d) thereafter shaping the tow by rolling said tow inwardly on itself from its outer edges to give it a substantially cylindrical form, the outer surface of which is substantially devoid of particles.

2. The process of claim **1** in which the heat sensitive particulate bonding agent is deposited on said surface of said band of tow after the deposition of the additive particles.

3. The process of claim **1** wherein the step of heating the particle laden filter tow comprises maintaining the temperature within a range which will soften the bonding agent particles but will not soften or char the filter tow.

4. The process of claim **1** wherein the step of depositing the particulate matter comprises depositing a mixture composed of additive particles and a particulate softenable bonding agent.

5. The process of claim **1** wherein the treated tow is caused to assume a substantially cylindrical or rod-like form by having its outer edges rolled inwardly upon themselves by passing the tow through a shaping trumpet.

6. The process of claim **1** in which the tow is composed of crimped filaments of cellulose acetate.

7. The process of claim **1** in which the additive is finely divided activated carbon having a particle size within the range of 20 x 30 mesh to 100 x 200 mesh and the solid particulate bonding agent is a polyolefin which softens at a temperature within the range of 90–180° C. and has a particle size within the range of 10 x 300 mesh.

8. The process of claim **1** in which the particulate bonding agent is a low density polyethylene which softens at a temperature within the range of 90–110° C.

9. Apparatus for the production of filamentary tobacco smoke filters containing a particulate additive, said apparatus comprising a plurality of elements disposed in line in a substantially horizontal plane, said elements including means for continuously moving a band of crimped, open or fluffed filamentary tow in said plane, means for depositing on the upper surface of the moving tow, a particulate additive and a particulate bonding agent, heating means for causing the bonding agent particles to soften, conveyor means for carrying the treated tow after it has left said heating means through a body of cooling air and shaping means for causing the tow leaving said conveying means to assume a substantially cylindrical form.

10. The apparatus of claim **9** in which the means for depositing the solid particles comprises at least one gravity feed vibratory particle distributor.

11. The apparatus of claim **9** in which the heating means is a radiant type heater.

12. The apparatus of claim **9** in which the tow conveying means is an open grid endless belt.

13. The apparatus of claim **9** in which the shaping means is a trumpet adapted to cause the treated tow to assume a substantially cylindrical or rod-like form by causing its outer edges to curl or roll inwardly upon themselves.

14. Apparatus for the production of filamentary tobacco smoke filters containing a particulate additive, said apparatus comprising a plurality of elements disposed in line in a substantially horizontal plane, said elements including means for continuously moving a band of crimped, opened or fluffed filamentary tow in said plane comprising rolls which feed the band of tow to said horizontal plane treating zone and rolls which withdraw the band from said zone, at least one gravity feed vibratory particle distributor for depositing, on the upper surface of the moving tow, a particulate additive and a particulate bonding agent, an infrared radiant heater for causing the bonding agent particles to soften, an open grid endless conveyor belt for carrying the treated tow after it has left said heating zone through a body of cooling air and a trumpet adapted to cause the treated tow to assume a substantially cylindrical or rod-like form by causing its outer edges to curl or roll upon themselves.

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