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(54) Smoke filters and their production.

(57) A tobacco smoke filter comprising a rod (314) of smoke filter material having a thin plastics sleeve (318) extruded therearound, the outer surface of the sleeve conforming to the outer surface of the rod. The sleeve is suitably at least 100 times thinner than the greatest transverse dimension of the rod, and may be of the same material as the rod. The sleeve may be extruded over the rod with application of suction via the rod to vacuum from the sleeve to the rod periphery, especially if the rod has previously been grooved and/or squashed over parts of its length to a reduced cross-section.

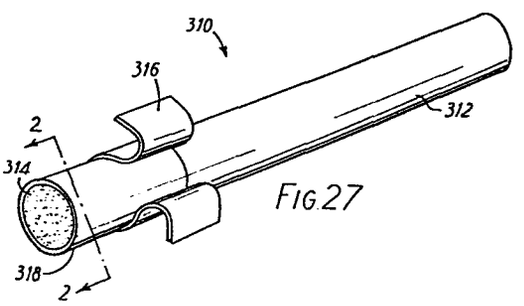

FIG.27

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SMOKE FILTERS AND THEIR PRODUCTION

The present invention relates to filter elements and to method and apparatus for fabricating such filter elements.

Although the present invention is primarily concerned with producing filter means for cigarettes, it should be noted that the products of the present invention are generally useful as filters for any tobacco smoking means, whether they be cigarettes, cigars, pipes, etc. Since filters for cigarettes have particular commercial importance, the preferred embodiments described herein relate to the production of filtered cigarettes.

In accordance with one aspect of the present invention, a plugwrap or overwrap for a smoke filter rod takes the form of a smoke-impervious plastics film extruded about the rod. The resulting overwrapped filter can be used with or without tipping paper; if tipping is used, the taste of the smoke is unaffected because the smoke-impervious film eliminates contact between the paper and the smoke. Preferably, the film is made from the same material as the filter such as cellulose acetate, so as to avoid introducing taste variations. Utilizing the same material in the filter rod and overwrap also has the advantage of permitting re-cycling of the waste filter material for use as the overwrap film. Plasticizers of the type which are conventionally used in filter rods

to bond fibers to one another serve to completely adhere the bonded fibers to the film, thereby eliminating the need for adhesive to hold the fibers to the overwrap. Elimination of this adhesive material reduces the cost and removes another foreign material that can adversely affect taste.

The invention also provides a smoke filter comprising a smoke-pervious rod and smoke-impervious wrap means circumscribing said rod, at least one groove formed in the rod and wrap means extending longitudinally of the wrap means from at least one end thereof and being fully open to ambient air along its entire length or a part thereof. The smoke-pervious rod usually extends the full length of the impervious wrap. The invention also provides method and apparatus for making such filters, and filter cigarettes incorporating them; in one such method and apparatus, the rod and circumscribing wrap means are grooved simultaneously; in another the rod is grooved first, and the subsequently applied wrap means (e.g. a plastics sleeve extruded over the rod) is conformed to the grooved rod profile - suitably by application of a pressure difference thereacross, e.g. by suction via the rod.

In accordance with another aspect of the present invention, a tobacco smoke filter has a rod of filter material which is wrapped with a smoke-impervious plugwrap, and tipping paper which circumscribes the plugwrap is wrapped closely about the plugwrap at the smoke

receiving end of the rod but loosely around the plugwrap at the smoke discharging end of the rod. Ventilation holes defined through the tipping paper upstream of the smoke discharging end permit entry of air into the space between the plugwrap and the loosely wrapped portion of the tipping paper. In preferred embodiments of the invention, the rod and plugwrap have a smaller cross-sectional perimeter proximate the smoke discharging end of the rod so that the tipping paper can be maintained at a constant cross-sectional diameter throughout its axial length and be loosely wrapped about the smoke discharging end. Preferably, the rod and the plugwrap are configured to have a raised or enlarged lip at the smoke discharging end to fit a smoker's lips in the manner of a cigarette holder, the lip perimeter being, in any case, smaller than the perimeter of the rod and plugwrap at the smoke receiving end.

Shaping of the rod and conforming plugwrap may be achieved simultaneously (e.g. by crimping) after the plugwrap has been applied. Instead the unwrapped rod may be shaped, followed by application of the plugwrap (e.g. by extrusion over the rod in the form of a film) which is conformed to the shaped rod - e.g. by a suction or like technique as described above. Various embodiments are disclosed wherein the cross-section of the rod tapers to form different configurations whereby air passages are defined between the plugwrap and the tipping paper. The invention also resides in the shaped

plugwrapped rods per se, i.e. in the absence of the outer tipping.

In filter elements according to the invention comprising a smoke-pervious rod having a plastics sleeve extruded thereabout (preferably by a method and apparatus in which suction is applied via the rod to effect intimate engagement between rod and sleeve), the plastics sleeve will usually be of substantially uniform thickness and will usually be relatively thin - e.g. the maximum transverse dimension of the rod will be at least 100 times the gauge of the sleeve.

The invention is illustrated, by way of example only, by the following description of preferred embodiments to be taken in conjunction with the accompanying drawings in which like items are frequently accorded like reference numerals and in which :

Figure 1 is an enlarged perspective of one form of cigarette and cigarette filter in accordance with the present invention, the tipping paper being partially torn away for illustrative clarity;

Figure 2 is an end view of the smoke discharging end of the filter of Figure 1;

Figure 3 is a view in perspective of another filter in accordance with the present invention;

Figure 4 is an end view of the filter of Figure 3;

Figure 5 is a view in perspective of another filter in accordance with the present invention;

Figure 6 is an end view of the filter of Figure 5;

Figure 7 is a view in perspective of still another filter in accordance with the present invention;

Figure 8 is an end view of the filter of Figure 7;

Figure 9 is a schematic illustration of a method and means for making filter elements in accordance with the present invention;

Figure 10 is a fragmentary view in perspective showing the details of one of the crimping members employed in Figure 9;

Figure 11 is a fragmentary elevational view in partial section of the crimping means utilized in deforming the filter plug in accordance with the present invention;

Figures 12 and 13 are fragmentary elevational end views in partial section of the crimping means in Figure 11;

Figure 14 is a schematic illustration of an alternative method and means for making the filter element in accordance with the present invention;

Figure 15 is a partially schematic view in section of an extrusion apparatus for applying plug wrap to the filter rod in the method and apparatus illustrated in Figure 14;

Figure 16 is a view in perspective of another form of filter and cigarette in accordance with the present invention, the tipping paper being partially torn away for illustrative clarity;

Figure 17 is a view similar to that of Figure 16 of a further form of filter and cigarette in accordance with the present invention;

Figure 18 is a view similar to that of Figure 16 of another form of filter and cigarettes produced in accordance with the present invention.

Figure 19 is a view similar to that of Figure 16 of another form of filter and cigarette in accordance

with the present invention;

Figures 20 to 26 are respective end views of filters of the type illustrated in Figures 16 to 18 showing the different numbers of grooves which can be provided in the outer periphery of the filter;

Figure 27 is a view in perspective of a further form of cigarette produced in accordance with the present invention, the tipping paper being partially torn away for illustrative clarity;

Figure 28 is a view in section through the filter rod of Figure 27 taken along lines 2-2 of Figure 27;

Figure 29 is a view in perspective of another filter in accordance with the present invention with the tipping paper once again being partially torn away for illustrative clarity;

Figure 30 is a view in section of a filter rod constructed in accordance with the present invention wherein ventilation holes are provided in the tipping paper and filter overwrap;

Figure 31 is a schematic illustration of a method and apparatus for fabricating filter elements in accordance with the present invention; and

Figure 32 is a partially schematic view in section of an extrusion apparatus for applying plugwrap to the filter rod in the method and apparatus illustrated in Figure 31.

Referring to the drawings with greater specificity, and particularly to Figures 1 and 2, a filtered cigarette according to the present invention is designated generally by the reference numeral 10. Cigarette 10 includes a tobacco rod 12 and a filter element 14 constructed in accordance

with one embodiment of the present invention. A tipping overwrap 16 secures the tobacco rod 12 and filter element 14 in end-to-end relationship in accordance with well known techniques in this field. The tipping paper overwrap 16 is provided with plural air dilution perforations 18 arranged circumferentially about filter element 14 to permit ventilating air to be drawn through the otherwise air-impervious tipping paper with each draw or puff of the cigarette. Filter 14 includes a plug 20 made of conventional tobacco smoke filter material and typically is made from a continuous tow of cellulose acetate filamentary material; it should be noted, however, that other filtering materials could be employed with slight modifications. For example, filamentary tow formed of other materials such as polyethylene, polypropylene, and the like, or even non-woven staple filbers may be used. It should be understood, however, that cellulose acetate filamentary tow is the preferred material from a commercial standpoint. In this sense, plug 20 is fabricated from conventional materials to function as a smoke-pervious filter plug for trapping solid particulates from the smoke passing therethrough.

Plug 20 is circumscribed along its entire length by a non-porous or smoke-impervious plug wrap 22. It will be recognized by those familiar with the art that a smoke-impervious plug wrap includes smoke-impervious outer surfaces of foamed material which is integral with the filter plug as well as smoke-impervious wrapping material which is not integral with the plug. Two methods, and apparatus for performing these methods, are disclosed hereinbelow.

Plug 20 has a smoke receiving end which abuts the tobacco rod 12 and a smoke discharging end constituting the distal end with respect to the tobacco rod. The plug 20 has a generally circular cross-section at the smoke receiving end and for a short distance downstream thereof. Thereafter, the plug cross-section begins to taper in both length and width in a downstream direction until a rectangular cross-section is achieved. Thus, from axial location 24, where the taper begins, to a location 26 further downstream where the taper ends, the cross-section of the filter plug 20 varies with the plug length. Downstream of location 26 the plug retains its rectangular cross-section until reaching a lip 28 formed at the smoke discharging end of the plug by increasing at least one of the cross-sectional dimensions abruptly. In the embodiment illustrated in Figures 1 and 2, the cross-sectional configuration extending between location 26 and lip 28 has a greater width than height; the lip 28 is formed in this embodiment by abruptly increasing the height dimension. This lip is contoured to fit the lips of a smoker and thereby permit the filter to serve as a cigarette holder. The natural rigidity of the plug 20 readily satisfies the stiffness requirements for such a cigarette holder.

Tipping wrap 16 is wrapped securely about the plug portion upstream of the location 24 at which the taper in the plug is initiated. The tipping paper has a constant diameter throughout its axial length so that it is not tightly wrapped about the portion of filter plug 20 extending downstream from location 24. The slack between the tipping paper 16 and the plug wrap 22, which is best illustrated in Figure 2, provides a flow path for air drawn through ventilation holes 18 in the space between the

tipping paper and plug wrap. It should be noted that the ventilation holes 18 are located at or downstream of the location 24 at which the downstream taper in the filter plug dimensions is initiated.

In the particular embodiment illustrated in Figures 1 and 2, the corners of the rectangular configuration of lip 28 are rounded so that the tipping paper 16 is caused to conform to the short side of the rectangle while being spaced from the long side. The two (2) air passages thus produced provide undiluted flow into the mouth of the smoker with each draw or puff. At first glance, it might appear that the smoker's lips would compress tipping paper 16 against the plug wrap 22 to block air flow through the space between the tipping paper and plug wrap. However, in testing this filter arrangement, we have found that the smoker tends to relax radially compressive pressure against the filter while keeping his or her lips in close contact with the tipping paper 16. As a result, the in-rushing air through ventilation holes 18 and the space between the tipping paper and plug wrap serves to expand the space to its full extent and permit free flow of the air.

A similar embodiment is illustrated in Figures 3 and 4 wherein the filter plug is provided with a circular lip 30 instead of rectangular lip 28. In other words, in the embodiment of Figures 3 and 4, wherein like reference numerals are used for similar components shown in Figures 1 and 2, the same rectangular cross-section is provided between location 26 and lip 30, as is provided in the embodiment of Figures 1 and 2. However, instead of increasing the height dimension linearly to form lip 28, the height dimension is increased arcuately to form a generally circular lip cross-section. The diameter of

lip 30 is less than the diameter of the plug wrap at the smoke receiving end of the filter and, likewise, the perimeter is also less at the smoke-discharge or discharging end. Therefore, the tipping wrap paper 16, which has a uniform diameter throughout its axial length, is arranged to conform to the portion of the filter plug upstream of location 24 but to loosely surround that portion of the filter plug disposed downstream of location 24. As best illustrated in Figure 4, an annular passage is provided about lip 30 through which air entering the gap from ventilation holes 18 is permitted to pass into the smoker's lip, undiluted. This configuration is desirable if one wishes to hide the fact that the filter plug tapers. More particularly, the lip 30 is only slightly smaller is diameter than the tipping paper at the smoke discharge end so that the annular space between the lip 30 and the tipping paper is discernable to the smoker only upon careful examination. The functioning of the filter of Figure 3 is, nevertheless, similar to the functioning of the filter of Figure 1, both in terms of providing an undiluted air flow passage and in terms of providing a lip 30 serving as a contoured mouthpiece for a cigarette holder.

The filter of Figures 5 and 6 is similar to the filter of Figures 1 and 2 except that it has a lip 32 which has a square configuration. That is, all four sides of the rectangular lip 32 are equal whereas only opposing sides of the rectangular lip 28 of Figure 1 are equal. As best illustrated in Figure 6, the square lip configuration 32 provides four spaces between the lip and tipping paper 16 which permit air to flow from ventilation holes, through the space between the plug wrap 22 and tipping paper 16 and into the mouth of the smoker. The filter of

Figures 5 and 6 functions both as a cigarette holder and to provide undiluted air flow in the same manner described above in relation to the filter of Figures 1 and 2.

Another filter embodiment is illustrated in Figure 7 which differs from the filters described above only to the extent that the rectangular lip 34 does not have rounded corners. Therefore, as best illustrated in Figure 8, the tipping paper 16 separates from the plug wrap 22 along all four sides to provide four distinct flow paths for the undiluted air. Two short openings and two long openings are provided to correspond to the difference in the lengths of the sides of lip 44.

The filters described in relation to Figures 1-8 provide a mouthpiece structure, in the form of lips 28, 30, 32, and 34 which serve as a cigarette holder. The inherent rigidity of the filter rod is sufficient for the filter rod to serve as the cigarette holder. In addition, the reduction in cross-sectional perimeter of the filter rods in a downstream direction provide, as described, gaps between the tipping wrap and plug wrap which permit undiluted air to enter the smoker's mouth with each puff. Moreover, the reduced cross-sectional area of the plug increases the resistance to smoke with each draw; this has been shown to improve the taste of air-ventilated cigarettes. The improved taste afforded by the filter of the present invention results from two primary features of the filter. First, the air passages between the tipping wrap and the plug wrap in accordance with the present invention have greater cross-sections than air passages in prior art air dilution filters, thereby reducing the velocity of air entering the smoker's mouth with the result that the air has less effect on the taste of the smoke. Second, the

reduced cross-section of the filter increases the velocity of the smoke which, as noted, enhances the smoke taste.

In all of the cases described hereinabove, the filter forms a mouthpiece which better fits the mouth of the smoker than is the case with conventional cylindrical cigarette filters. The smoker always has a clean cigarette holder with every cigarette and, since the holder is already attached to the cigarette, there is no need to transport a re-usable holder.

Figures 9-13 illustrate one overall method and means used to fabricate the filter elements in accordance with the present invention. Basically, this overall technique is similar in some respects to the techniques described and illustrated in detail in U.S. Patents Nos. 3,637,447, 4,046,063 and 4,075,936 to which attention is directed.

According to preferred embodiments of the present invention, the filtering material utilized in the production of filter elements is a continuous filamentary tow designated generally by the reference numeral 40, which includes a multiplicity of bondable fibrous members activated by contact with a hot fluid such as steam. Filtering material 40 is continuously passed into and through an elongated bonding zone 50 which includes a conventional stuffer jet 41 and steam head 42, similar in nature to those shown in the various above-mentioned prior art patents. Following the steam treatment, the resulting rod is cooled at cooling head 43 being overwrapped in garniture means 51 with a conventional plug wrap material 45. The plug wrap material 45, which is impervious to smoke, is treated with glue or adhesive 44 to assure bonding of the overwrap.

Garniture 51 provides a continuous pulling mechanism which draws the rod through these initial processing stages.

Upon leaving the garniture 51, the overwrapped is subjected to water and steam treatment at water head 46, prior to deformation of the rod. The rod is deformed by means of heated crimper wheels in crimping mechanism 47, portions of which are described below in relation to Figures 10-13. After the rod is deformed, the rod is passed to a cooling head 48 through which it is continuously pulled by a second garniture means 52, the latter passing the crimp rod to cutter head 49. The rod is severed transversely at selected locations at cutter head 49 to provide the individual filter plugs.

All of the elements described with respect to Figure 9 are conventional except for the heated crimp wheels in the crimper mechanism 47. These wheels are shown in detail in Figures 10-13 to which specific reference is now made.

It should be noted that Figures 12 and 13 are alternative representations whereby the crimping wheels illustrated in Figure 12 are employed to produce the square cross-sectional embodiment of Figure 5. The crimping wheels illustrated in Figure 13 are employed to provide the rectangular cross-section of the other embodiments. Opposed crimping wheels 61 and 62 have arcuate peripheries to permit a filter rod to pass therethrough while being crimped. Crimping recesses are defined in the arcuate periphery to achieve the deformation of the filter rod in the desired manner. Specifically, portions of the rod which are not crimped contact recessed portions 70 of wheels 61 and 62 when passing through the crimping station 47. Recessed sections 70 are partially cylindrical sections

extending axially along the periphery of wheel 61 with the recesses extending radially into the wheel 61. Between successive recesses 70 the wheels 61 and 62 are contoured to form the tapered portion, the constant rectangular cross-sectional portion, and the lip portion of two (2) filters formed lip-to-lip. Specifically, a section 71 on wheel 61 registers with a similar section 71 on wheel 62 to compress the tapered portion between sections 26 and 24 of the filter plug. Two (2) additional portions 72 of wheels 61 and 62 are rotated in registration to deform the rod into the constant rectangular cross-sectional portion. Recesses 75 are rotated into registration to define the lip portion of the filter rods. Wheels 63 and 64 in Figures 12 and 13 are suitably contoured to provide the taper along the height dimension sides of the filter plug cross-section.

The method and apparatus described in relation to Figures 9-13 assumes that the filter rod is wrapped with the plug wrap prior to deformation to achieve the desired plug cross-section. It is also possible to deform the plug prior to application of the plug wrap and then extrude the plug wrap about the deformed rod in the form of an extruded plastic film. This method is illustrated below with reference to Figures 14 and 15.

Referring specifically to Figure 14, wherein like components of Figure 9 are designated with the same reference numerals, the continuous filamentary tow 40 is continuously passed through a conventional stuffer jet 41 and steam head 42, following the stream treatment the resulting rod is cooled at cooling head 43 before being passed through pulling device 51. Upon leaving the pulling device 51, the unwrapped rod is passed through crimping

mechanism 47 where it is deformed in the manner described above in relation to Figures 10-13 to achieve the desired configuration of the various filters illustrated in Figures 1-8. After the rod is deformed, it is passed through a second pulling device 81 to a vacuum chamber 82. After leaving the vacuum chamber, the rod is passed to an extruder and tube die 83 which is described below in greater detail with reference to Figure 15.

In the extruder and tube die 83, a film of plastics material is extruded over the deformed filter rod so as to conform to the exact shape of the rod. Any suitable smoke-impervious plastics film may be utilized for this purpose and, in one preferred embodiment is polypropylene.

The wrapped rod then passes through a further water bath 84 to a third pulling device 85 before being cut into individual filter plugs at cutter head 86.

Referring specifically to Figure 15, the vacuum chamber 82 is illustrated with the unwrapped rod 87 passing through a bore 88 extendng longitudinally therethrough. The inlet end 89 of bore 88 is flared to provide a flow outlet which expands in the direction opposite the translation of rod 87. Bore 88 is somewhat larger in diameter than the diameter of rod 87 so that air can flow in an annular path through bore 88 in opposition to the rod movement. In order to withdraw air from bore 88, an annular nozzle is provided at the point where bore 88 begins to flare in portion 89. The annular nozzle is fed by air under pressure which aspirates air from the bore 88 and out through the flared outlet 89. As a consequence, an extremely low pressure is provided in bore 88. A portion

of the vacuum chamber 82 extends into the extruder and tube die member 83 such that bore 88 communicates coaxially with a similarly provided bore 90 in the tube die and extruder member 83. Rod 87 passes through bore 90 which is aspirated by the annular nozzle 91 in the same manner as bore 88.

Plastic is fed into the tube die and extruder member 83 via nozzle 92 which feeds the plastic in its molten form to an annular nozzle 94 disposed concentrically about the outlet of bore 90. The low pressure region formed around rod 87 in bore 90 causes the annular flow of plastics film from nozzle 94 to surround, and conform to the rod as the rod egresses from the tube die and extruder member 83. This plastics film 95 constitutes another form of the plug wrap 22 described above in relation to the embodiments of Figures 1-8.

If desired, the plastics film 95 may have incorporated therein finely ground tobacco particles. These particles provide some exposed tobacco on the surface of the film which impart flavor to the smoke as it passes through the tobacco rod under the film. This is accomplished without any loose particle fallout from the film since the particles are solidified in place as the film solidifies about the deformed rod. Generally, the tobacco particles would constitute one percent by weight of the molten material extruded about the rod.

The method described in relation to Figures 14 and 15, whereby the vacuum draws the plastics film to the exact shape of the rod and permits the smoke-impermeable film to conform to the deformed rod, is considerably cheaper than the conventional plug wrap approach described above in relation to Figure 9. The film 95 is generally extruded

to a thickness on the order of 0.5 mil but this thickness can be controlled by varying the speed ratio between the formed rod and the extruded film.

With respect to adding flavor by incorporating particles into the film, materials other than tobacco may be employed. These include carbon and magnesium hydroxide which can be compounded with plastics resin as flavor release agents. While most thermoplastics can be utilized for film extrusion onto the deformed rod, polypropylene and cellulose acetate have proved most viable.

With respect to the filter configurations illustrated above in Figures 1-8, it should be understood that a variety of cross-sectional configurations can be utilized. The important aspect of the invention is that tipping paper be loosely wrapped about the smoke discharging end of the filter so that air can be drawn in with each puff through the space between the tipping wrap and the plug wrap. For some complicated cross-sectional filter plug shapes, where mechanical devices would not be adequate to press the tipping paper around the film, the tipping paper can be laminated at certain locations with heat shrinkable film. Under such circumstances, after the cigarette has been fully assembled, hot air can be blown across the cigarette to shrink the film which then draws the tipping paper around the desired locations.

Regardless of which method is employed to make the combined filter and holder described herein, the filter and holder can be made without increasing the cost of the cigarette and, in fact, the overall cost is reduced in view of the lesser amount of acetate required in the reduced filter section. By decreasing the surface area, the desired pressure drop is achieved with less filter material.

In Figure 16 a filtered cigarette according to the present invention is generally designated by the reference numeral 110. Cigarette 110 includes a tobacco rod 112 and a filter element 114 constructed in accordance with one embodiment of the present invention. A tipping overwrap 116 secures the tobacco rod 112 and filter element 114 in end-to-end relationship in accordance with well known techniques in this field. Filter 114 is a generally cylindrical plug of conventional tobacco smoke filter material and typically is made from continuous tow of cellulose acetate filamentary material; it should be noted, however, that other filtering material may be employed with slight modifications. For example, filamentary tow formed of other materials such as polyethylene, polypropylene, and the like, or even non-woven staple fibers may be used. It should be understood, however, that cellulose acetate filamentary tow is the preferred material from a commercial standpoint. In this sense, filter plug 114 is fabricated from conventional material to function as a smoke-pervious filter plug for trapping solid particulates in the smoke passing therethrough.

Unlike many conventional air dilution filters, filter plug 114 is not circumscribed by a non-porous or smoke-impervious plug wrap between the plug and tipping paper 116. Rather, the air-impervious tipping paper 116 is applied directly to the plug 114 and a portion of tobacco rod 112. Tipping paper 116 circumscribes filter plug 114 along the entire length of the plug. There are no ventilation holes provided in tipping paper 116 so that ambient air cannot enter the filter plug through the tipping paper 116 nor can smoke from the plug 114 egress through the tipping paper. The tipping paper 116 in addition to securing the smoke receiving end of plug 114 to one end of tobacco rod 112 in concentric end-to-end relation, also serves to conduct ambient air into the smoker's mouth which each puff on the cigarette. Specifically, the diagrammatic representation of plug 114 in Figure 16 shows the tipping paper 116 partially torn away. This is to represent the fact that the plug 114, for the embodiment of Figure 16, is not grooved prior to application of the tipping paper thereto. In other words, a plurality of grooves 118 are defined longitudinally in both the tipping paper 116 and plug 114, but are defined after the tipping paper is applied and the complete cigarette assembled. Grooves 118 are open to ambient along their entire length and extend from a predetermined point along the length of plug 114 to the smoke discharging end of the filter. In other words, after the cigarette has been made and cut, grooves are placed in the outside of the tipping paper, to a depth in plug 114, in accordance with the exact amount of dilution desired. The number of angularly spaced grooves 114 is also determined by the amount of dilution desired. As noted, the grooves extend from the smoke dis-

charging end of the filter to a length sufficient so that the smoker's lips will not normally extend longitudinally beyond the length of the grooves. For example, the grooves can extend the entire length of plug or rod 114 or some shorter distance, as desired. Thus, the cigarette 110 of Figure 16 can be fabricated by any conventional method and apparatus and, after it is fabricated, passed through a crimping mechanism to form grooves 118, as desired.

It is important to note that the grooves 118, rather than being covered so that access is provided through a porous material or through ventilation holes, is open along its entire length. Since the grooves are recessed with respect to the outer periphery of the tipping paper, the grooves provide passages through the lips of the smoker which engage the outer periphery of tipping paper 116. These passages conduct air into the mouth of the smoker with each puff or draw at the smoke discharging end of the filter. The absence of barriers or restrictions to the flow reduces flow impedance as compared to prior art dilution filters and thereby permits better control of the air dilution technique. In addition, since the plug wrap normally disposed between the tipping paper and the filter rod is eliminated, the cigarette 110 is simpler and less costly to manufacture.

As described, in the fabrication of cigarette 110 of Figure 16, the grooves 118 are formed simultaneously in filter rod 114 and tipping paper 116. In cigarette 120, illustrated in Figure 17, filter rod 124 is pre-grooved with grooves 128 before application of the tipping paper 126 to secure tobacco 122 to the filter rod. In order to assure that the tipping paper 126 conforms to the grooves 128 in the filter rod, a vacuum system is employed as part of the

tipping wrap machine to draw a vacuum upon the completed cigarette before the adhesive has dried. In this manner, the tipping paper is forced to conform to the pre-grooved periphery of filter rod 124. With respect to the appearance of the final product to the naked eye, cigarettes 110 and 120 appear identical. Cigarette 120 functions in the same manner as cigarette 110 so that the grooves 128, to which tipping paper 126 conforms, conduct air directly into the mouth of the smoker with each puff along with smoke filtered through rod 124.

Another cigarette embodiment 130 of the present invention is illustrated in Figure 18. Tobacco rod 132 is secured in end-to-end relation with filter rod 134 as in the embodiments of Figures 16 and 17. However, filter rod 134 is circumscribed along its entire length by a non-porous or smoke-impervious plug wrap 135. It will be recognized by those familiar with this art that the smoke-impervious plug wrap includes smoke-impervious outer surfaces of foamed material which are integral with the filter plug as well as smoke-impervious wrapping material, which is not integral with the filter plug. Plural grooves 138 are defined in the plug wrap 135 and plug 134 and take the form of recesses having their depth dimension extending radially inward from plug 134 and their length dimension extending from the smoke discharging end to a length sufficient to avoid the entire length of grooves 138 being disposed in a smoker's mouth during use. A ring of tipping paper 136 is disposed about the junction between the filter rod 134 and tobacco rod 132 to join the two rods together. Tipping paper 136 differs from tipping paper 126 and tipping paper 116 in that it is much shorter in axial length and is not grooved. Rather, the grooves 138 are defined in the smoke-impervious plug wrap 135 and extend into the filter 134, as

described. Air dilution is effected in cigarette 130 in the same manner described above for cigarettes 110 and 120 of Figures 16 and 17, respectively. Specifically, grooves 138 in the plug wrap 135 are exposed to ambient and provides passages passed the smoker's lips and into the smoker's mouth. Ambient air is therefore drawn into the smoker's mouth with each draw or puff so that the ambient air enters in parallel to the filtered smoke passing through the smoke discharging end of the filter and into the smoker's mouth.

Although cigarette 130 employs a plug wrap whereas the plug wrap is eliminated in cigarettes 110and 120, the savings on the amount of tipping paper employed may, in some cases, make up the difference in cost. Moreover, since normal tipping paper is placed directly in the mouth, the requirements therefor are considerably more stringent than would be the case in the simple ring tipping paper application for cigarette 130. In other words, less expensive material can be used for tipping paper 136 and for tipping papers 116 and 126.

Referring now to Figure 19 of the accompany drawings, another cigarette embodiment 140 is illustrated in accordance with the present invention. Like cigarette 130, a tobacco rod 142 is joined to a filter rod 144 which has plug wrap material 145 circumscribing its entire length. A ring of tipping paper 146 covers only a short length of both the filter rod and tobacco rod to join the two end-to-end in concentric relation. Filter rod 144 and plug wrap 145 are contoured to the shape of a cigarette holder in the manner described above in connection with Figs. 1 to 15.

Specifically, the generally cylindrical filter rod 144 remains generally cylindrical from its smoke receiving end to a location axially displaced therefrom and then is tapered to form a generally rectangular cross-section. A raised lip 147 at the smoke discharging end, also having a rectangular cross-section, fits the smoker's lips to provide a cigarette holding function. Grooves 148 are defined longitudinally along the filter 144, into the plug wrap 145 and filter rod 144. In the case of the embodiment illustrated, wherein the rectangular cross-section of the filter near the smoke discharging end has two long sides and two short sides, the grooves 148 are defined in the short sides. It should be noted, however, that a square configuration may also be provided in which case the grooves would be provided in all four (4) sides.

The grooved filter 144 and plug wrap 145 may be fabricated by either of the two methods described above with reference to Figs. 9 to 15. Specifically, as described with respect to Figures 9-13, one method forms the cigarette holder shape and the grooves 148 in the filter rod 144 after it is wrapped with plugwrap 145. Alternatively, as described in relation to Figures 14 and 15, the filter rod 144 may be pre-shaped and pre-grooved and the plugwrap extruded thereover in the form of a plastics film which conforms precisely to the tapered and grooved periphery of the filter rod. In either case, the operation of the filter 140 is substantially the same as the filters described in relation to Figs.16 to 18. In other words, groove 148 is exposed to ambient air and provides a passage for that air into the smoker's mouth,past

the smoker's lips. With each puff or draw on the cigarette, the smoker draws in filtered smoke from the smoke discharging end of filter 144 and ambient air via grooves 148.

Figures 20-26 illustrate end views of various grooved filters in accordance with Figures 16-18. These views are provided to show that substantially any number of grooves, with substantially any spacing therebetween, may be provided. For example, cigarette 150 of Figure 20 shows filter rod 154 and tipping paper 156 provided with a single groove 158 at the smoke discharging end of the filter. Of course, if cigarette 150 is made in accordance with the principals of cigarette 130 of Figure 18, element 156 would, instead of being tipping paper, be plug wrap material.

Likewise, cigarette 160 of Figure 21 shows filter 164 and tipping paper 166 provided with two diametrically spaced grooves or recesses 168.

Cigarette 170 of Figure 22 shows plug wrap 175 and filter rod 174 provided with three equally spaced grooves or recesses 178.

Cigarette 180 of Figure 23 has filter rod 184 and plug wrap 185 provided with four 90°-spaced recesses or grooves 188.

Cigarette 190 of Figure 24 shows tipping paper 196 and filter rod 194 provided with five equally spaced recesses or grooves 198.

Cigarette 200 of Figure 25 shows plug wrap 205 and filter rod 204 provided with six equally spaced grooves or recesses 208.

Cigarette 210 of Figure 26 illustrates filter rod

214 and tipping paper 216 provided with eight equally spaced grooves or recesses 218. It should be noted that equal spacing between the grooves or recesses in any of the embodiments is not necessary; that is, the grooves or recesses can be grouped or spaced as desired around the periphery of the filter rod. Moreover, it is not mandatory, although simpler for fabrication, that the recesses or grooves extend longitudinally parallel to the axis of the filter rod. In other words, the recesses can be skewed relative to the filter rod axis, spiraled, etc.

For all of the filtered cigarettes of Figs. 16 to 26, the most important aspect is the fact that the air ventilation passage is exposed to ambient throughout its length so that air does not have to pass through porous tipping paper or restricted ventilation openings in non-porous paper. The unimpeded air flow into the smoker's mouth with each draw or puff permits accurate control over the air dilution to a degree not possible in the prior art devices. Since the air passage is open to ambient along its entire length, the filter rod requires only one wrap along its entire length, whether the wrap be the plug wrap or the tipping paper. When the plug wrap is used, only a short axial length of tipping paper is required to join the filter plug to the tobacco rod. The result is a cigarette which is simpler and less expensive to manufacture than prior art air dilution filtered cigarettes.

Referring to Figures 27 and 28, a filtered cigarette according to the present invention is generally designated by the reference numeral 310. Cigarette 310 includes a tobacco rod 312 and a filter element 314 constructed in accordance with one embodiment of the present invention. A ring of tipping paper 316 joins the tobacco rod 312 and filter element 314 in axially aligned end-to-end abutment. The tipping paper 316 has a relatively short axial length and extends only a short axial distance along the tobacco rod 312 and the filter element 314. The whole purpose for the tipping paper 316 is to join the tobacco rod 312 and filter element 314; other means of joining these two members may be employed.

The filter element 314 is a generally cylindrical plug of conventional tobacco smoke filter material and is typically made from continuous tow of cellulose acetate filamentary material. It should be noted, however, that other filter material may be employed with slight modifications. For example, filamentary tow formed of other materials such as polyethylene, polypropylene, and the like, or even non-woven staple

fibers may be used. It should be understood, however, that cellulose acetate filamentary tow is the preferred material from a commercial standpoint. In this sense, filter plug 314 is fabricated from conventional material to function as a smoke-pervious filter plug for trapping solid particulates in the smoke passing therethrough. Filter plug or rod 314 is circumscribed along its entire length by a smoke-impervious or non-porous plug wrap or overwrap 318. An important aspect of this filter of the present invention resides in the fact that the overwrap 318 is extruded about the filter plug 314 in the form of a film. In the preferred embodiment, if the filter material is cellulose acetate filamentary tow, then the extruded film is made of cellulose acetate also. In general, the preferred embodiment of the present invention employs the same material for the filter rod and the filter overwrap.

It is important to note that the overwrap film 318 is strictly that, namely, an overwrap. It should not be confused with prior art attempts to extrude entire filter structures, which attempts have proven largely unacceptable from a commercial point of view. Thus, whereas the filter rod 314 has a diameter on the order of 0.25 inches, the thickness of the overwrap film 318 is on the order of 0.25 mils to 2.5 mils and is therefore between 100 and 1,000 times less than the filter rod diameter.

By using an extruded film overwrap having the same material as the filter rod itself, the chance of any foreign ingredients coming into contact with the smoke is virtually nil. Moreover, by introducing conventional plasticizers such as triacetin or any other conventional plasticizer used in cigarette filters, complete adherence of the bonded fibers to the film is assured. This eliminates the need for a sep-.

arate adhesive material which is required to hold paper overwrap to a filter rod. This not only reduces the cost of the adhesive material but also eliminates another material which could contact and contaminate the taste of the smoke.

A considerable material cost saving is provided when the film overwrap is made from the same material as is employed for making the filter rod. Specifically, using the same material permits re-cycling of the waste from the normal filter-making process. If the filter material is cellulose acetate, for example, all of the waste in making the filter rod is conventional acetate without paper overwrap. This cellulose acetate waste can be formed into granules or pellets and extruded as the overwrap film. This re-cycling is not possible if there is paper contamination in the cellulose acetate waste because molding-grade resin can not be achieved with paper contamination present.

The use of the tipping paper 316, as illustrated in Figure 27, may be dispensed with if another technique for bonding the filter rod 314 to the tobacco rod 312 is employed. In either case, the portion of the cigarette which contacts the lips of the smoker is the overwrap material 318 which is smooth and does not stick to the smoker's lips as does paper coating. In addition, the overall surface character of the filter is commercially advantageous with respect to paper overwrap. It should also be noted that the thin film provides structural strength so as to permit high speed filter fabrication operation. Even a very thin film overwrap is sufficient to compress an oversized rod and provide the structural strength necessary for both high speed production and desirable smoking characteristics.

Although the cigarette illustrated in Figures 27 and 28 has no provision for air ventilation of the filter, it is clear that holes may be provided in the overwrap film 318 in order to provide ventilation communication between the filter rod 314 and ambient air.

The cigarette filter embodiment illustrated in Figure 29 shows a tipping paper overwrap circumscribed about the entire length of the extruded overwrap film 318, as well as a portion of the tobacco rod 312. In all other respects, the filter arrangement of Figure 29 is identical to that illustrated and described in Figure 27. It is possible, of course, to deform the filter rod of Figure 29 in the manner described with reference to Figures 1 to 15, in which case the tipping paper 320, suitably provided with ventilation holes, defines a ventilation passage with the deformed portion of the filter rod. The result is air dilution of the smoke, a feature which has gained some popularity in the tobacco industry in recent years.

Referring to Figure 30 specifically of the accompanying drawings, a filter rod such as that illustrated in Figure 29 is shown in section and is provided with a plurality of ventilation holes extending through the paper tipping 320 and the film overwrap 318. As noted above, the tipping paper 320 can be eliminated and the holes can extend through the overwrap film 318 alone. The holes serve to admit air into the smoke as the smoker draws on the exposed end of the filter rod, thereby providing a degree of air dilution determined by the number and size of the apertures. The overwrap film can be perforated at the same time that the tipping paper 320 is perforated by any techniques well known in the prior art for this

purpose. However, the most uniform perforation method is with lasers.

A method and apparatus for fabricating the filter elements of the present invention is illustrated in Figure 31, to which specific reference is now made. Basically, the fabrication technique is similar in many respects to those already described and referred to.

The filtering material utilized in this production of filter elements is a continuous filamentary tow designated generally by the reference numeral 340. This filamentary tow 340 includes a multiplicity of bondable fibrous members activated by contact with a hot fluid such as steam. Filtering material 340 is continuously passed into and through an elongated bonding zone which includes a conventional stuffer jet 340 and steam head 342, similar in nature to those illustrated and described in the various above-mentioned patents. Following the steam treatment, the resulting rod is cooled at cooling head 343 before being passed through a pulling device 351. Upon leaving the pulling device, the unwrapped rod is passed to a vacuum chamber 382 after which the rod is passed to an extruder and tube die 383, the latter being described in greater detail below with reference to Figure 32.

In the extruder and tube die 383, a film of plastics material is extruded over the filter rod so as to conform to the exact shape of the rod. Any suitable smoke-impervious plastics film may be utilized for this purpose and, in the preferred embodiment, is cellulose acetate. The wrapped rod then passes through a water bath 384 to a pulling device 385 before being cut into individual filter plugs at cutter head 386.

Referring specifically to Figure 32 of the accompanying drawings, the vacuum chamber 382 is illustrated with the unwrapped rod 387 passing through a bore 388 extending longitudinally therethrough. The inlet end 389 of bore 388is flared to provide a flow outlet which expands in the direction opposite the translation direction of rod 387. Bore 388 is somewhat larger in diameter than the diameter of rod 387 so that air can flow in an annular path through bore 388 in opposition to rod movement. In order to withdraw air from bore 388, an annular nozzle is provided at the point where bore 388 begins to flare in portion 389. The annular nozzle is fed by air under pressure which aspirates air from the bore 388 and out through the flared outlet 389. As a consequence, an extremely low pressure is provided in bore 388. A portion of the vacuum chamber 382 extends into the extruder and tube die member 383 such that bore 388 communicates coaxially with a similarly provided bore 390 in the tube die and extruder member 383. Rod 387 passes through bore 390 which is aspirated by the annular nozzle 391 in the same manner as bore 388.

Plastic is fed into the tube die and extruder member 383 by a nozzle 392 which feeds the plastic in its molten form to an annular nozzle 394 disposed concentrically about the outlet of bore 390. The low pressure region formed around rod 387 in bore 390 causes the annular flow of plastics film from the nozzle 394 to surround and conform to the rod as the rod egresses from the tube die and extruder member 383. This plastics film 395 constitutes the plug wrap 318 described above in relation to the embodiment illustrated in Figures 27 to 30.

The method described in relation to Figures 31 and 32, whereby the vacuum draws the plastics film to the

exact shape of the filter rod and permits the smoke-impermeable film to conform to the deformed rod, is considerably cheaper than the conventional plug wrap approach wherein paper is used as the plug wrap. The film 395 is generally extruded to a thickness between 0.25 mils and 2.5 mils, the thickness being controlled by varying the speed ratio between the formed rod and the extruded film.

As noted above, when the filter material 340 and the film 395 are the same, any waste material which is formed during the normal manufacturing process can be re-cycled as the extruded overwrap film 395.

Although the filter rod formed as part of the process illustrated in Figures 31 and 32 is cylindrical, the cylindrical periphery can be deformed in the manner described with reference to Figures 1 to 26 in order to achieve air dilution characteristics for the filter.

The apparatus for forming the filter according to the present invention runs more efficiently than do prior art filter fabricating machines because there is no requirement to slow down or stop to change the plug wrap. In fact, with tow splicing equipment incorporated, the machines are capable of running at 100% efficiency around the clock.

Another advantage to using cellulose acetate film as an overwrap for the cellulose acetate tow material is that it may be formulated with a plasticizer to produce a flexible film which prevents formation of air pockets associated with tipping in the paper-wrapped filters. These pockets are caused by the differential in size between the filter and the cigarette. Since paper does not conform, it wrinkles and causes these

air pockets to form. The thin film-wrapped filters of the present invention, however, do not require the close circumferential tolerance required by paper-wrapped filters. Using the present invention, cellulose acetate filter rods of 100 millimeter length can be wrapped at a material cost of about 4 p per thousand rods. The least expensive paper wrap has a material cost of 10 p per thousand rods and sometimes varies as high as 20 p per thousand rods, without even considering the cost of glue and other additives employed in conjunction with the paper wrap to produce a satisfactory filter.

Instead of the cellulose acetate, another material which is suitable for use for the plastic film overwrap 318 is Surlyn which is an ionomer sold by DuPont. An ionomer is an ionically cross-linked thermoplastic polymer. The Surlyn ionomer resins are derived from ethylene/methacrylic acid copolymers. This material is a heat seal polymer with high clarity, melt strength and solid state toughness and resistance to oil/fat permeation. Surlyn is available as either a sodium or zinc ionomer, and although all grades generally offer the above properties when compared to other heat-seal polymers, sodium ionomers are known for exceptional toughness and resistance to fats and oils while zinc ionomers exhibit outstanding adhesion to unprimed foil and possess excellent chemical resistance.

Another possible material for the film overwrap is Elvax, an ethylene-vinyl acetate copolymer resin manufactured by DuPont. The vinyl acetate units in the copolymer modify the basic polyethylene structure and properties. By varying the vinyl acetate content and the molecular weight (melt index), properties can be

tailored for specific applications.

A variety of different materials can be employed, but it must be stressed that the advantage of using the same material for the overwrap as for the filter rod provides both cost advantages and taste advantages which are not possible in the prior art.

Accordingly the invention provides a tobacco smoke filter comprising a rod of smoke filter material having a thin plastics sleeve extruded therearound, the outer surface of the sleeve conforming to the outer surface of the rod; it also provides a method of making a tobacco smoke filter which comprises providing a rod of smoke filter material, and forming a sleeve around the rod with application of suction via the rod so that the sleeve conforms closely to the outer surface of the rod.

C L A I M S :

1. A tobacco smoke filter comprising a rod of smoke filter material having a thin plastics sleeve extruded therearound, the outer surface of the sleeve conforming to the outer surface of the rod.

2. A filter according to claim 1 wherein the greatest transverse dimension of the rod is at least 100 times more than the gauge of the sleeve.

3. A filter according to claim 1 or 2 wherein the rod and sleeve are of the same material.

4. A filter according to any of claims 1 to 3 wherein the rod is grooved.

5. A filter according to any of claims 1 to 4 wherein the rod is deformed to a smaller cross-sectional area over part of its length.

6. A method of making a tobacco smoke filter which comprises providing a rod of smoke filter material, and forming a sleeve around the rod with application of suction via the rod so that the sleeve conforms closely to the outer surface of the rod.

7. A method according to claim 6 wherein, before application of the sleeve, the rod is grooved and/or has

a portion of its length deformed to a reduced cross-sectional area.

8. A method according to claim 6 or 7 wherein the sleeve is a film of plastics material extruded around the rod.

9. A smoke filter having smoke receiving and discharging ends and of the type in which a rod of smoke-pervious material is circumscribed with a rod wrap of smoke-impervious material which is in turn wrapped with air-impervious tipping means, wherein said tipping means is contoured to match the contour of said rod wrap for a first length of said element extending from said smoke receiving end, wherein said tipping means has a large contour relative to the contour of said rod wrap along a second length of said element extending from said smoke discharging end to define a space between said rod wrap and said tipping means, and wherein said tipping means includes ventilation holes defined therein at a location along said second length of said element for permitting air to flow into and through said space in response to suction applied at said smoke discharging end of said element.

10. A smoke filter comprising a smoke-pervious rod and smoke-impervious wrap means circumscribing said rod,

at least one groove formed in the rod means extending longitudinally of the wrap means from at least one end thereof and being fully open to ambient air along its entire length or part thereof.

11. A smoke filter according to claim 9 with the tipping means omitted.

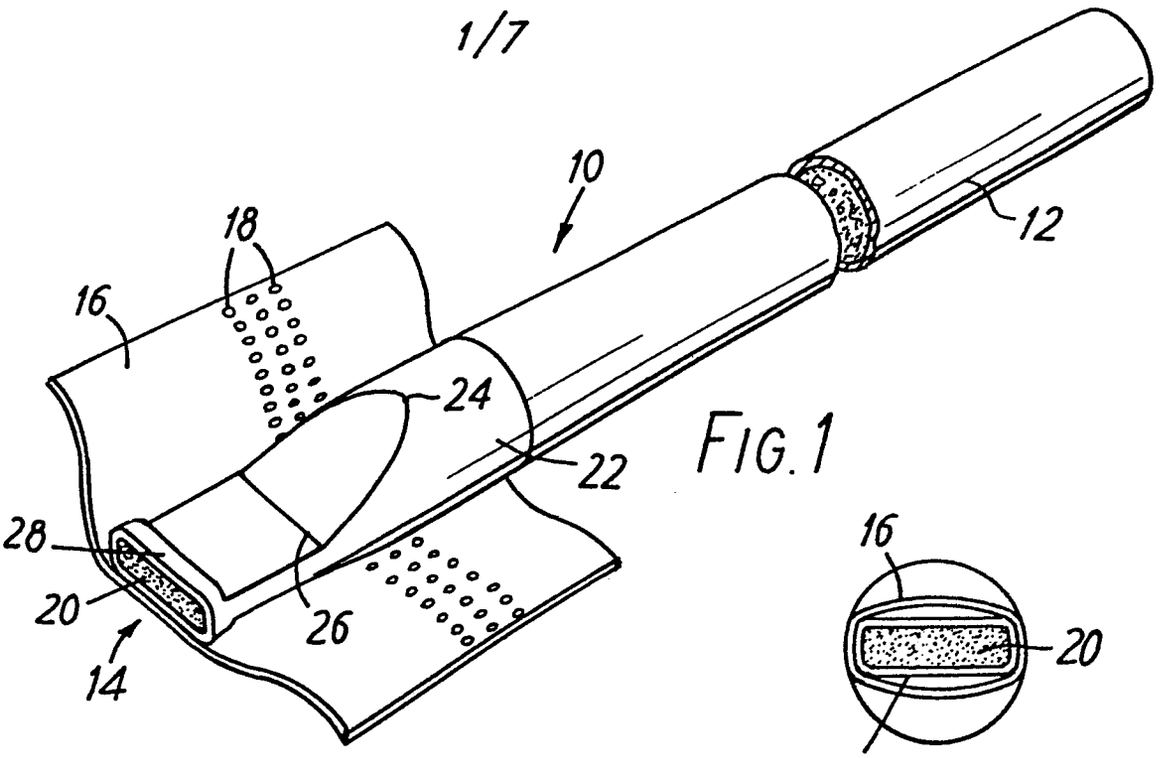

FIG. 1

FIG. 2

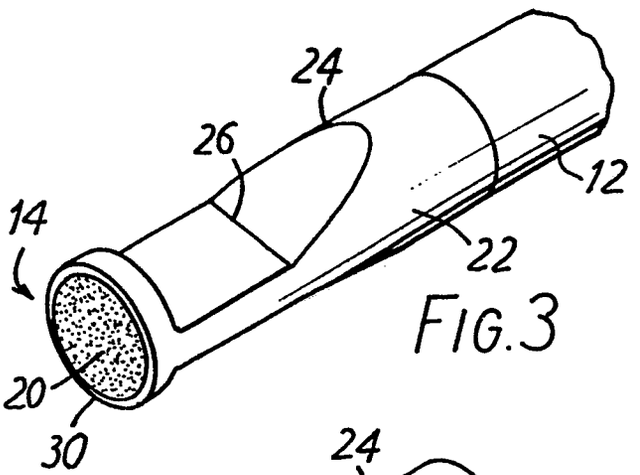

FIG. 3

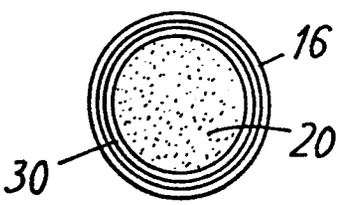

FIG. 4

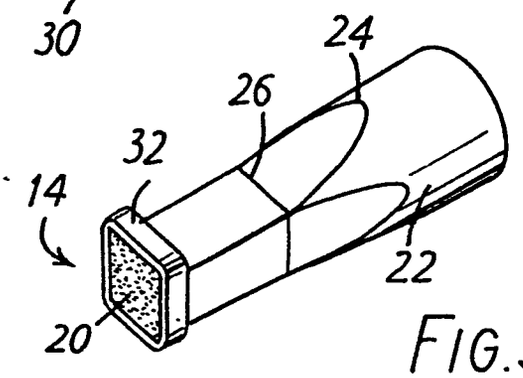

FIG. 5

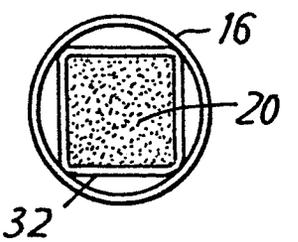

FIG. 6

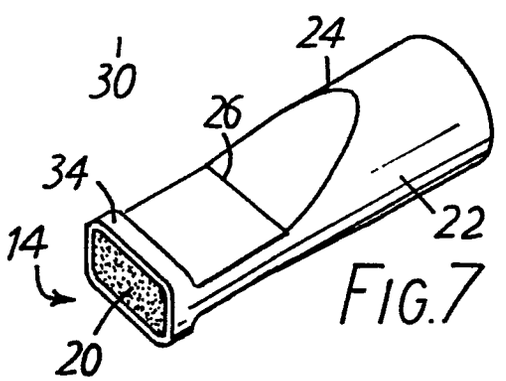

FIG. 7

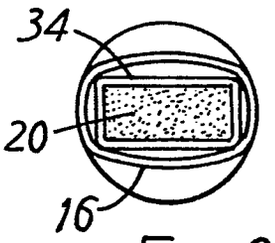

FIG. 8

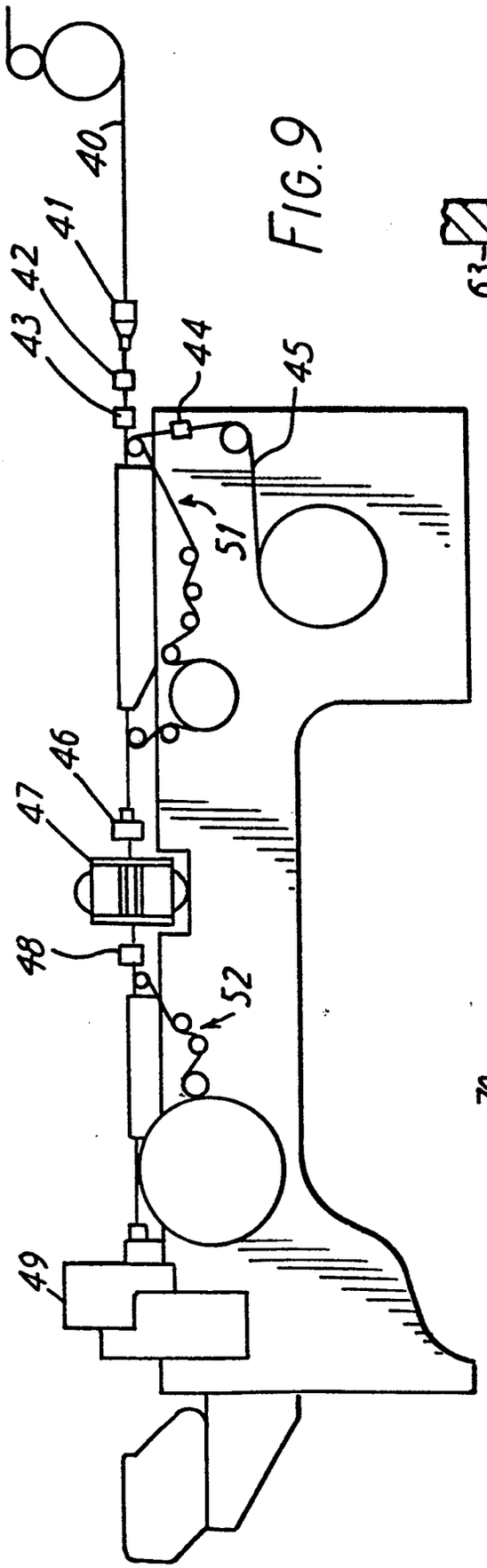

FIG.9

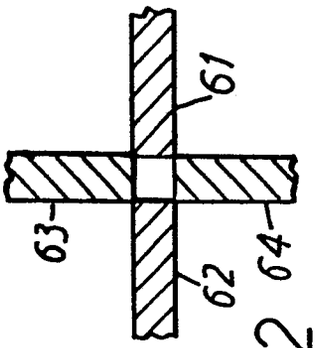

FIG.12

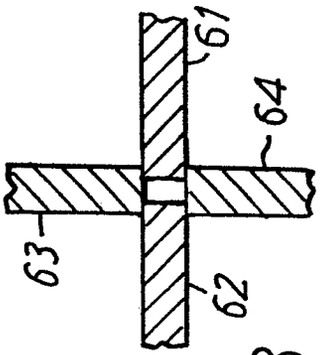

FIG.13

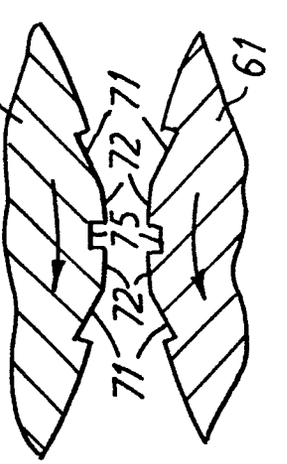

FIG.11

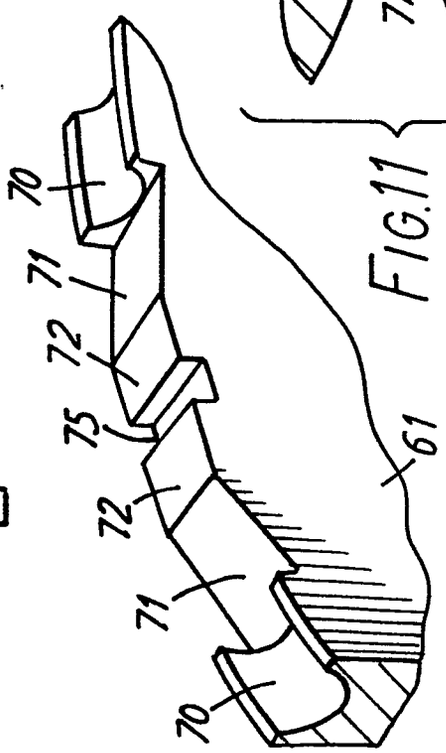

FIG.10

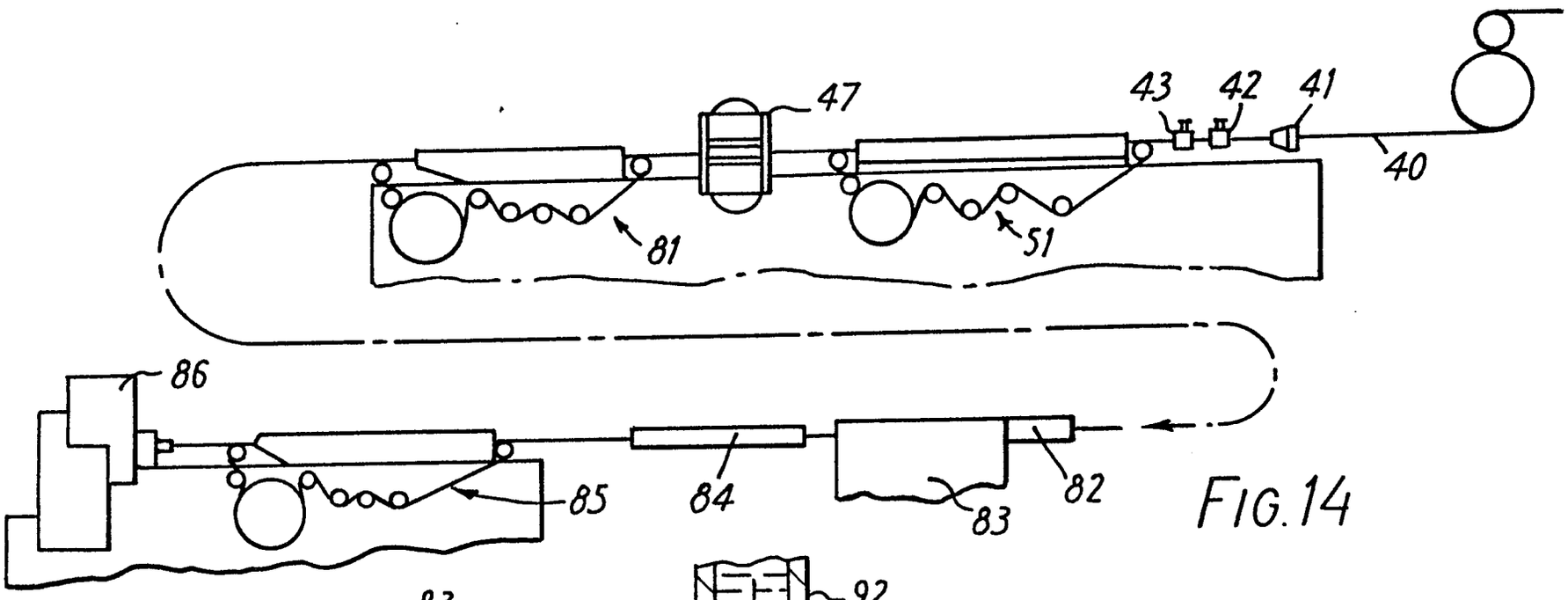

FIG.14

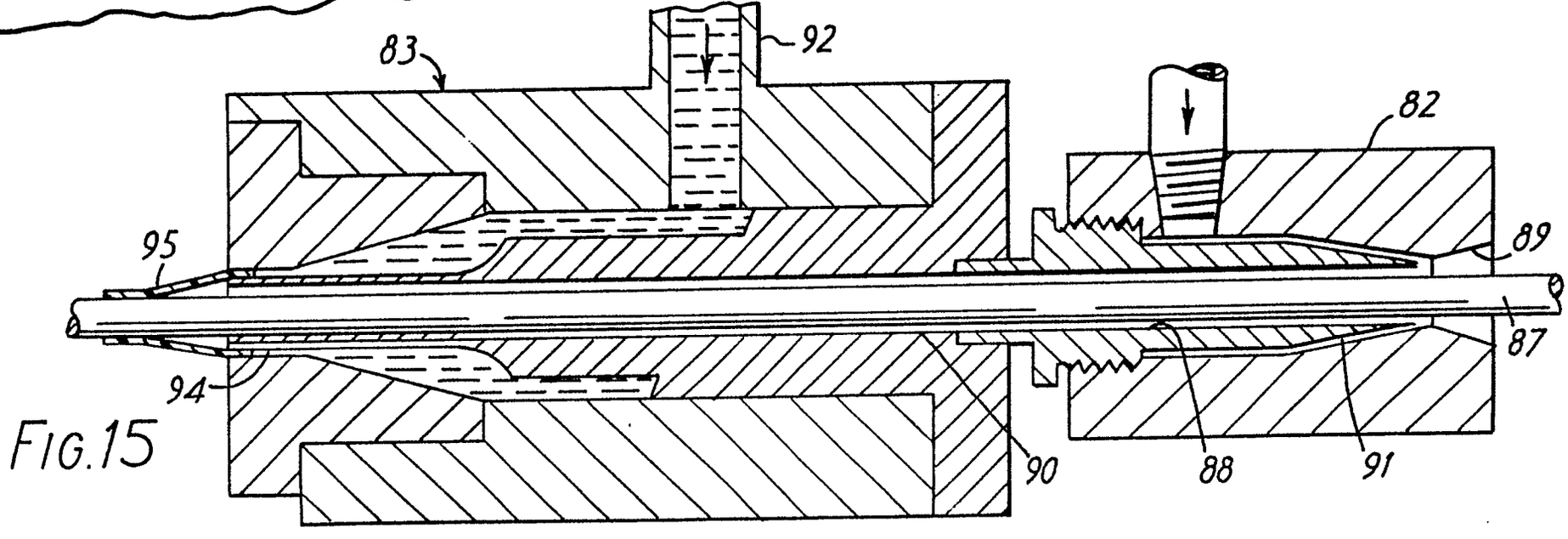

FIG.15

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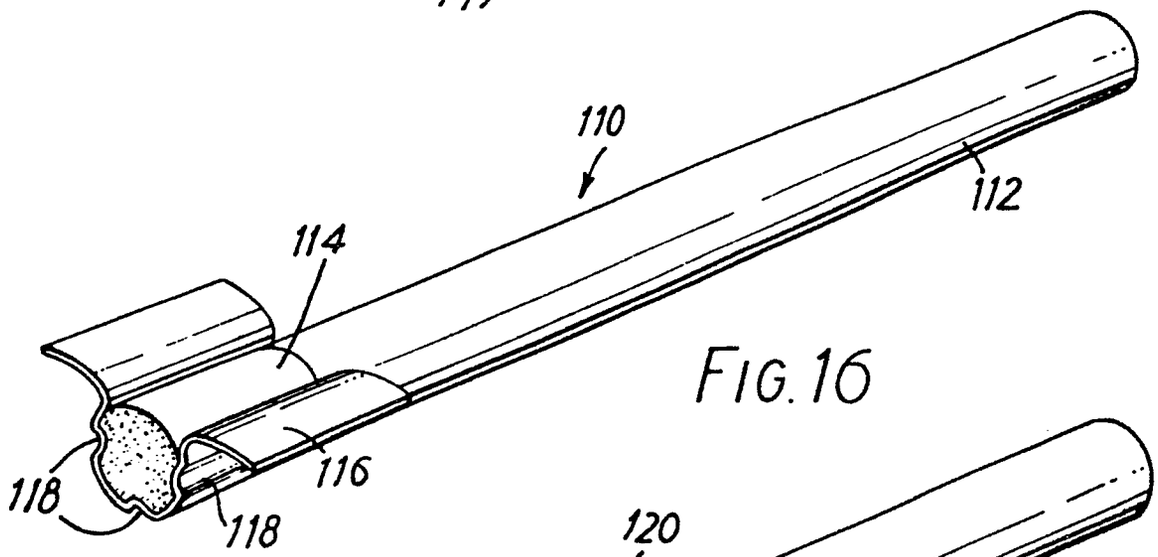

FIG. 16

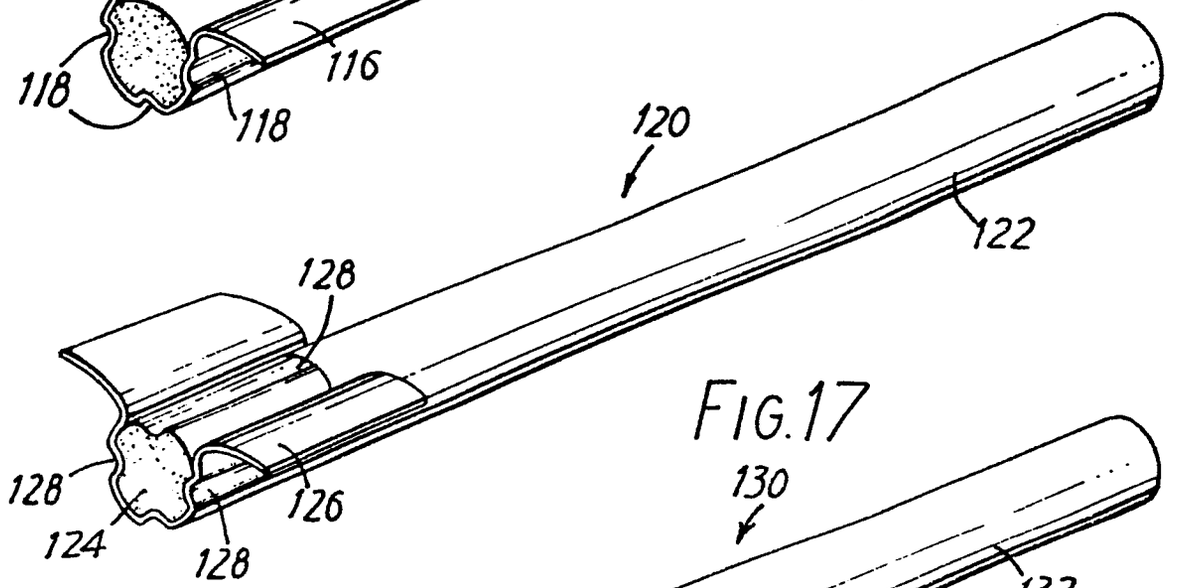

FIG. 17

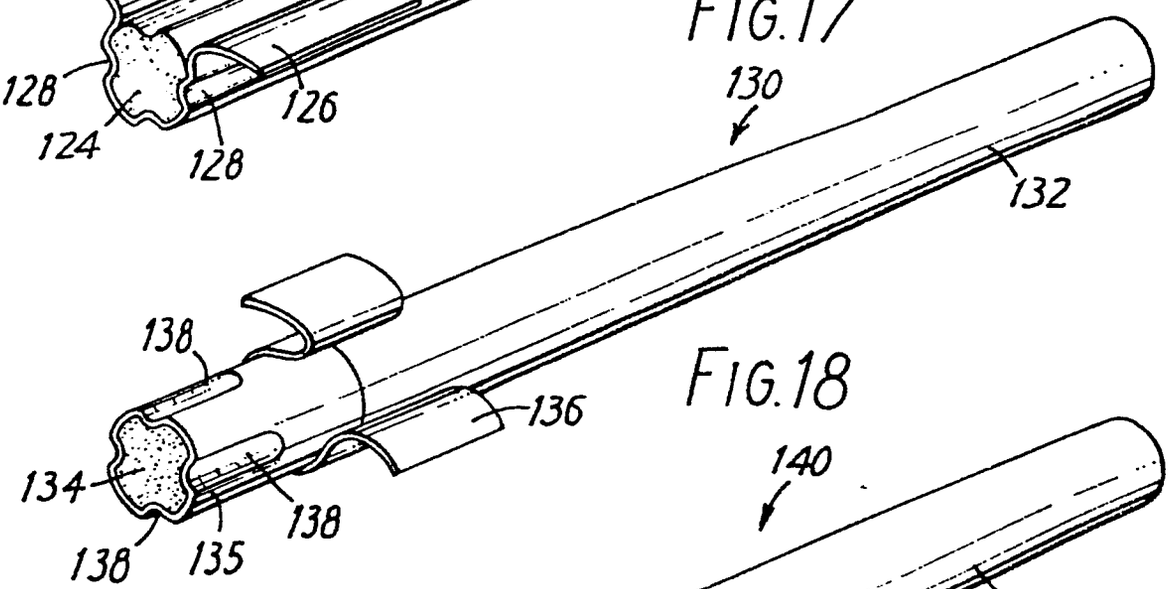

FIG. 18

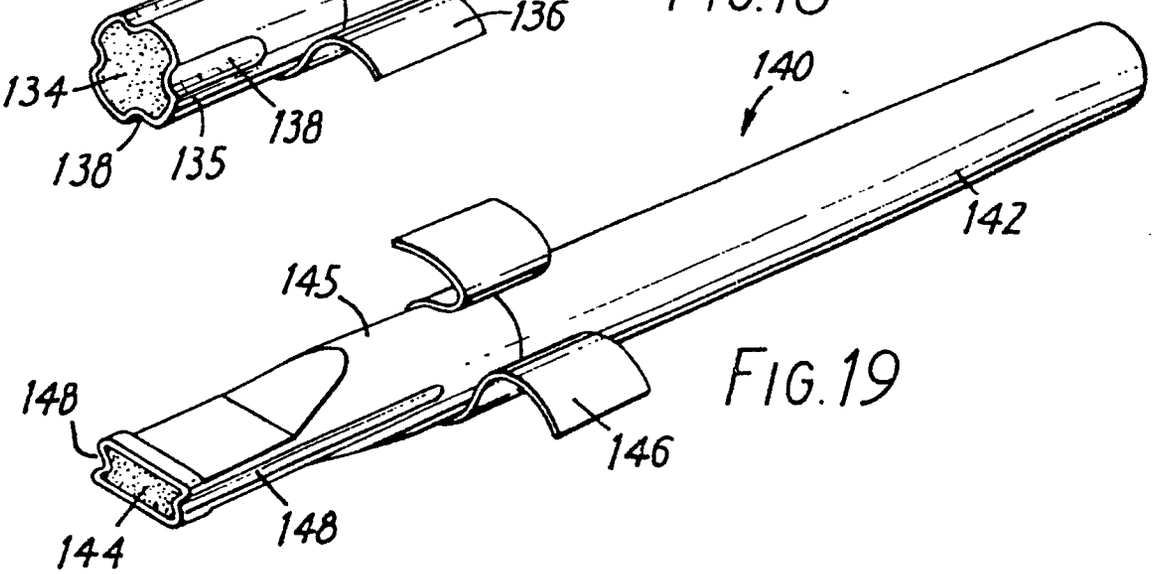

FIG. 19

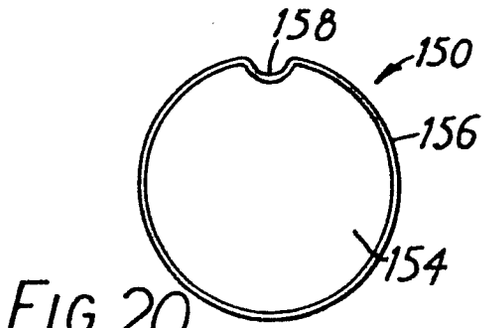

FIG.20

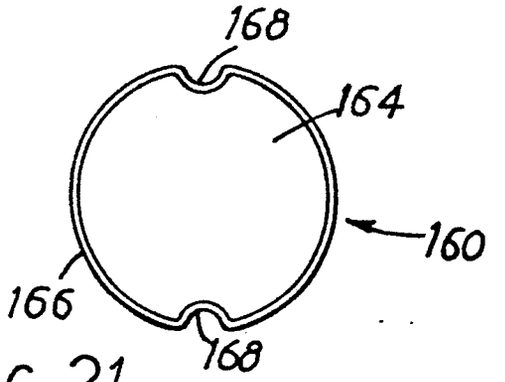

FIG.21

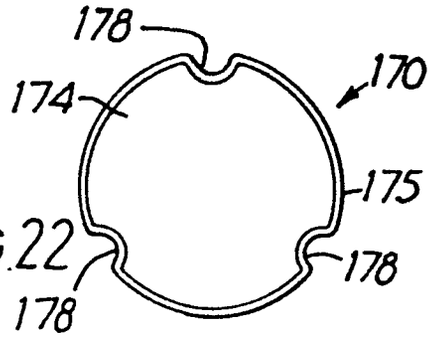

FIG.22

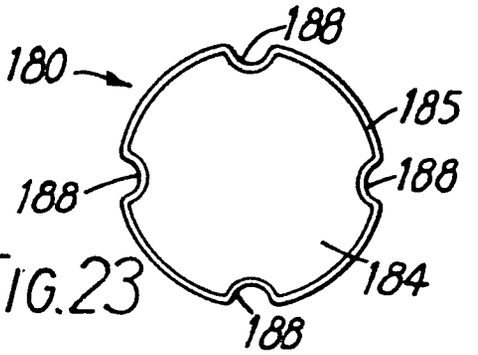

FIG.23

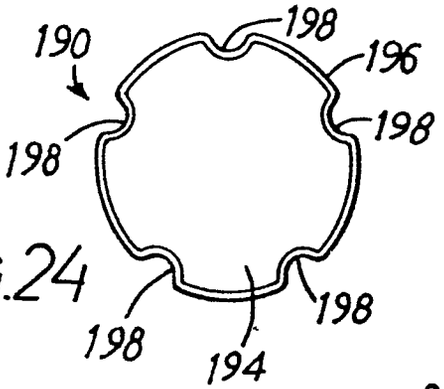

FIG.24

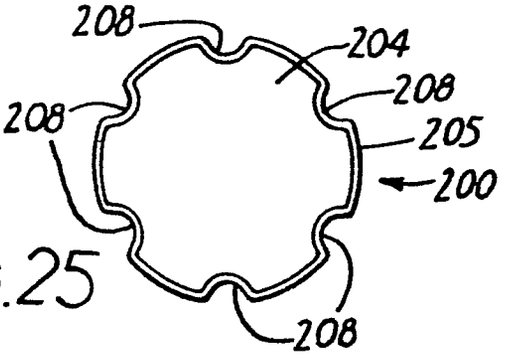

FIG.25

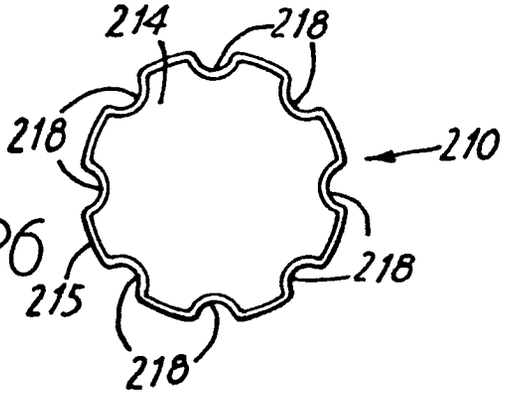

FIG.26

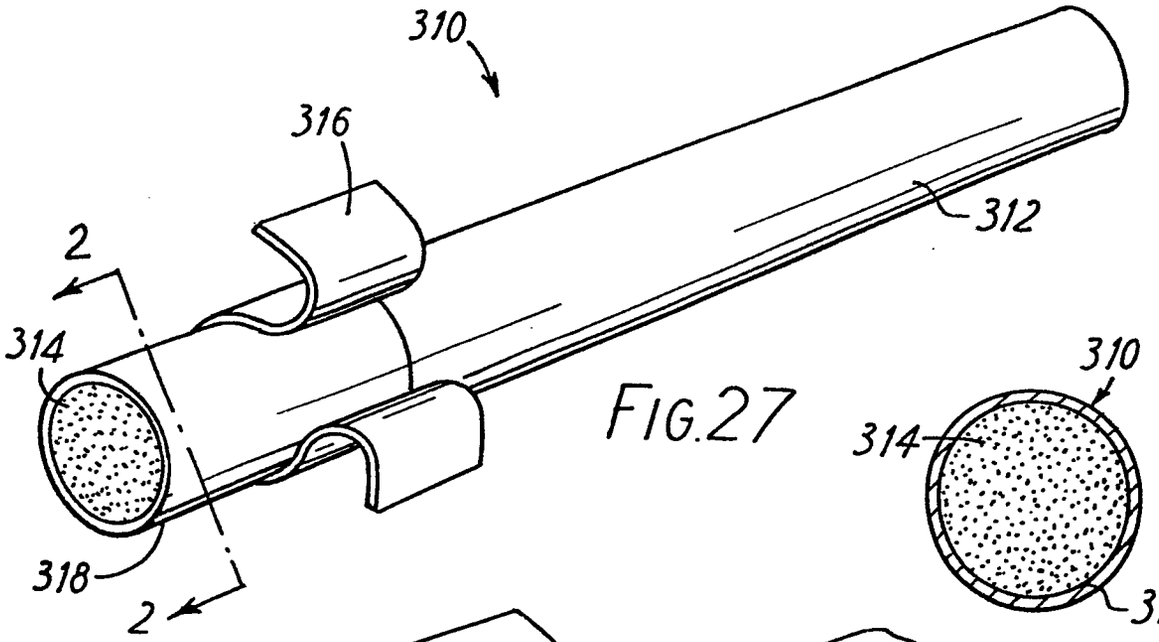

FIG.27

FIG.28

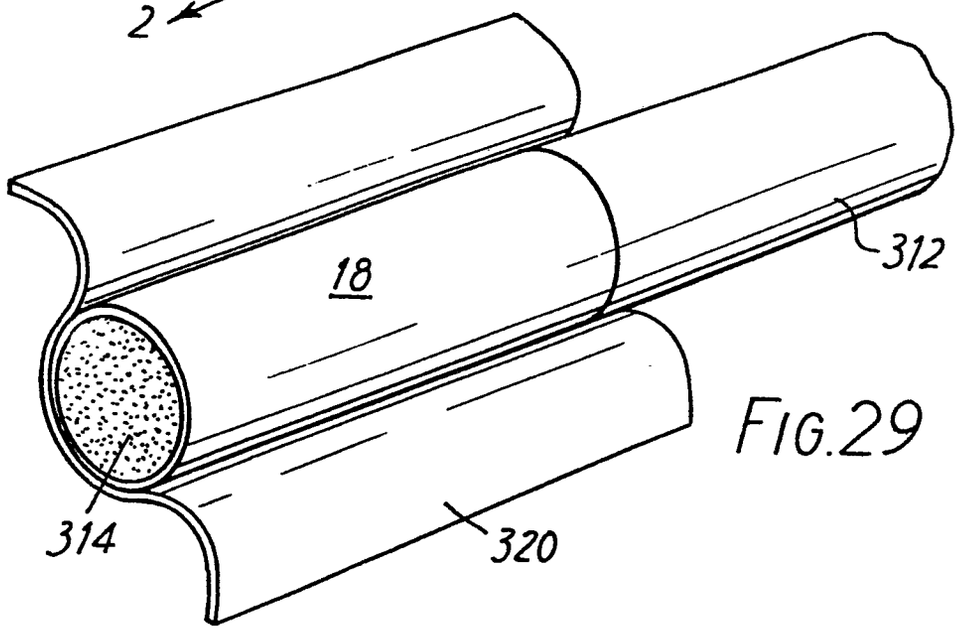

FIG.29

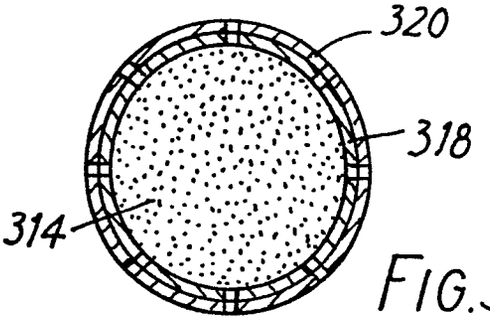

FIG.30

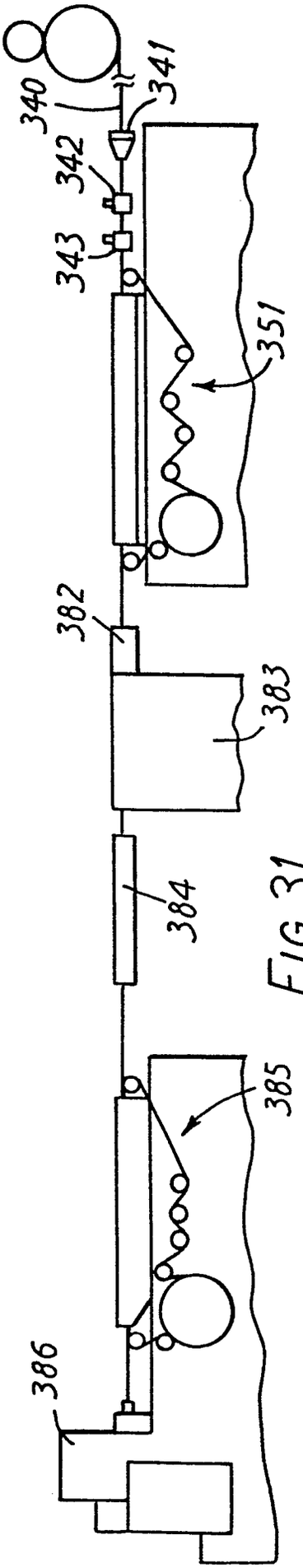
340
341
342
343
351
382
383
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FIG. 31

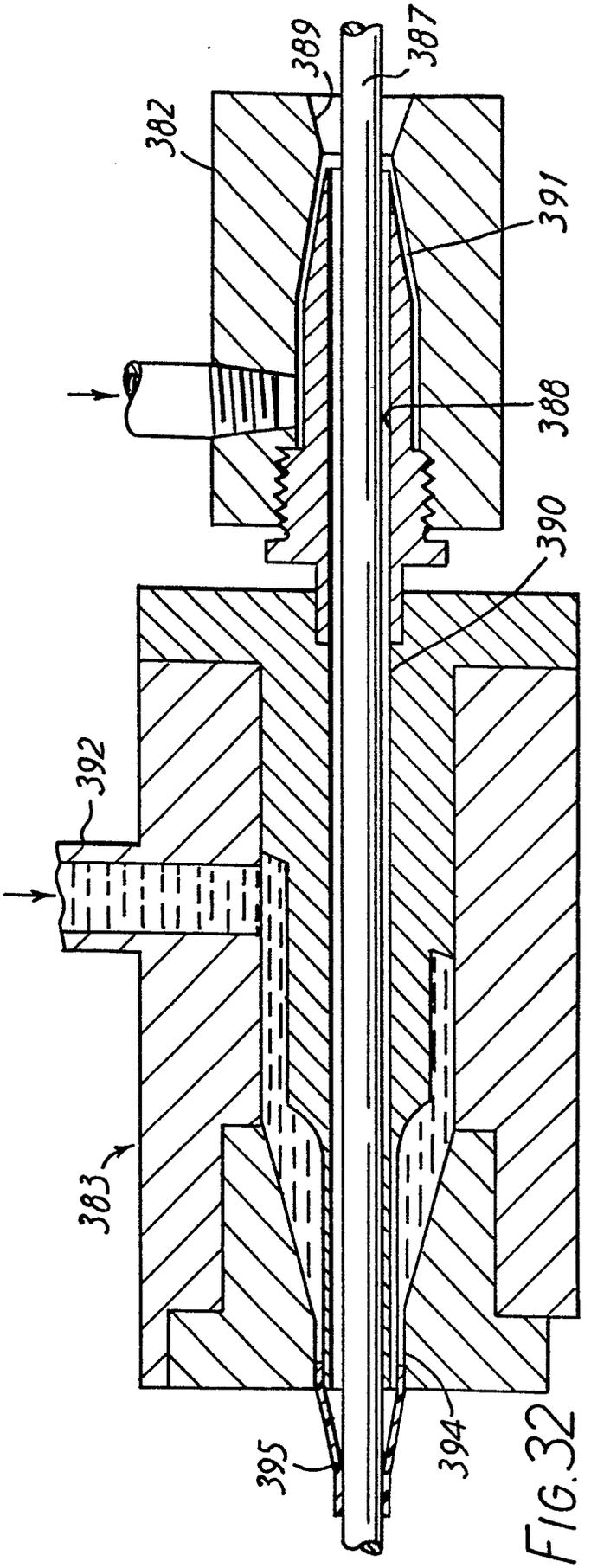
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FIG. 32