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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements relating to Tobacco-Smoke Filters

We, BRITISH-AMERICAN TOBACCO COMPANY LIMITED, of Westminster House, 7, Millbank, London, S.W.1, a Company incorporated under the laws of Great Britain, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns improvements relating to tobacco-smoke filters and particularly to a method for manufacturing such filters.

Among many substances suggested as desirable or advantageous in the manufacture of tobacco smoke filters, the use of foamed materials has evoked considerable interest, since these materials, while possessing good filtration properties, also possess the desirable features of low density and high resilience. However, it is a difficulty with such materials that grave technical problems are encountered when the production of continuous rods of filter material at high machine speeds is required.

An object of the present invention is to provide, in addition to an effective filter, a method and means whereby a continuous rod comprising foam material can rapidly and easily be manufactured.

According to the invention, a synthetic-foam filter material comminuted to a particulate form is fed to a moving band, generally a paper band, and is brought to filter-rod form while carried upon the said band, in which it becomes enrobed. In this method, either comminuted synthetic-resin foam material alone or such material mixed with a powdered or granular adhesive or bonding material may be brought to continuous filter-rod form while carried upon the band.

The foam is preferably a polyurethane-resin foam, although other synthetic-resin foams can be employed. The foam may be rigid or flexible and of open or closed cell structure. Suitably it is comminuted to a particle size of less

than 1.2 mm. and preferably less than 0.4 mm. Apart from polyurethane foam, foams prepared from polyvinyl chloride, polyolefines such as polyethylene, polystyrene, and copolymers such as polystyrene/acrylonitrile copolymers may be employed. Foams from polymeric materials formed by condensation of phenols, urea or melamine with formaldehyde are less desirable.

The powdered or granular adhesive material may be a thermoplastic or thermosetting synthetic-resin material, suitably a polyethylene resin. Alternatively, it may be a low-melting inorganic substance, suitably a hydrated salt of, for instance, phosphoric acid. By a low-melting substance is meant one with a melting point below 250°C. and preferably between 100 and 150°C. The particle size of the adhesive material is, suitably, less than 1.2 mm. and preferably less than 0.3 mm.

The adhesive material may constitute up to 80% of the total weight of the mixture with the comminuted foam. Suitably the ratio of comminuted foam to adhesive material may be between 4 to 1 and 1 to 4 by weight. If polyethylene resin is used as the adhesive material, the said ratio is preferably between 2 to 1 and 1 to 2. If sodium phosphate is employed, the ratio is preferably between 4 to 1 and 1 to 1. If desired, fibrous, granular or powdered fillers or modifiers may additionally be incorporated.

In one manner of carrying the invention into effect, a mixture of comminuted foam material and powdered or granular adhesive material is fed from a hopper in which it is maintained at a substantially constant predetermined level. Screw means or vibrating means may be employed to ensure even withdrawal of the mixture from the base of the hopper. Vibrating means may also serve substantially to eliminate aggregation as well as to feed the mixture to a point where it is allowed to fall onto the surface of the band moving, say, along the

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bed of a conventional cigarette-making machine. Advantageously, the said surface may have been coated with a heat-activateable thermoplastic adhesive layer which is subsequently rendered partially adhesive by heating means. The material on the band passes to a station at which its upper surface is levelled and voids in the material are reduced. A reciprocating levelling device may be employed, but it is preferred to use a wheel with a toothed or coarsely milled periphery which is rotated, in contact with the surface of the material, in the opposite direction to the movement of the band. The moving band supporting the material passes to a compression station and then to heating and shaping stations in which it becomes partially wrapped around and adhered to the material and the material is pressed to give firm attachment of the adhesive particles to the foam particles and to ensure desirable firmness and permeability characteristics in the completed rod. The shaping may be performed conventionally with the assistance of a sequence of heating and cooling dies, the resultant continuous rod of filter material wrapped in the band being finally cut into sections of the length of an individual filter or a multiple of that length.

In another manner of carrying the invention into effect, the comminuted foam, with or without powdered or granular adhesive material, is simply brought to filter-rod form while carried on the band by feeding the material on the band directly into the garniture of a conventional cigarette-making machine. There is then no need to apply the above-mentioned adhesive coating to the band surface. Even if an adhesive material is mixed with the foam material, there is also no need for immediate heating, as the adhesive material can be activated by subsequent heating whenever and wherever this may be convenient.

Although polyurethane foams available commercially exhibit differences due to their composition and physical structure, they all, in a particulate form, possess a marked selectivity for hydrogen cyanide, as well as being capable of removing considerable proportions of other smoke constituents, including steam-volatile phenols. It is surprising, moreover, that the filtration characteristics of the particulate foam material are dependent, for any value of pressure drop through the filter, upon the particle size. Consequently the said characteristics can be varied, without changing the pressure drop, by altering the particle size of the said material. The proportions of different smoke constituents removed can also be influenced by the selection of the chemical composition and/or physical characteristics of the originating foam material employed. Such influence can also be exercised by the selection of the adhesive material. For instance, sodium phosphate enhances the removal of hydrogen cyanide, while favouring the passage of nicotine.

A required pressure drop can readily be obtained by variation of the rate of feed and extent of compression of the foam material during production of the filter rod. Preferably the pressure drop for a 7 mm. length of rod is between 15 and 20 cm. water gauge.

Filters produced by the method of the invention will preferably be used in conjunction with at least one section of conventional filter material at the mouth end or between two sections of such material.

Ways of carrying out the method of the invention and apparatus for the purpose will now be more fully described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 is a general diagram illustrating steps of one way of carrying out the method,

Fig. 2 a diagrammatic perspective view of apparatus used for some of the steps of Fig. 1,

Fig. 3 a diagram, similar to Fig. 1, illustrating another way of carrying out the method,

Fig. 4 a view similar to Fig. 2 of apparatus used for some of the steps of Fig. 3, and

Fig. 5 a similar view showing a third form of mixture-feeding device.

For the first form of the method, to be described with reference to Figs. 1 and 2, the foam material employed was a white polyurethane material, known by the Registered Trade Mark "Spandofam 200", supplied by the Baxenden Chemical Co. This is a rigid, closed-cell, foam of small cell size incorporating a flame retardant. Blocks of this material were sawn into strips of about 1 inch square cross-section and were fed to a disintegrator 1 (an 11 inch Christy Norris Disintegrator driven at 6,000 revolutions per minute) to produce about 8 lbs. per hour of coarsely milled material passing a screen of 6.5 mm. hole diameter. This material was comminuted in a hammer mill 2 (a Raymond mill of similar capacity to the disintegrator) so that it would pass a screen of 1.6 mm. hole diameter. The particle size of 90% of the comminuted foam was found to lie between 0.15 and 0.71 mm, the majority of the particles being between 0.15 and 0.42. This was the preferred range of size.

The adhesive material employed was crystalline trisodium orthophosphate dodecahydrate. The particle size of this material was reduced in a hammer mill 3 (the Raymond mill) to pass a screen of 0.65 mm. hole diameter. The particle size was preferably between 0.05 and 0.3 mm. The resultant material was thoroughly mixed with the comminuted foam particles in the proportion of 4 parts foam to one part trisodium phosphate by weight, using a tumble mixer 4 with a mixing time of 10-15 min. The mixture was passed to a hopper 5 fitted with a paddle agitator rotating at 5 revolutions per minute, the contents of the hopper being maintained at a constant depth of approxi-

mately 4 inches. From the hopper 5, of which the lowest part only is seen in Fig. 2, the mixture was fed by a screw feeder 6 (1 inch diameter and 1 inch pitch rotating at about 30 r.p.m.) to a chute 7 which guided it on to a moving flat band 8 of conventional filter-wrapping paper coated on its upper surface with thermoplastic adhesive material. This band, moving between side guides 9 (Fig. 2), passed over a heater 10 maintained at a temperature of 75°C, which activated the adhesive coating and caused attachment to the band of particles of mixture adjacent thereto. Simultaneously, the upper surface of the mixture held between the guides 9 and levelled by a wheel 11 driven, at adjustable speed, by a small electric motor 12 and mounted with its periphery about 12 mm. above the surface of the band. The wheel 11 consisted of two adjacent spur wheels (each of 2.5 inches diameter and $\frac{5}{8}$ inch width with 60 teeth each of about 1/16 inch depth), the teeth of the two wheels being offset. The wheel 11 rotated oppositely to the movement of the band and thus acted as a refuser wheel. The band with its levelled layer of mixture then passed to a compression station 13 comprising a sequence of four compression rollers 14—17 driven together, at adjustable speed, by an electric motor. The rollers 14—17, which were mounted so as to be vertically adjustable, were set at progressively smaller distances above the band 8, i.e. from 12 mm. to 6 mm. At least the rollers 14, 17 were provided with concave surfaces of 2 mm. depth. The rollers were of about 50 mm. outside diameter and 13 mm. wide. However, the diameter and width of successive rollers may be varied slightly and they may be made of different materials, for example the wheels 14, 15 of mild steel, 16 of a hard composition and 17 of brass. Preferably and as shown, a device 18 for eliminating static is provided beside the compression station 13. During its travel under the higher rollers 14, 15, the band 8 moved in a flat bed between the guides 9. During its travel under the lower rollers 16, 17, it passed into a curved trough 19 which brought it to a channel shape preparatory to being formed into rod-shape. The partially shaped band with the compressed mixture of foam granules and sodium phosphate then passed into a shaping die 21, and through a sequence of heating, shaping and cooling stations 22a, b c. This sequence may be similar to that described in our United Kingdom Patent No. 1,103,822. The wrapped filter rod thus produced was divided into lengths in known manner by cutting means 24.

For the form of the method now to be described with reference to Figs. 3 and 4, use was again made of a mixture of four parts by weight of comminuted foam particles and one part by weight of trisodium orthophosphate dodecahydrate, which mixture was pre-

pared in the manner described above with reference to Figs. 1 and 2.

In this case, however, the mixture was fed to a vibrating hopper 25 mounted in the position normally occupied by the tobacco-feed hopper of a conventional cigarette-making machine. The hopper 25 (Fig. 4) was conical in shape, its wall being inclined at 20° to the vertical, with a discharge opening at 26 of 3 inch diameter. The mixture falling from the hopper passed under a vertically adjustable gate 27 to a wide shallow trough 28 (20 inches long and 7 inches wide) of a horizontal vibrating feeder. Both the height of the gate 27 and the amplitude of vibration can be used to control the rate of feed of the mixture. Generally, the gate was set at a distance 29 of about 20 mm. above the trough 28, to give a feed rate of about 120 gm. of mixture per minute.

The material leaving the trough 28 fell down a short vertical chute 30 onto a band 8 of filter-rod wrapping paper moving between the side rails 31 of the machine, which formed guide walls for the band and the layer of mixture thereon. The band then passed under a levelling station 11 comprising a spur wheel 32 (4 inch diameter, $\frac{5}{8}$ inch wide and provided with 64 teeth about 1/16 inch deep). This wheel, disposed with its periphery 20 mm. above the band, was rotated at a peripheral speed of 90 feet per minute counter to the movement of the band, which was 60 feet per minute, so that it acted as a refuser wheel. It was independently driven by a small motor 33 with provision for speed adjustment. The band 8 and mixture then passed, in a converging section of the rails 31, to a station 13, where the mixture was compressed by the compression wheel 34 conventionally used in the machine, except that the wheel had been provided with a peripheral concavity 2 mm. deep and independent driving means comprising a variable speed motor 35 and chain drive 36. The wheel 34 was rotated at a peripheral speed of about 50 feet per minute, 8 mm. above the band 8. The band and mixture then passed through the conventional shoe 37, tongue piece 38 and garniture 39 of the machine and were thereby formed into rod-shape and the seam in the band sealed, just as in cigarette manufacture, the rod being finally cut, at 24, into lengths in known manner. Preferably a suction pipe 34' is provided adjacent to the wheel 34 to ensure that no particles of the mixture become trapped in the seam.

To effect bonding of the rod lengths, they were conveyed, at a speed of 10 feet per minute, on an endless wire mesh conveyor 40 of aperture $\frac{3}{8}$ inch through a tunnel 41, about 5 feet long, heated by three assemblies of infrared heating elements, consisting of six tubular heaters of 1 kw. capacity, mounted 3 above and 3 below the moving belt and each shielded to contain the radiation. On emergence from the tunnel 41 and after cooling, the rods were

found to be firmly bonded, i.e. the foam granules were firmly adhered to one another.

This bonding stage need not immediately follow upon the production of the rod lengths.

5 It may be performed at any time prior to their use in filter-tip cigarette manufacture. Moreover, the lengths need not travel through heating and cooling chambers in their axial direction. They may travel transversely of that
10 direction, which may have advantages with respect to economy in space and to the convenient location of this part of the apparatus away from the aforesaid machine.

15 In the alternative form of feeding device shown in Fig. 5, the mixture was supplied to a hopper 5 fitted with an adjustable vibrator 42. It was urged by a flanged roller 43 through an adjustable gate 44 and under an adjustable
20 roller 45 with shallow longitudinal grooves. Both the lowest part of the hopper 5 and the roller 45 engaged snugly between the flanges 46 of the roller 43 and reached into close proximity with the latter. The roller 43 had an overall diameter of 14 inches and flanges 1
25 inch deep, while the roller 45 had a diameter of 4 inches and a length of $4\frac{1}{2}$ inches and was formed with 50 evenly spaced shallow grooves $1/16$ th inch deep. The rollers 43 and 45 were driven by the same motor, the drives being
30 variable to assist in controlling the rate of feed. A bar 47 on the feeding side of the roller 45 was provided as a precaution against over-feeding in the event of malfunction of the gate 44. It served also as a stiffening member for the housing (not shown) of the device. The
35 mixture smoothed by the grooves of the roller 45 emerged onto a chute 48 whose uppermost part was gently curved while its lower part, extending down between the side guides of a channel 49, was steeply tilted. The mixture
40 formed a smooth even carpet which slid quietly

away following the initial curvature of the chute and then broke up and fell as loose particles into the channel 49. An effective and readily controllable mixture feed was thus
45 achieved. In the channel 49, as in the case of the arrangements previously described, the mixture was carried away by a band to apparatus comprising levelling, compressing and subsequent stages. These stages may be
50 equipped similarly to those described with reference to Figs. 1 and 2 or Figs. 3 and 4.

The different forms of the method and apparatus described above readily afford the flexibility necessary to accommodate different
55 kinds of foam material and to allow of the production of filter rods with predetermined physical characteristics.

To investigate the effect of variation of pressure drop, the method and apparatus described with reference to Figs. 1 and 2 were used to
60 prepare two groups of rods from a mixture of two parts of the same comminuted polyurethane material to one part by weight of adhesive material in the form of polyethylene powder. For group 1, the feed-rate of the mixture at 7 and the degree of compression at 13
65 were arranged to give filters having a conventional pressure drop. For group 2, these variables were adjusted to give filters having a low pressure drop. Filter tips of 15 mm. length were cut from each group and were
70 attached to cigarettes. The cigarettes were smoked using a smoking engine which provided one puff per minute of two seconds duration and 35 ml. volume.

The proportions, by weight, of total particulate matter, nicotine, steam volatile phenols and hydrogen cyanide removed from the smoke
80 were then determined. The results obtained are listed below:

Filter	Pressure Drop (cm. water gauge at air flow of 1050 cc. per min.)	Proportion Removed (%)			
		Total particulate matter	Nicotine	Steam Volatile phenols	Hydrogen cyanide
Group 1	13.0	42	30	54	66
Group 2	5.2	27	18	48	60

The method and apparatus described with reference to Figs. 3 and 4, but dispensing with the items 1 to 4, 40 and 41, were also used to prepare filter rods consisting solely of wrapped polyurethane foam particles previously sieved to seven, known, ranges of particle size. For each range, the feed rate from the hopper 25 to the band 8 and the degree of compression at the station 13 were adjusted to give substantially the same pressure drop in the final filter rods. The filter rods produced were tested for pressure drop and those providing a pressure

drop of 15 cm. water gauge for 15 mm. length were selected. Lengths of 15 mm. were cut from these rods and were mounted between two filter-rod sections, each 7 mm. long, of fibrous cellulose acetate of filament denier 15 and total denier 64,000. The resultant composite tips were attached to cigarettes and smoked as described above and the proportion of total particulate matter removed from the smoke was determined. The results obtained are shown below:

Filter	Granule size (diameter in mm.)	Weight of granules (mg.)	Proportion of total particulate matter removed (%)
1	greater than 1.68	65	37
2	1.68 — 1.20	65	40
3	1.20 — 1.00	75	47
4	1.00 — 0.85	75	48
5	0.85 — 0.60	85	52
6	0.60 — 0.42	90	51
7	0.42 — 0.35	90	54

For the same pressure drop, the filtration effect increased with decreasing granule size.

To investigate the effect of using different forms of polyurethane foam material, five such materials A to E were tested. Brief particulars of these materials are as follows:

A) A white toluene diisocyanate based rigid foam, blown by halogenated hydrocarbon vapour. Small uniform cells, just distinguishable by the naked eye, with thin walls.

B) A fawn-coloured diphenylmethane 4:4' diisocyanate based rigid foam, blown by halogenated hydrocarbon vapour. Cell size and wall thickness similar to those of A.

C) A white toluene diisocyanate based rigid foam, blown by carbon dioxide formed during reaction. Large cells, approximately 2—5 mm. for the majority of the cells, and thick walled.

D) A pale brown diphenylmethane 4:4' diisocyanate based rigid foam, blown by halogenated hydrocarbon. Cell size and wall thickness slightly larger than in A and B, with the cells, maximum diameter about 1 mm, clearly perceptible to the naked eye.

E) This was similar to B, but had been obtained from a different supplier.

The materials were comminuted by the procedure described with reference to Figs. 1 and 2 and the bulk density of the resulting foam granules was measured. Four parts by weight of each of the comminuted materials were then mixed with one part by weight of comminuted sodium phosphate dodecahydrate and formed into wrapped filter rods by the procedure described with reference to Figs. 3 and 4. The rods so formed were cut into 7 mm. lengths, and the average weight of the cut sections was determined. The sections were then each mounted between two sections of fibrous cellulose acetate filter rod constituted as described above. The composite tips were attached to cigarettes and smoked as described above. The proportions of total particulate matter, nicotine, steam volatile phenols and hydrogen cyanide removed from the smoke were determined. The results are given below:

Foam	Weight of foam particles in filter (mg)	Pressure drop of filter (cm. water gauge at air-flow of 1050 cc/min.)	Bulk density of foam particles (gm/cc.)	Proportion removed (%)			
				Total particulate matter	Nicotine	Steam volatile phenols	Hydrogen cyanide
A	48	15	0.11	50	37	59	59
B	59	14	0.12	62	50	66	56
C	160	15	0.35	59	40	61	39
D	48	20	0.10	53	45	60	46
E	64	15	0.14	56	41	59	52

As will be seen, all of these materials were effective as filters and exhibited high selectivity for hydrogen cyanide, as compared with conventional filtering materials.

- 5 To investigate the effect of using different proportions of adhesive material, the procedure described with reference to Figs. 3 and 4 was used to prepare filter rods from mixtures of different proportions of comminuted "Spandofam 200" and sodium orthophosphate dodecahydrate. For each mixture, the feed rate to the machine and the degree of compression was adjusted to give roughly the same pressure

drop for the final rods produced. The rods were cut into 7 mm. lengths and attached, between two 7 mm. sections of cellulose acetate fibrous filter material constituted as described above, to cigarettes, which were smoked, again as described above, in comparison with cigarettes having no foam-filter section and cigarettes having a foam section without any admixture of adhesive material.

The proportions of total particulate matter, nicotine, steam volatile phenols and hydrogen cyanide removed from the smoke were determined. The results are given below:

Ratio of phosphate to foam particles	Weight of foam particles in filter (mg)	Pressure drop of filter (cm. water gauge at airflow of 1050 cc/min.)	Proportion removed (%)			
			Total particulate matter	Nicotine	Steam volatile phenols	Hydrogen cyanide
—	0	1.8	14	14	25	below 10
—	53	15.8	65	56	67	52
1:4	56	16.8	59	44	63	55
1:3	57	21.0	59	40	64	58
1:2	52	17.5	59	40	66	59
1:1	48	17.5	58	40	54	61

- If desired, other materials which can enhance the filtering properties of the bonded foam rod may be added to the mixture, such as activated charcoal, active earths such as bentonite, molecular sieve materials and substances which can remove certain specific compounds from the tobacco smoke stream. The filtering effect of a polyurethane foam rod bonded with hydrated sodium acetate is, for instance, enhanced by the addition of zinc acetate which increases the proportions of hydrogen cyanide and hydrogen sulphide removed from the smoke. The following example illustrates this addition:
- Filter rods were prepared comprising polyurethane foam and hydrated sodium acetate in the proportions of 4:1 by weight respec-

tively, and containing different proportions by weight of zinc acetate calculated on the total weight of the mixture. Conditions were arranged to give the same pressure drop for the rods. 7 mm. sections of these rods were attached, between two 7 mm. sections of cellulose acetate filter material of filament denier 15 and total denier 64,000, to cigarettes, which were smoked, as described above, in comparison with cigarettes provided with similar filters which contained no zinc acetate.

The proportions of total particulate matter, nicotine, steam volatile phenols, hydrogen cyanide and hydrogen sulphide removed from the smoke were determined, and the results are given below:

Zinc Acetate % (by weight)	Pressure drop of filter (cm. water gauge at airflow of 1050 cc/min.)	Proportion removed %				
		Total particulate matter	Nicotine	Steam volatile phenols	Hydrogen Cyanide	Hydrogen Sulphide
0	20	54	46	68	44	below 10
10	20	63	56	70	63	37
25	20	64	58	73	69	52
50	20	67	62	74	79	62

- The following example is of the use of another foam material:

A sheet of commercially available closed-cell polystyrene foam was cut into 1 inch squares and ground, as described above, to pass a 1.6 mm. diameter circular hole screen. The material produced had a bulk density of 0.04 gm/cc. Cupric nitrate trihydrate was ground to pass the same size screen. The foam and salt were mixed in the proportions of 2 parts foam to 1 part salt by weight and were formed into rods, using the apparatus and procedure described. Although stringent control of the heating stages was required to prevent melting of the foam, a firm well-bonded rod was produced.

- Other adhesive materials can be employed. Examples of other materials found to give satisfactory bonding of foam to form a filter rod were sodium perborate tetrahydrate, hydrated calcium bromide, aluminium bromide nonahydrate, ferrous sulphate heptahydrate, cupric nitrate trihydrate, sodium aluminium sulphate dodecahydrate, potassium aluminium sulphate dodecahydrate, potassium chromium

sulphate dodecahydrate, sodium acetate trihydrate, magnesium acetate dihydrate, aluminium stearate and magnesium stearate. These binding agents were tested, using the above-described apparatus and procedure, by grinding polyurethane foam of type A above and the particular binding agent to pass a 1.6 mm. diameter circular hole screen and mixing them in the proportions of 4 parts foam to 1 part binder (by weight).

WHAT WE CLAIM IS:—

1. A method for the production of a tobacco-smoke filter rod, wherein a synthetic-foam filter material comminuted to particulate form is fed to a moving band and is shaped to rod form while carried upon the said band in which it becomes enrobed.

2. A method according to claim 1, wherein the comminuted foam material has mixed with it a powdered or granular thermally activatable adhesive material and the mixture is shaped to rod form.

3. A method according to claim 1 or 2, wherein the foam material is a polyurethane-resin foam.

If desired, other materials which can enhance the filtering properties of the bonded foam rod may be added to the mixture, such as activated charcoal, active earths such as bentonite, molecular sieve materials and substances which can remove certain specific compounds from the tobacco smoke stream. The filtering effect of a polyurethane foam rod bonded with hydrated sodium acetate is, for instance, enhanced by the addition of zinc acetate which increases the proportions of hydrogen cyanide and hydrogen sulphide removed from the smoke. The following example illustrates this addition:

Filter rods were prepared comprising polyurethane foam and hydrated sodium acetate in the proportions of 4:1 by weight respec-

tively, and containing different proportions by weight of zinc acetate calculated on the total weight of the mixture. Conditions were arranged to give the same pressure drop for the rods. 7 mm. sections of these rods were attached, between two 7 mm. sections of cellulose acetate filter material of filament denier 15 and total denier 64,000, to cigarettes, which were smoked, as described above, in comparison with cigarettes provided with similar filters which contained no zinc acetate.

The proportions of total particulate matter, nicotine, steam volatile phenols, hydrogen cyanide and hydrogen sulphide removed from the smoke were determined, and the results are given below:

Zinc Acetate % (by weight)	Pressure drop of filter (cm. water gauge at airflow of 1050 cc/min.)	Proportion removed %				
		Total particulate matter	Nicotine	Steam volatile phenols	Hydrogen Cyanide	Hydrogen Sulphide
0	20	54	46	68	44	below 10
10	20	63	56	70	63	37
25	20	64	58	73	69	52
50	20	67	62	74	79	62

The following example is of the use of another foam material:

A sheet of commercially available closed-cell polystyrene foam was cut into 1 inch squares and ground, as described above, to pass a 1.6 mm. diameter circular hole screen. The material produced had a bulk density of 0.04 gm/cc. Cupric nitrate trihydrate was ground to pass the same size screen. The foam and salt were mixed in the proportions of 2 parts foam to 1 part salt by weight and were formed into rods, using the apparatus and procedure described. Although stringent control of the heating stages was required to prevent melting of the foam, a firm well-bonded rod was produced.

Other adhesive materials can be employed. Examples of other materials found to give satisfactory bonding of foam to form a filter rod were sodium perborate tetrahydrate, hydrated calcium bromide, aluminium bromide nonahydrate, ferrous sulphate heptahydrate, cupric nitrate trihydrate, sodium aluminium sulphate dodecahydrate, potassium aluminium sulphate dodecahydrate, potassium chromium

sulphate dodecahydrate, sodium acetate trihydrate, magnesium acetate dihydrate, aluminium stearate and magnesium stearate. These binding agents were tested, using the above-described apparatus and procedure, by grinding polyurethane foam of type A above and the particular binding agent to pass a 1.6 mm. diameter circular hole screen and mixing them in the proportions of 4 parts foam to 1 part binder (by weight).

WHAT WE CLAIM IS:—

1. A method for the production of a tobacco-smoke filter rod, wherein a synthetic-foam filter material comminuted to particulate form is fed to a moving band and is shaped to rod form while carried upon the said band in which it becomes enrobed.

2. A method according to claim 1, wherein the comminuted foam material has mixed with it a powdered or granular thermally activatable adhesive material and the mixture is shaped to rod form.

3. A method according to claim 1 or 2, wherein the foam material is a polyurethane-resin foam.



4. A method according to claim 1, 2 or 3, wherein the foam material has a particle size of less than 1.2 mm.
5. A method according to claim 2, 3 or 4, wherein the adhesive material is a thermoplastic or thermosetting synthetic resin.
6. A method according to claim 2, 3 or 4, wherein the adhesive material is a low-melting inorganic substance.
10. 7. A method according to claim 6, wherein the adhesive material is a hydrated salt of phosphoric acid.
15. 8. A method according to any one of claims 2 to 7, wherein the adhesive material has a particle size of less than 1.2 mm.
20. 9. A method according to any one of claims 1 to 8, wherein a coating of a thermally activatable adhesive material is applied to the surface of the band to which the material is thereafter fed.
25. 10. A method according to any one of claims 1 to 9, wherein the material is fed to the band from a hopper in which it is maintained at a substantially constant level.
30. 11. A method according to any one of claims 1 to 10, wherein the material is fed to the band with the assistance of vibratory means.
35. 12. A method according to any one of claims 1 to 11, wherein the material, after being fed to the band, is subjected to the action of a levelling device.
40. 13. A method according to claim 12, wherein the levelling device comprises a wheel having a roughened periphery and arranged above the said band with the part of its periphery adjacent to the band moving in the opposite direction to the latter.
14. A method according to any one of claims 1 to 13, wherein the material, after being fed to the band, is subjected to the action of a compression device.
15. A method according to claim 14, wherein the compression device comprises at least one wheel with a concave periphery and arranged above the said band with the part of its periphery adjacent to the band moving in the same direction as the latter.
16. A method according to any one of claims 1 to 15, wherein the material is shaped to rod form by being passed with the band through a heating means and a sequence of dies.
17. A method according to any one of claims 1 to 15, wherein the material is shaped to rod form by being passed with the band through the garniture of a conventional cigarette-making machine.
18. A method according to claim 17, wherein the material, after being passed with the band through the garniture, and being enrobed in rod form in the band is heated to activate the adhesive material.
19. A method for the production of a tobacco-smoke filter substantially as hereinbefore described.
20. A tobacco-smoke filter comprising synthetic resin foam material comminuted to a particulate form and wrapped in a band.
21. A tobacco-smoke filter comprising synthetic resin foam material comminuted to a particulate form and bonded by an adhesive material.
22. A tobacco-smoke filter comprising a polyurethane foam comminuted to a particulate form.
23. A filter according to claim 22, wherein the polyurethane foam is bonded by a synthetic resin adhesive material.
24. A filter according to claim 22, wherein the polyurethane foam is bonded by a low-melting inorganic substance.
25. A tobacco smoke filter produced by the method claimed in any one of claims 1 to 19.

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