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VENTILATED SMOKING ARTICLE

The invention relates to a smoking article, in particular but not exclusively a cigarette, incorporating a filter in which grooves are pressed into the circumference of the filter.

Various forms of embodiment of such filters are known. Thus US 4,406,294 discloses a cigarette filter with a cylindrical filter plug, with an air-permeable plug wrap for the filter plug and with grooves impressed into the circumference of the filter plug extending over a part of the filter length from the mouth end of the filter. The grooves are, however, impermeable. The cylindrical filter plug and hence also the grooves are attached by an air-permeable tipping paper provided with ventilation openings. The filter has an uncomplicated structure and achieves an essentially normal drop in pressure over the cigarette.

US 4,256,122 discloses a cigarette filter with a similar structure, where, however, the circumferential surface of the filter plug, including the walls of the grooves, are impermeable by virtue of an impermeable plug wrap. Here, though, some of the grooves are open at the mouth end of the filter plug. Figs 2, 3 and 5 show embodiments which also include grooves which are still open on the tobacco end. With this filter a strong tobacco-flavoured cigarette is obtained which retains the high reduction of the unwanted smoke constituents and the good processability on standard cigarette machines. However, some of these embodiments require precise registration of the perforated tipping wrapper with circumferential grooves, giving manufacturing and quality problems.

US 4,649,943 shows a further modification of such a filter, in which the grooves are open at the mouth end of the filter. In addition, at least one perforation is provided in the area of the grooves intended for the introduction of air through the plug wrap into the filter plug, thereby providing the filter with an improved air distribution in the filter rod. In addition a tipping wrapper of impermeable material which has an air-permeable region contributes to this. The lining paper (plug wrap) is impermeable but provided with ventilation openings.

Further, DE-PS 21 07 850 discloses a filter tip, the circumference of which is provided with longitudinal grooves. A plug wrap is not mentioned and the grooves are preferentially open at the mouth end of the filter.

US 4,362,171 discloses a cigarette filter with grooves which are open neither at the tobacco end nor at the mouth end and thus extend only over the centre of the filter plug. Each groove is provided with an opening, so that ventilation air is guided longitudinally along the filter rod in the direction of the mouth end. Thus outside air is introduced at high velocity in a

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simple manner into the cigarette filter, without the danger of a blockage due to lip pressure and/or a loss of pressure.

US 4,343,319 discloses a similar cigarette filter with a smoke-impermeable wrapper for the filter plug and with a central tube, extending axially through the filter plug, which is located in flow connection with the opening in the grooves. In this way the smoke leaving the tobacco rod is divided into two parts. One part flows through the central pipe and the other part flows through the filter material. The presence of tubes and interconnecting passages adds to the complexity of the filter manufacture.

Further, a cigarette filter with an air-impermeable wrapper for the filter core and with grooves in the circumference of the filter core and which extend over the whole length of the filter core is disclosed in DE 30 48 905 A1. This filter can be manufactured more easily, since it is not necessary to change the production direction.

A filter for tobacco smoke provided with grooves in its circumference which are produced by a corrugated material around the actual filter is known from GB 2102271. The plug wrap surrounding the filtration material is smoke-impermeable. Grooves are provided between the plug wrap and the corrugated material, and also between the tipping wrapper and the corrugated material. The tipping wrapper is provided with ventilation openings. This filter element should be versatile and flexibly usable.

GB 2 089 641 A discloses a filter for a cigarette with a central, hollow tube, which extends from one end of the filter into the filter material. The filter core is surrounded by a non-porous wrapper and the filter plug and the wrapper have at least one groove, which extends longitudinally from one end of the filter plug. In this way a normal decrease of pressure through the cigarette is achieved for a filter with low to moderate efficiency. Formation of a hollow tube adds to the manufacturing requirements.

Further, GB 2 136 669 A shows a cigarette filter with a filter plug which is surrounded by a smoke-permeable material. The filter has longitudinal corrugations which form grooves outside of the smoke-permeable wrapper which are open at one end of the filter and extend in longitudinal direction from this end towards the other end but not over the entire length of the filter plug. The smoke permeable wrapper carries means, i.e. a coating, which makes it smoke-impermeable over a region which extends over only a part of the length of the grooves and separates from the corresponding end of the filter a grooved region of the wrapper which is smoke permeable.

GB 2 095 093 A discloses a filter with a filter plug with a non-porous wrapper and with grooves which extend from one end of the filter a certain distance in the direction of the other end of the filter. The grooves can be open to the atmosphere and so aligned that they extend up to the mouth end of the filter or to the tobacco end of the filter. It is also possible to have an alternating arrangement of grooves which begin at the mouth end and at the tobacco end. The filter is fastened to the tobacco rod by a narrow strip of material in order to prevent disruption of the entry of the ventilation openings to the grooves.

US-A-3,752,165 shows a filter for a smokable article with a filter plug which is wrapped in a thin, porous wrapper paper. A plurality of grooves is formed in the wrapper paper and into the filter material at one end of the filter. The grooves extend from one end of the filter to a point shortly before the opposite end and are surrounded by a smoke-impermeable plug wrap. The grooves extend from one end of the filter to a point which is some distance from the other end. A high efficiency for the removal of the tar from the tobacco smoke with an acceptable decrease of pressure can be achieved with this filter.

Further, a filter is known from US-A-3,910,288 with a filter plug provided around its circumference with grooves which extend from the tobacco end of the filter up to a place before the mouth end of the filter. The grooves are formed in a rigid plastic wrapper which surrounds the filter material. At one end of every groove an opening is provided which makes a connection to the filter material possible. Filter ventilation is not provided.

This filter is very resistant to crushing, so that the and/or each groove can remain open during the entire smoking of the smokable article. By gradually changing the portion of the smoke which flows through the groove from a previously defined value to a value of 0, the filter achieves an almost homogeneous delivery of particulate material per puff with a relatively constant increase of the degree of efficiency of the filter.

Finally, US-A-3,596,663 shows a filter for a smokable article with a filter plug with grooves, the length of which is not defined. The filter wrapper and the lining paper are in each case porous and/or provided with perforations. The air-permeable wrapper is corrugated in order to increase the size of the air-permeable surface and thus to simplify the path of the air which is allowed through the ventilated wrapping paper to the filter material of the filter plug. Thus a ventilated filter is produced that significantly reduces the restriction of the air passage to the filtering medium.

It can thus be stated in summary that for many years cigarette filters have been provided with grooves which permit smoke and/or air to be directed differently as a function of the position and the length of the grooves and the porosity and/or ventilation of the tipping or filter-

wrapping paper. In this way it is possible to achieve a dilution of the smoke, turbulence of the smoke in the mouth area, and the separate guidance of ventilation air and smoke, as well as some other effects.

In recent years attention has been directed to one smoke component, i.e. carbon monoxide (CO), for which no effective, economical filter is yet known. Particularly in view of the new legal requirements which prescribe a maximum CO quantity in the tobacco smoke of a cigarette, attempts are being made to reduce the CO content of the smoke to below a given maximum value.

The object of the invention is to produce a filter for a smoking article, in particular a cigarette, which enables an effective, in particular adjustable, decrease of the CO content of the smoke compared with other components, such as tar and nicotine.

This is achieved in accordance with the invention by the features of Claim 1.

Appropriate embodiments are defined by the characteristics of the subordinate claims.

Due to the flow mechanics in the filter of this invention, the retention of the filter material is reduced because of the well known dependency of the linear flow velocity: retention decreases with increasing flow velocity. Due to the fact that the CO level is not affected by the filtering material, the CO/tar ratio decreases.

If an air-impermeable plug wrap is used with the filter in accordance with invention then the ventilating air flows over the grooves toward the tobacco rod when smoking the cigarette and from there back through the filtration material into the mouth of the smoker.

As an alternative it is possible to employ a plug wrap which is inherently porous or ventilated and hence provided with ventilation openings. Some of the ventilation air then flows through this path and hence through the permeable plug wrap into the filter and to the mouth of the smoker. This portion can be adjusted by appropriate adjustment of the inherent or artificial porosity of the plug wrap, by which means the pressure drop/smoking mechanics as well as the CO/tar ratio can also be influenced.

As a further alternative, porous or ventilated plastic sheets or foils may be used as plug wrap material.

The use of on-machine laser perforation of tipping paper and impermeable plugwrap is particularly useful for low delivery products with a tar delivery of less than 3mg, preferably less than 1mg. For such low delivery products it may be advantageous to provide two rows of ventilation holes, one row located above the axially extending grooves and another row located downstream of those holes. On-line machine perforation perforates both the plug wrap and the

filtration material underneath, allowing the ingress of ventilating air thereto. Thus, mixed ventilation occurs, i.e. through grooves and filtration material.

Synthetic or thermoformable plugwraps such as those described in British Patent Nos. 2058543, 2056841 or 2134365 may also be especially suitable as heat mouldable plug wrap for the present invention.

Experiments have shown that the CO/tar ratio attainable changes as a function of the filter ventilation, i.e. the CO/tar ratio is reduced by increasing the filter ventilation, providing a further correcting variable for the CO/tar ratio.

In a preferred embodiment two to ten grooves are provided, since the use of only one groove leads to a very asymmetrical distribution of the ventilation air in the smoke which could impair smoking enjoyment. More than ten grooves greatly complicate the production process and also hardly leave enough space for adequate flow cross-section of the individual grooves. Good results were achieved with four grooves.

The grooves have a V-shaped or preferably a U-shaped cross section, since this has manufacturing and rheological advantages.

By choosing the appropriate number of grooves, their appropriate depth, width and length it is possible to adjust the filter properties to the target properties of the cigarette to be produced.

All conventionally used filter materials may be employed as filter material where one or several of these materials can be used. Preferably a conventional filter tow of cellulose acetate is used. For hardening the filters, conventional techniques are used, for example adding triacetin or Tegda to the filter tow.

It is also possible to add additives, such as activated charcoal, zeolites, flavour-modifiers or an ion exchange resin, such as that known as Duolite (see US Patent Nos. 3,716,500 or 3,943,832) which is a porous particulate salt of a weakly basic anion exchange resin, to the filter in order to reduce other vapour phase constituents.

Preferably the filtration material is homogeneous. As used herein 'homogeneous' as applied to filtration material means there are no flow openings, tubes or other elements in the filtration material. A homogeneous filtration material may, though, be comprised of different filtration materials, such as in differing filtration sections, should the filter be a multiple filter. A homogeneous filtration material has benefits of simplicity in manufacture.

Preferably the additive is located in a region of the filter which does not have grooves. This prevents thermal decomposition of the additive upon moulding to produce the grooves.

In accordance with a preferred embodiment the grooves extend over less than 80% of the length of the filter, where good results were obtained with about 60%.

The depth of the grooves should be within the range 0.5 to 2 mm, preferably about 1 mm, where suitable flow volumes are achieved.

Taking this criterion into consideration the width of the grooves, measured at the circumference of the filter, should lie between 1 and 3 mm, preferentially between 1.5 and 2.5 mm.

The depth of the grooves along the rod axis may not necessarily be constant. It may for example increase towards the open end, the tobacco side of the filter. The grooves may also be non-linear, following for example a screwed or helical form around the filter.

In some cases it may be necessary that a further groove is added to the filter, which runs radially around the filter circumference. This groove shall connect the axial grooves. It is useful that this radial groove is located directly below the ventilation zone of the tipping paper, which enhances the ventilation effect. In cases of larger ventilation zones it may also be necessary to use two or more radial grooves.

The filter of this invention may obviously be included as part of a dual or triple filtering device.

The tipping paper serving to attach the filter to the tobacco rod may have a conventional structure, provided that it permits ventilation. This can be achieved either by use of a porous, therefore inherently air-permeable tipping paper or by producing ventilation openings by mechanical or electrostatic means or using laser beams.

In order that the invention may be clearly understood and readily carried into effect, reference will now be made, by way of example, to the following diagrammatic drawings, in which:

Figure 1 shows a perspective view of a filter attached to a tobacco rod with partly wrapped tipping paper,

Figure 2 shows a curve plotting of the CO/tar ratio as a function of the filter ventilation for a filter in accordance with the invention and a comparison filter,

Figure 3 shows an embodiment of a filter with particulate additive therein, and

Figure 4 shows another embodiment of a filter with particulate additive therein.

Figure 1 shows a perspective view of a part of a proposed filter cigarette generally indicated by the reference symbol 10 with a conventional tobacco rod 12 and a filter element 14 appended to one end of the tobacco rod 12. The filter element 14 consists of a cylindrical filter plug 16 of cellulose acetate tow as filtration material, which is homogeneously distributed over the entire volume of the filter plug 14. Thus, no flow openings, tubes or other means are

provided in the filter plug 16. As used herein 'homogeneous' as applied to filtration material means there are no flow openings, tubes or other elements in the filtration material. A homogeneous filtration material may, though, be comprised of different filtration materials, such as the differing filtration sections described below with respect to Figure 4, none of which incorporate flow openings, tubes, etc.

The filter plug 16 is covered with a plug wrap 18 which is air-impermeable, although in other embodiments (not shown) it can be inherently porous and/or provided with ventilation openings depending upon requirements, taking account particularly of the tobacco taste desired.

Grooves 20 are stamped into the circumference of the filter element 14, four grooves 20 in the embodiment shown, which are distributed symmetrically over the circumference of the filter element 14. The grooves 20 extend up to the tobacco rod end of the filter element 14, where they are open so that there is a flow connection between the grooves 20 and the tobacco rod 12.

The grooves 20 run over the circumference of the filter plug 16 in an axial direction and end at a rheologically adequate distance from the mouth end of the filter element 14 and hence at a distance at which neither air nor smoke from the grooves 20 can directly reach the mouth end of the filter element 14.

Investigations have shown that the axial length of the grooves 20 should be less than 80% of the length of the filter plug 14. About 60% is preferred.

The grooves 20 have a depth of approximately 1.5 mm and a U-shaped cross section and a width of approximately 2 mm at the circumference.

The filter element 14 is surrounded in the usual way by a tipping paper 22, which is provided in the embodiment shown with two circumferential parallel rows of ventilation holes 24. A larger or smaller number of rows of ventilation holes can also be provided or the tipping paper 22 can be inherently porous. It is only necessary to ensure that the porosity and/or the number and size of the ventilation openings 22 ensure the desired degree of ventilation.

For the arrangement of the plug wrap 18 there are in principle two possibilities, i.e. the use of an air-impermeable paper or an air-permeable paper. In the case of use of an air-impermeable paper as plug wrap 18, ventilation air flows through the ventilation openings 24 when smoking the cigarette into the grooves 20 and then from the grooves 20 toward tobacco rod, where the direction is reversed and the ventilation air then flows, together with the smoke from the tobacco rod 12, through the filter plug 16 into the smoker's mouth.

If the plug wrap is air-permeable, either inherently porous or provided with ventilation openings, then an adjustable portion of ventilation air flows by this flow path through the air-

permeable plug wrap into the filter and to the mouth of the smoker. This is in addition to the air flowing through the grooves 20. In this way the dilution of the smoke can be adjusted by air ventilation in two places, i.e. firstly by ventilation through the tipping paper 22 and along the grooves 20, and secondly by ventilation air which enters directly through the plug wrap 18 into the filter plug 16.

If necessary, further short grooves open only to the mouth side of the filter 14 can be impressed into the exterior surface of the tipping paper 22. These have no rheological function, since they are not connected with the ventilation zone 24, but only alert the smoker to the presence of grooves in the filter element 14.

Figure 2 shows a graph of the effect of the filter ventilation on the CO/tar ratio with a filter in accordance with the invention from conventional cellulose acetate filter tow, an air-impermeable plug wrap and four grooves 20 with the above dimensions, which are symmetrically distributed over the circumference of the filter plug 16 and which, commencing from the tobacco end, extend over 60% of the length of the filter element 14.

In experiments the ventilation of the filter element 14 was varied, namely from zero to a maximum ventilation degree of 70%. For products of 3mg or less it is necessary, in order to obtain the required ventilation level, to use additional on machine laser perforation, as well as pre-perforated tipping. This increased ventilation level also helps reduce cigarette pressure drop. The reduction in CO/tar ratio obtained is balanced with the level of ventilation used.

In Figure 2 the full circles indicate the measured values for a conventional filter made from monoacetate filter tow without grooves, while the squares describe the measured values for a filter element 14 in accordance with the invention with the structure and the same dimensions as the comparison filter described above.

One can recognise very well that the filter element 14 in accordance with the invention reduces the CO content of the smoke relative to the delivered tar and hence the CO/tar ratio from about 1.4 to about 0.7, while through ventilation alone, and hence without use of grooves, the CO/tar ratio can be lowered to only to about 1.12.

Thus the CO/tar ratio can be reduced to below the limit set by the new regulations with the filter element 14 in accordance with the invention by the appropriate selection of a suitable degree of ventilation for the tipping paper 22.

Additional investigations of cigarettes with filters according to this invention showed that these results were confirmed also for different tobacco blends in the tobacco section of the cigarette. In Tables 1-3 the results are shown for the tobacco column of three commercially available cigarettes to which the filter of this invention was added. The corresponding cigarettes

with conventional filters gave tar levels of about 10mg, 6mg and 3mg respectively. The measurements were done following DIN and ISO standards.

The filters used for these measurements had the following parameters of the grooves: 4 grooves, 17 mm long, about 1.5 mm wide and 0.5-1 mm deep. The plug wrap was air impermeable and not additionally ventilated.

The findings show clearly that the filters of this invention (named EF) made it possible to produce cigarettes with comparable pressure drops to the cigarettes with standard filters (named SF) by adjusting the ventilation level, but with clearly reduced CO/tar ratios.

Table 1:

	SF	EF	EF	EF	EF	EF
Pressure drop filter in mm(H_2O)	72	76	76	74	73	72
Filter ventilation	22,6	0,0	12,0	51,8	57,2	62,1
tar in mg	10,25	12,4	11,7	8,8	7,2	5,7
CO in mg	11,21	13,3	12,1	6,7	4,5	2,9
Pressure drop cigarette in mm(H_2O)	117	137	121	104	93	93
CO/tar	1,09	1,07	1,03	0,76	0,63	0,51

Table 2:

	SF	EF	EF	EF	EF
Pressure drop filter in mm(H_2O)	108	90	89	91	89
Filter ventilation	43,0	0,0	50,6	58,3	69,1
tar in mg	5,6	11,4	7,8	6,1	4,3
CO in mg	6,7	13,1	5,8	3,5	1,8
Pressure drop cigarette in mm(H_2O)	112	144	114	110	107
CO/tar	1,19	1,15	0,74	0,57	0,42

Table 3:

	SF	EF	EF	EF	EF
Pressure drop filter in mm(H_2O)	124	100	98	99	98
Filter ventilation	56,7	0,0	45,2	51,1	62,5
tar in mg	3,33	8,8	6,3	5,2	4,4
CO in mg	4,24	11,3	5,4	3,6	2,6
Pressure drop cigarette in mm(H_2O)	107	144	125	121	120
CO/tar	1,27	1,28	0,86	0,69	0,59

Figure 3 shows in cross section a filter element 14 of the invention, where like parts are labelled in accordance with Figure 1, attached to a tobacco rod 12. The plug wrap 18 used to overlie the filter plug 16 includes a portion that has particulate activated carbon adhered thereto in the region 26. Grooves 20 are formed in the plug wrap 18 after the plug wrap is wrapped around the filter plug 16. The filter element is thus an integral element.

An alternative embodiment along the same theme is shown in Figure 4. However, in this embodiment the filter element comprises three sections: a grooved section in which grooves 20 are formed in the surface thereof, a Dalmatian carbon section 28 comprising particles of activated carbon dispersed in cellulose acetate tow, and a conventional cellulose acetate tow section 30. The three sections may be joined together by one plug wrap which is mouldable to produce the grooves of the grooved section. Alternatively, the grooves are formed in the surface of either a self-sustaining non-wrapped acetate (NWA) section or a plug wrap enwrapping a cellulose acetate section. The three sections are then aligned together and then overwrapped with a further plug wrap (not shown).

The embodiments of Figure 3 and 4 avoid the problem of having to mould grooves into a filter section containing particulate matter, during which moulding there may be adverse effects on the particulate matter if contacted with heating elements. However, it is possible to thermally form grooves in a carbon-containing section, particularly if use is made of a thermoformable plugwrap, and such is an option open to the cigarette designer.

In addition, the presence of additive material affects other vapour phase constitutents and can be particularly advantageous for the selective removal of some of those compounds on

the Hoffmann analyte list (see Hoffmann, D., Hoffmann, I., "Tobacco Smoke Components", Beitrage zür Tabakforschung International 18 (1998) 49).

CLAIMS

1. A smoking article comprising a cylindrical filter plug (16) of homogeneous filtration material, an air-impermeable plug wrap (18) for the filter plug (16), circumferentially spaced grooves (20) extending longitudinally along the filter plug (16) also impressed into the plug wrap (18), and a tipping paper for connecting the filter plug (16) to a tobacco rod (12), characterised in that all grooves (20) are open on the side of the tobacco rod (12) and extend continuously only over a part of the length of the filter plug (16), and hence not up to the mouth end of the filter plug (16) and that all grooves (20) are covered with the ventilated tipping paper (22) such that ventilating air enters the grooves (20) via the ventilated tipping paper (22).

2. A smoking article in accordance with Claim 1, characterised in that the filtration material of filter plug (16) is homogeneous over the full length of the filter plug (16).

3. A smoking article in accordance with Claim 1 or 2, characterised in that the grooves (20) extend over a maximum of 80% of the length of the filter plug (16).

4. A smoking article in accordance with any one of the Claims 1 to 3, characterised in that the length of the grooves (20) amounts to about 40 to 70% of the length of the filter plug (16).

5. A smoking article in accordance with Claim 4, characterised in that the length of the grooves (20) amounts to 55 to 65% of the length of the filter plug (16).

6. A smoking article in accordance with any one of the Claims 1 to 5, characterised in that two to ten grooves (20) are provided.

7. A smoking article in accordance with Claim 6, characterised in that three to five grooves are provided.

8. A smoking article in accordance with Claim 7, characterised in that four grooves are provided.

9. A smoking article in accordance with any one of the Claims 1 to 8, characterised in that the grooves (20) are distributed symmetrically over the circumference of the filter plug (16).

10. A smoking article in accordance with any one of the Claims 1 to 9, characterised in that the grooves (20) are V-shaped or U-shaped.

11. A smoking article in accordance with any one of the Claims 1 to 10, characterised in that the grooves have a depth from 0.5 to 2 mm.

12. A smoking article in accordance with any one of the Claims 1 to 11, characterised in that the grooves (20) at the circumference have a width of 1 to 3 mm.

13. A smoking article in accordance with Claim 12, characterised in that the grooves (20) at the circumference have a width of from 1.5 to 2.5 mm.

14. A smoking article in accordance with any one of the Claims 1 to 13, characterised in that the filter plug (16) consists of filter tow made of cellulose acetate.

15. A smoking article in accordance with Claim 14, characterised in that the filter plug (16) contains additives such as activated charcoal, zeolites, Duolite or flavour-altering additives.

16. A smoking article in accordance with any one of the Claims 1 to 15, characterised in that the tipping paper (22) is porous.

17. A smoking article in accordance with any one of the Claims 1 to 15, characterised in that the tipping paper (22) is provided with ventilation openings (24) by mechanical or electrostatic means or by laser beams.

18. A smoking article in accordance with any one of the Claims 1 to 17, characterised in that the degree of ventilation of the tipping paper (22) lies between 30 and 80%.

19. A smoking article in accordance with Claim 18, characterised in that the degree of ventilation of the tipping paper (22) lies between 40 and 70%.

20. A smoking article in accordance with any one of Claims 1 to 19, characterised in that the plug wrap is provided with ventilation openings.

21. A smoking article in accordance with Claim 20, characterised in that the ventilation openings are provided by on-line machine perforation.

22. Use of a smoking article in accordance with any one of the claims 1 to 21 for the reduction of the CO/tar ratio as a function of the filter ventilation.