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The history of the Philishave

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The original rotary-shaving principle

An article that appeared in Philips Technical Review in 1939 tells how it all began [1]. The rotary-shaving principle it described has meanwhile become rather more familiar. Fast-rotating cutters are combined with openings that trap the bristles of the beard and point in all directions, so that the system does not require accurate shaving movements. This was a very promising approach, as can be seen from the success of the Philishave as a product since 1950 [2]. Was the choice of this principle based on intuition or science?

The original point of departure was the rotation of cutters at a high speed, 5 to 6 m/s. Because of this rotation the cutting velocity can remain constant. This is not so in shaving systems using vibrating cutters. The high speed of rotation guarantees effective cutting action. In the first type of Philishave, the 'Staalbaard' (Dutch for 'steel beard'), see *fig. 1*, it was even assumed that relatively blunt cutters would still cut sufficiently well. The choice of material did not therefore depend entirely on its hardness. Bronze cutters were therefore used at first, because of their good running characteristics. The material of the cutters is in fact the only thing that was later modified; in other respects the principle used in the first Philishave is essentially the same today.

The original Philishave had a cutter wheel with three 'blades'. The shaver-head assembly was based on a statically determined design — with exactly the right number of support points for the cutter wheel, so that there were no special requirements for flatness of head or cutter. To enhance the cutting capacity the number of blades per cutter was soon increased to six. These six-blade heads, which did have a tight tolerance for flatness, were produced for many years.

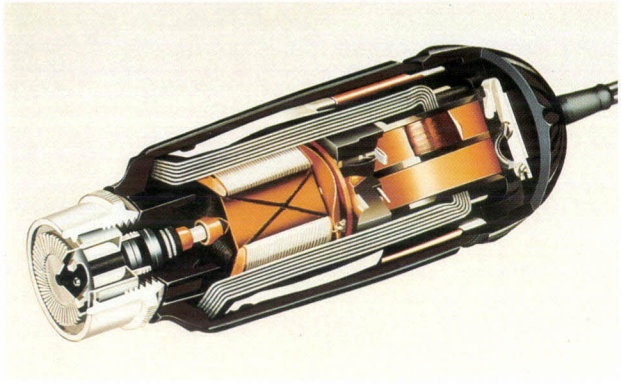

Fig. 1. The 'Staalbaard', the type 7733 Philishave brought out in 1947.

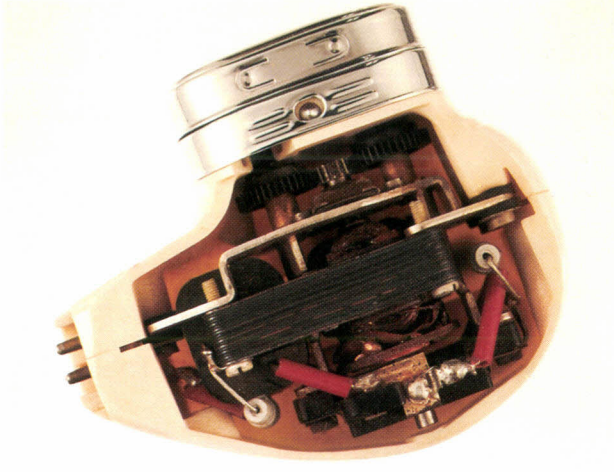

Fig. 2. The 'Eitje' (little egg), the type 7743 Philishave produced between 1951 and 1957.

Improving bristle capture

Dry shaving can be considered as a statistical process. At each pass of the shaver over the beard, some of the bristles are captured in a slot and some are not. Only the bristles that have been captured can be shaved off. So, however effective the cutters, better shaving can only be achieved by increasing the probability of capturing the bristles. One way of doing this would be to increase the number of shaver heads (see *fig. 2*), and another way would be to use more slots per head. To obtain more slots it was first necessary to increase the outer diameter of the shaver head. *Fig. 3* shows that the first head was 17 mm in diameter and had 48 slots. In 1962 a Philishave was introduced that had cutter heads of 22.5 mm diameter and 74 slots. At the same time Philishaves continued to be produced with 19.5-mm cutter heads and 60 slots.

In 1970 we managed to put 90 slots into this 19.5-mm shaver head. This was a great improvement. But

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the improvements were not entirely due to the increase in the number of slots. The techniques used for polishing the heads and grinding and lapping the cutters were also undergoing continuous improvement, and the number of heads was increased to three. The triple-head shaver (*fig. 4*) is the one that has become most widely known.

A new principle

Empirical investigations to determine the proper dimensions of lamella and slot have continued for many years. Much progress has been made, but, as might be expected, it diminishes with the years, certainly when the advances are compared with the effort. There is a law of diminishing returns.

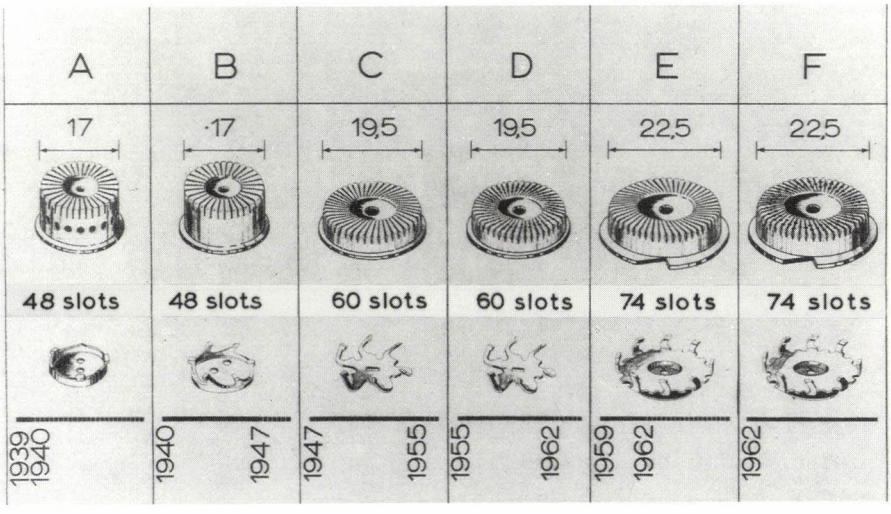

Fig. 3. The shaver heads from 1939 to 1962.

The trade-off between smoothness and skin damage

We have seen that a shaver head has slots that have to capture the bristles. The metal 'lamellae' between the slots act both as cutting edges and prevent contact between skin and cutter.

It would be ideal if the skin pressed into the slot occupied a distance exactly equal to the thickness of a lamella. The bristle would then be snipped off very short and there would be no damage to the skin. Thinner lamellae and more deeply polished slots give a smoother shave, but also cause more skin irritation. Minor variations in the geometry very quickly affect the trade-off between smoothness and skin damage. Very close tolerances are therefore specified for the thickness of the lamellae, the radius of their rounded edges and the width of the slots.

There is still the great difficulty that there are marked variations in the distance that the skin protrudes into the slots, since the skin differs considerably from one person to another. This implies that a particular dimensioning of the slots and lamellae, however close the tolerances, can produce quite different results for different people. For this reason some types of Philishave have been given adjustable shaver heads, so that the pressure of the lamellae on the skin can be altered to suit the user.

Fig. 4. The triple-head HP 1335 Electronic shaver, now in production.

[1] A. Horowitz, A. van Dam and W. H. van der Mei, The dry shaving apparatus 'PhiliShave', Philips Tech. Rev. **4**, 350-354, 1939.

[2] Philishave is a trademark of Philips Export B.V.

Attempts have therefore been made to find new ways of manipulating the trade-off mentioned above, towards a smoother shave. The successful outcome is a device referred to in the Philips shaver laboratory as the 'retraction cutter'. Users know this as the 'lift-blade shaving system'.

The development of the new principle began in 1974. A thin and very light second cutter blade, the 'lift blade', is mounted against the oblique front edge of each main cutter blade. As soon as the lift blade touches a bristle, it is lifted by the horizontal component of the cutting force. The bristle is then carried along a little way by the lift blade, so that it is pulled away from the skin. Then the main cutter blade snips it off; see *fig. 5*.

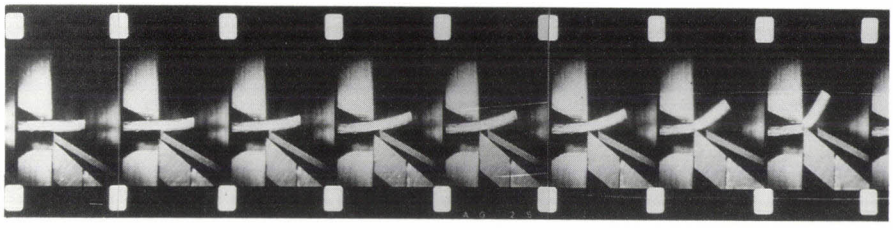

Fig. 5. Superfast moving pictures demonstrating the retraction mechanism on a 10 : 1 scale model of skin and bristle.

In the practical design, see *fig. 6*, this process takes place in 0.04 millisecond. The lift blade forms part of a mass-spring system, which must be carefully dimensioned because the resulting accelerations may reach 80 000 m/s^2 . During the development it was not at all clear whether the skin would be able to follow the bristle: not only are there elastic and plastic components of the forces in the skin; viscous components also have to be considered.

In fact the skin does follow the bristle, so that the bristle follows the lift blade, as has been shown by super-high-speed moving pictures taken '*in vivo*'. This could also be seen from scanning electron micrographs of severed bristles, which clearly showed the notches made by the lift blade; see *fig. 7*. These micrographs are also used to determine the height of the 'bristle lift' produced by the lift blade.

A special technique had to be developed for the super-high-speed moving pictures. The short process time requires a frequency of 32 000 frames per second. The exposure time per frame is about 0.01 ms, which means that, with the double magnification of the imaging system, a great deal of light is required. The heat generated from this would burn hair and skin. But since it is essential that hair and skin should in no way be affected by the experiment, the series of pictures lasted in all only 0.15 s. Ensuring that the series of exposures coincided with the actual cutting of a bristle therefore called for extreme accuracy.

The first shavers with a lift blade came on to the market in 1980. Experience has shown that these appliances do in fact produce a significantly smoother shave.

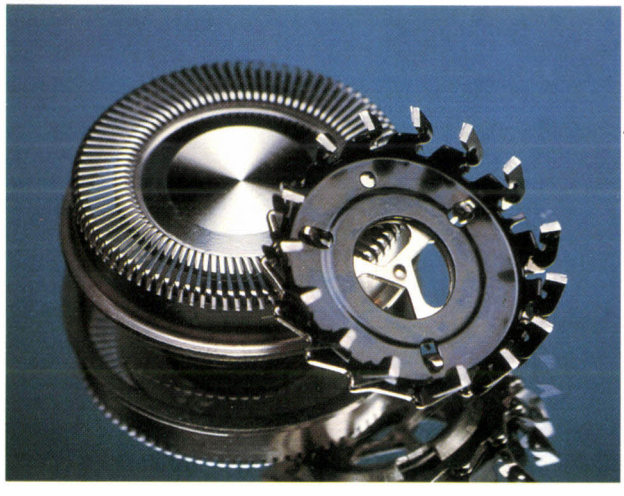

Fig. 6. The shaver-head assembly with lift-blade cutter.

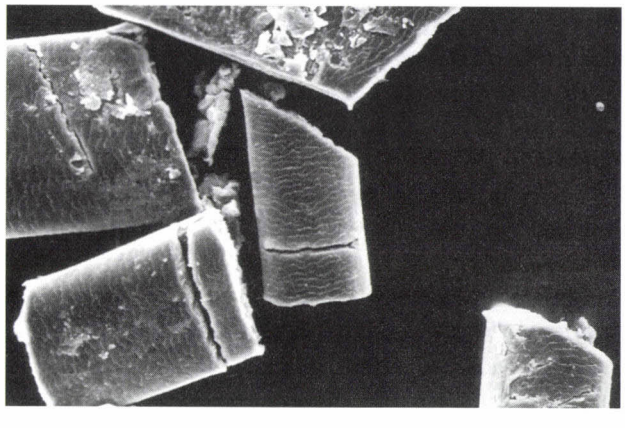

Fig. 7. 'Snipped-off' bristles. The distance between the notch made by the precursor blade and the end of the bristle is the length by which the bristles are pulled up. This takes place against the direction of the 'scales' on the hair.

General aspects

The market success of shavers does not depend entirely on the shave they give. Today's user is more demanding in matters of personal comfort. Better styling, lower weight, smaller dimensions, independence from the mains supply, quiet operation are all factors that are playing an increasingly important part in the development of a dry shaver. As can be seen from the cut-away view of a twin-head shaver from the fifties, shown in fig. 2, almost all of the space inside this mains-powered appliance is taken up by the motor. It is clear that the shape of this appliance is largely dictated by the components it has to accommodate.

Battery-powered shavers were also introduced — later versions with rechargeable batteries — and these were fitted with permanent-magnet (PM) motors. Better magnetic materials and improved design led to a gradual reduction in the size of the motors.

New winding techniques enable PM motors to be used at higher voltages, e.g. 50 V. With modern electronics and pulse-width modulation of the supply, these motors can also be used in mains appliances. Internal electronic control can keep the speed constant even with different mains voltages and varying loads. PM motors are quieter, and are much smaller, so that the motor only occupies a small part of the space available in the housing, as can be seen in *fig. 8*. Shaver head, drive and motor together form a relatively compact unit. This gives designers greater freedom with the styling of the appliance.

The rechargeable shavers are based on the low-voltage version of the PM motor. Formerly the batteries for these appliances had to be charged via 50-Hz transformers. Nowadays switched power supplies are used because they only require a very small transformer. Recharging can be completed in an hour, and if the batteries are run down, the appliance can be operated from the mains. Two LEDs on the casing flash a warning when the batteries are nearly run down.

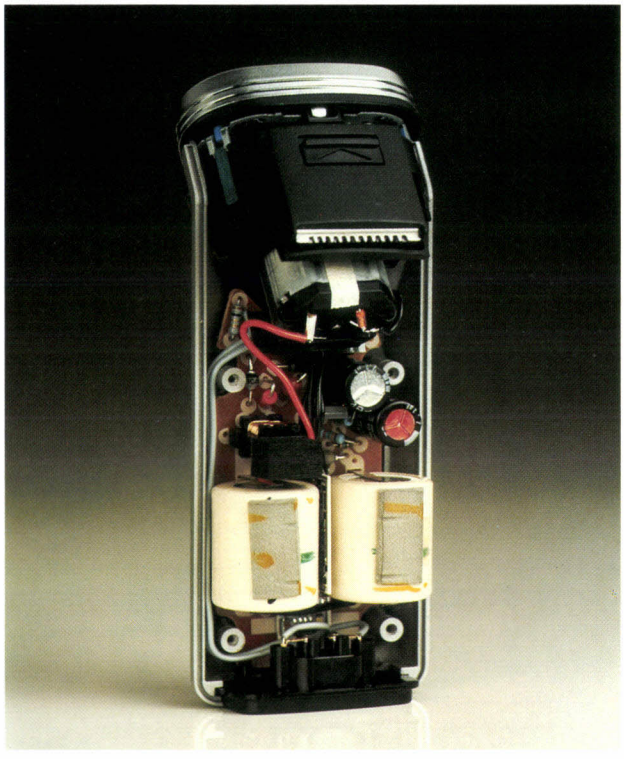

Fig. 8. Interior view of the HP 1335 shaver shown in fig. 4.

So is the success of the Philishave based on intuition or science? This could be agreed either way — and at length. What we do know is that some 50 years of Philishave history have taught us that a *combination* of intuition and scientific research generally give the most successful development.

Summary. The principle of the Philishave has not changed since 1939: it still has the rotating cutter. Bristle capture has however been improved by increasing the number of heads and the number of slots per head. Improved control of the geometry has also provided a better trade-off between a smooth shave and skin damage. The recent introduction of the retraction cutter gives an even better shave.