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CHEVRON CUTTING--EXPERIMENT WITH NEW
RUNWAY MIXTURES

K. Tyran

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16 Abstract Chevron cutting occurs in different forms depending on the type of tire and the rubber on the running surface. Hardest wear is shown by the main tires of the B-747. Four defects have occurred, in the form of two rip separations and two breakouts of the running surface. Tires capped by Thompson are more affected than any of the other rubber-capping fabrics. For Thompson tires, Chevron Cutting can be greatly reduced with a fiberglass-rubber mixture. For Goodyear tires, it can be eliminated with spiral wrap rubbercapping; resistance to damages through cuts seems to be more positive for Goodyear tires. For Mäder tires, the extent of Chevron Cutting is generally smaller than for Thompson cappings.			
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CHEVRON CUTTING--EXPERIMENT WITH NEW
RUNWAY MIXTURES

K. Tyran
Swissair-Technical Department

1. Explanation

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Since the introduction of the new runway construction with crosswise running grooves damages to the running surfaces occur in the form of V-shaped breaks which are designated as "Chevron Cutting".

These damages occur upon landing when the stationary tire touches the grooved runway and slides over the groove edges. Chevron Cutting is influenced by tire pressure, touchdown velocity and mass moment of inertia of the wheel (Figs. 1, 2, 3).

After the start of operation with grooved runways a reduction in the efficiency of tires used for landing was recorded. Since Chevron Cutting also had negative effects on the possibility of keeping damages through cuts under control and presumably offers less resistance to the penetration of foreign bodies, an experiment (Publ. Nr. 72'539) was carried out with new running surface constructions.

*Numbers in the margin indicate pagination in the foreign text.

Compiled:

Checked:

Reviewed:

K. Tyran, TZMPP

E. Rueger, TZMP

E. Schientarelli
TZM

2. Running Surface Fabrics--Description

2.1 Thompson

A rubber mixture reinforced with fiberglass was developed especially against Chevron Cutting by the firm of Thompson--USA. The fiberglass fibers are 3 mm long and 0.03 mm dia. and are mixed with the rubber of the running surface above the reinforcement layers only. In the bonding region between carcass and rubber capping no change was made in the rubber mixture. Tires of such construction were put into operation in the USA several years ago. In addition to the rubber mixture reinforced with fiberglass, 2 tires with running surfaces made of natural rubber were tested.

2.2 Goodyear

A so-called "spiral wrap" running surface construction was developed by the Goodyear Company. This is a reinforcement of the running surface through cord threads in the rubber of the running surface. The threads are applied with the unvulcanized rubber strip, circumferential in spiral-form, through a special rubbercapping process (Orbitread). Tires of such construction have been made in the USA for the past 5 years. Fig. 4 shows the distribution of the cord threads in the running surface.

The running surfaces of the Goodyear Company consist of natural rubber in contrast to the other products which contain a certain amount of synthetic rubber.

2.3 Mader

The Mader Company has developed a soft rubber mixture which has not been tested so far

Physical data:

Characteristics tested on Plates, Vulc. 45'/ 140°C, VSM-3-Dumb- bells		Soft Mixture AB 5550/1	Normal Mixture AB 1910/5 (newest mixture)
Hardness	Shore A	60	64
Tensile strength	kg/cm ²	256	240
Elongation	%	570	490
Module 300%	kg/cm ²	100	126
Notch tensile strength (Delft)	kg/cm ²	110 longitud.	110
		140 across	138
Wear	mm 3	45	43
	% Stand.	38	37

3. Experiment

3.1 Description

The two B-747 aircraft were designated for the service evaluation because the tires of this type of aircraft are strongly affected by "Chevron Cutting" and because their favorable route structure permitted good monitoring.

The tires were mounted in pairs, i.e., one tire of the present material and one of the Chevron Cutting-resistant construction was mounted on the same axle. This was an attempt to arrive at equivalent evaluations.

The criteria for evaluation are:

- Susceptibility to "Chevron Cutting"
- Wear
- Sensitivity to cuts

Wear was measured at 4 locations of the circumference and an average value was formed.

Two values of wear were determined in each case since wear is greater at wheel positions 7, 8, 11, and 12 than at the other MLG wheel positions.

Remaining depth of grooves and the premature going out of service, because of damage through cuts, were not taken into consideration for the average number of landings achieved with the test tires.

Nine pairs of tires were subjected to the tests for each rubbercapping material. Direct comparison between the three fabrics tested, as regards wear and Chevron-Cutting susceptibility, cannot be made since the tire fabrics were not subject to the same loads, resp., the same weather conditions.

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The tests were carried out during the following periods:

Thompson: November 1976-March 1977
Goodyear: February 1977-May 1977
Mäder: April 1977-June 1977

... 3.2 Thompson

3.2.1 "Chevron-Cutting"-susceptibility

The running surface mixture, which was reinforced with fiberglass, showed remarkable improvement when compared to the previous running surface mixture with regard to susceptibility to "Chevron Cutting."

There were no Chevron Cuts on two of the nine test tires. They did appear on the remaining seven test tires but to a much smaller extent than for the previous running surface mixture. The breaks are up to 8 mm long and about 0.8 mm deep. For the previous mixture breaks were as much as 40 mm long and 3-4 mm deep (see Figs. 5, 6, 7 and 8). Two of the tires capped with natural rubber showed better performance with regard to Chevron Cutting than those with the previous running surface mixture.

3.2.2 Wear

Wear at wheel positions	1-6, 9, 10 and 13-16
Previous running surface mixture:	0.025 mm per landing
Fiberglass reinforcement.	0.031 mm per landing
Natural rubber mixture	0.029 mm per landing
Wear at wheel positions.	7, 8, 11 and 12
Previous running surface mixture:	0.037 mm per landing
Fiberglass reinforcement	0.059 mm per landing

Average wear is about 20% greater all over for the fiberglass-rubber mixture.

Average number of landings achieved.

Previous running surface mixture. 153 landings

Fiberglass reinforcement mixture: 129 landings

3.2.3 Sensitivity to Cuts

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Based on visual checks of the test tires sensitivity to cuts seems to be rather higher for the fiberglass-compound

tires. But reliable answers about the sensitivity to cuts can only be supplied after more extensive experiments.

3.3 Goodyear

3.3.1 "Chevron Cutting"-susceptibility

The "spiral wrap" construction of the running surface has shown the best performance of all tested fabrics with regard to Chevron Cutting. No Chevron Cuts appeared on the tires tested.

Fig. 9 shows Chevron Cutting on a normal running surface construction. Fig. 10 shows a worn-out "spiral wrap"-tire.

3.3.2 Wear

Wear at wheel positions 1-6, 9, 10 and 13-16

Previous running surface construction	0.070 mm per landing
SPIRAL WRAP:	0.071 mm per landing

Wear at wheel positions 7, 8, 11 and 12

Previous running surface construction:	0.090 mm per landing
SPIRAL WRAP:	0.096 mm per landing

There is no difference in wear, resp. landing efficiency, between the normal running surface construction and the spiral wrap running surface.

Average number of landings achieved:

Previous running surface construction (new tires)	101.4 landings
SPIRAL WRAP (recapped tires):	120.3 landings

Note Since the Goodyear Company has so far not carried out any cappings for the B-747 comparative experiments had to be carried out between new tires and recapped spiral wrap tires. New tires have a groove depth of 8.9 mm and cappings of 11 mm. This is the reason for the number of landings being smaller for new tires.

3.3.3 Sensitivity to Cuts

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Based on visual checks the spiral wrap tires seem to show better performance with regard to damage from cuts. Reliable statements can only be made about F.O.D. performance after more extensive experiments.

3.4 Mader

3.4.1 "Chevron Cutting"-susceptibility

The softer rubber mixture showed no difference from the previous normal running surface mixture with regard to susceptibility to Chevron Cutting. Length and depth of the breaks is also about the same for both mixtures. Figs. 11 and 12 show the extent and Figs. 13 and 14 the characteristic of Chevron Cuts on Mader rubber cappings.

3.4.2 Wear

Wear at wheel positions 1-6, 9, 10, and 13-16

Previous running surface mixture.	0.051 mm per landing
Soft rubber mixture.	0.053 mm per landing

Wear at wheel positions 7, 8, 11 and 12

Previous running surface mixture	0.061 mm per landing
Soft rubber mixture	0.063 mm per landing

There are no differences between the previous running surface mixture and the soft rubber mixture with regard to wear.

Average number of landings achieved

Previous running surface mixture:	158.6 landings
Soft rubber mixture.	157.8 landings

3.4.3 Sensitivity to Cuts

No obvious differences could be detected in sensitivity to cuts between the two rubber mixtures.

4. Influence of Runway Grooves on Landing Efficiency

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*(Grooves (macrotecture) have no influence on rubber wear)

After runway 14/32 was put into operation in April 1976 landing efficiency dropped by about 8%, as compared to the same time period in the previous year. *(As result of the micro-
texture) During the same period of the following year landing

efficiency increased again by 5% so that it stands only slightly below that before the grooved runway was put into operation.

Comparison of yearly efficiencies shows no differences between 1975 and 1977. It can be assumed that the temporary drop in efficiency in 1976 was probably due to the roughness of the new runway surface and not due to the grooves, resp. the Chevron Cutting.

5. Runway Texture with Brush Finish

In the attempt to reduce the amount of Chevron Cutting a surface texture in the form of a brush finish crosswise to the touchdown direction was provided over a length of 1200 m during the construction of runway 16/34.

During the first phase of operation of this runway the previous "Chevron Cutting" characteristic changed for one of the rubber-capping fabrics (Thompson) The breaks become closer, shorter and shallower (see Fig. 15). This effect was not observed any longer after a few days had passed. It is assumed, therefore, that the brush finish texture is quickly filled by the worn rubber and thus loses its effect.

6. Tire Defects Because of "Chevron Cutting"

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Defects that are caused by Chevron Cutting are relatively harmless. No complete separations from the running surface or blowouts will result. Only breaking off of rubber or rib separations above the reinforcement layers can happen (see Fig. 14).

The following defects were caused by Chevron Cutting so far

<u>A/C</u>	<u>L-Gear</u>	<u>Fabric</u>	<u>Description of Defect</u>
DC-10-30	NLG	Mader	Rib completely separated
DC-10-30	NLG	Mader	Rib separated by 60 cm (Fig 16C)
DC-10-30	NLG	Mader	Rubber breaking off (Fig. 16A)
B-747	MLG	Kleber	Rubber breaking off (Fig. 16B)

7. Evaluation for Susceptibility to "Chevron Cutting" of Rubbercapping Fabrics Now in Use

The extent of Chevron Cutting differs for the various rubber capping fabrics according to the different rubber mixtures. It could be observed, for instance, that breaks at the running surfaces are shorter for natural rubber mixtures than for synthetic mixtures (Fig. 15). Chevron Cutting occurs with different intensity at all types of aircraft, resp. tire dimensions.

The evaluation in Table I allows a survey of the extent of Chevron Cutting for different rubbercapping fabrics and different dimensions. The evaluation is related to the number, resp. frequency, of Chevron Cuttings and not to the dimensions of the breaks.

Re-treader	DC-9-32		DC-9-33/51		DC-8-62		DC-10-30		B-747
	MLG	NLG	MLG	NLG	MLG	NLG	MLG	NLG	MLG/ NLG
MAEDER	0	0	0-X	0	X	0	X-XX	X	XX
THOMPSON	X	0	X-XX	0	XX	0	XX	X	XXX
GOODYEAR	0	0	-	0	X	0	X-XX	X	-

Chevron Cutting None = 0, Slight = X; Medium = XX, Heavy = XXX

8. Summary/Conclusions

8.1 THOMPSON-tires

- Chevron Cutting can be greatly reduced with the fiber-glass-rubber mixture.
- Based on wear measurements 20% lower efficiency is expected for this rubber mixture than for the previous one.
- Resistance to damages through cuts appears to be worse, based on visual inspection.

8.2 GOODYEAR-tires

- Chevron Cutting can be eliminated with spiral wrap rubbercapping.
- The cord threads in the circumference of the running surface do not reduce landing efficiency appreciably, according to wear measurements.
- Resistance to damages through cuts seems to be more positive.

8.3 MAEDER-tires

- No differences were noticed between the softer mixture and the previous running surface mixture, as regards Chevron Cutting, wear and sensitivity to cuts.
- The extent of Chevron Cutting is generally smaller for Mader running surfaces than for the previous Thompson cappings.

8.4 General

Chevron Cutting occurs in different forms depending on the type of tire and the rubber on the running surface. Hardest wear of all tires is shown by the main tires of the B-747.

Tires capped by Thompson are more affected than any of the other rubbercapping fabrics.

8.5 Defects

Four defects have occurred up til now, in the form of 2 rip separations and 2 breakouts of the running surface.

Three defects occurred on DC-10-30 tires that were capped by the Mäder Company (Figs. 16A, 16C). One defect occurred on a new B-747 tire from the Kleber Company (Fig. 16B).

9. Suggestion

9.1 THOMPSON

Lower efficiencies are expected for the rubber mixture reinforced with fiberglass, according to wear measurements.

Since this rubber fabric is still purchased from the USA an increase of 10% in capping costs is to be expected. In case of an eventual switch to a European source of supply the increase in price would amount to between 3-5%, according to Thompson estimates. /9

It is suggested that this rubber mixture not be used because of the financial disadvantages involved. Of all

aircraft tires and capping fabrics used the B-747 running surfaces by Thompson are the most seriously affected by Chevron Cutting. It is suggested that this type of tire be capped with natural rubber or some improved rubber mixture, for the time being.

9.2 GOODYEAR

--Because positive results have been achieved with the spiral wrap tires and no price increases are expected for the moment, it is suggested that this construction be continued for the B-747. After sufficient experience with it the introduction of this construction may be considered for other types of aircraft.

9.3 MAEDER

--Since no better results were achieved with the soft rubber mixture it is suggested that this mixture not be introduced.

--It is suggested that the Mäder Company make some changes in the rib configuration of the rubber mixture on this type of tire since only Mäder-capped DC-10-30 NLG-tires suffered defects from Chevron Cutting.

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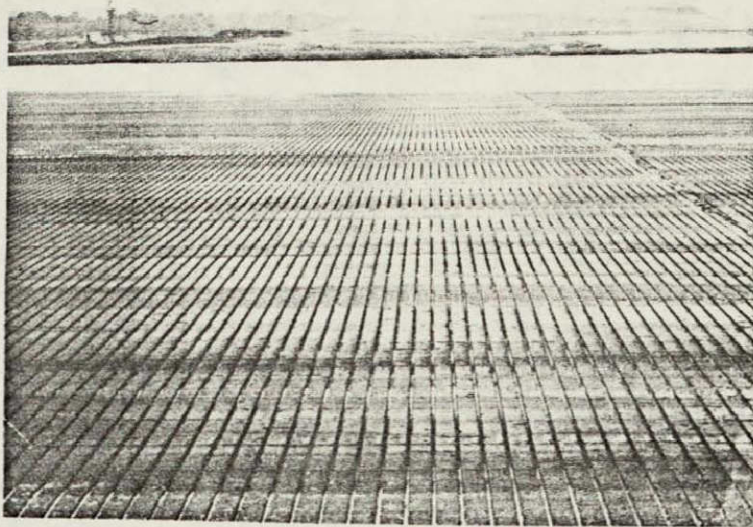
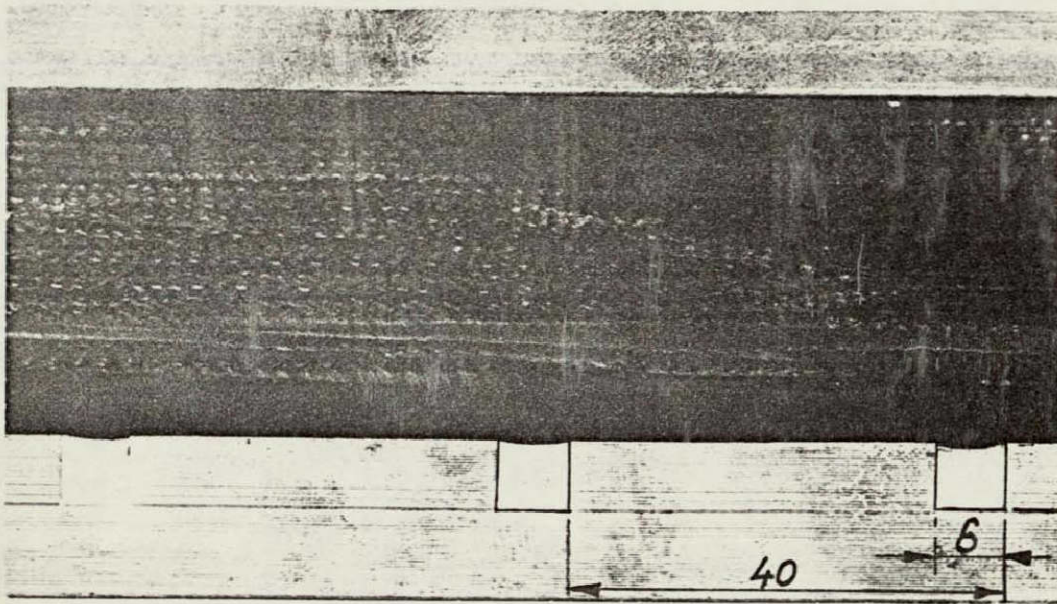


Fig. 1 Runway 14/32 Touchdown Zone



Tire cross-section

Fig. 2 Runway profile. A B-747 tire with 13.35 kp/cm^2 tire pressure is pressed about 1.4 mm deep into the groove.

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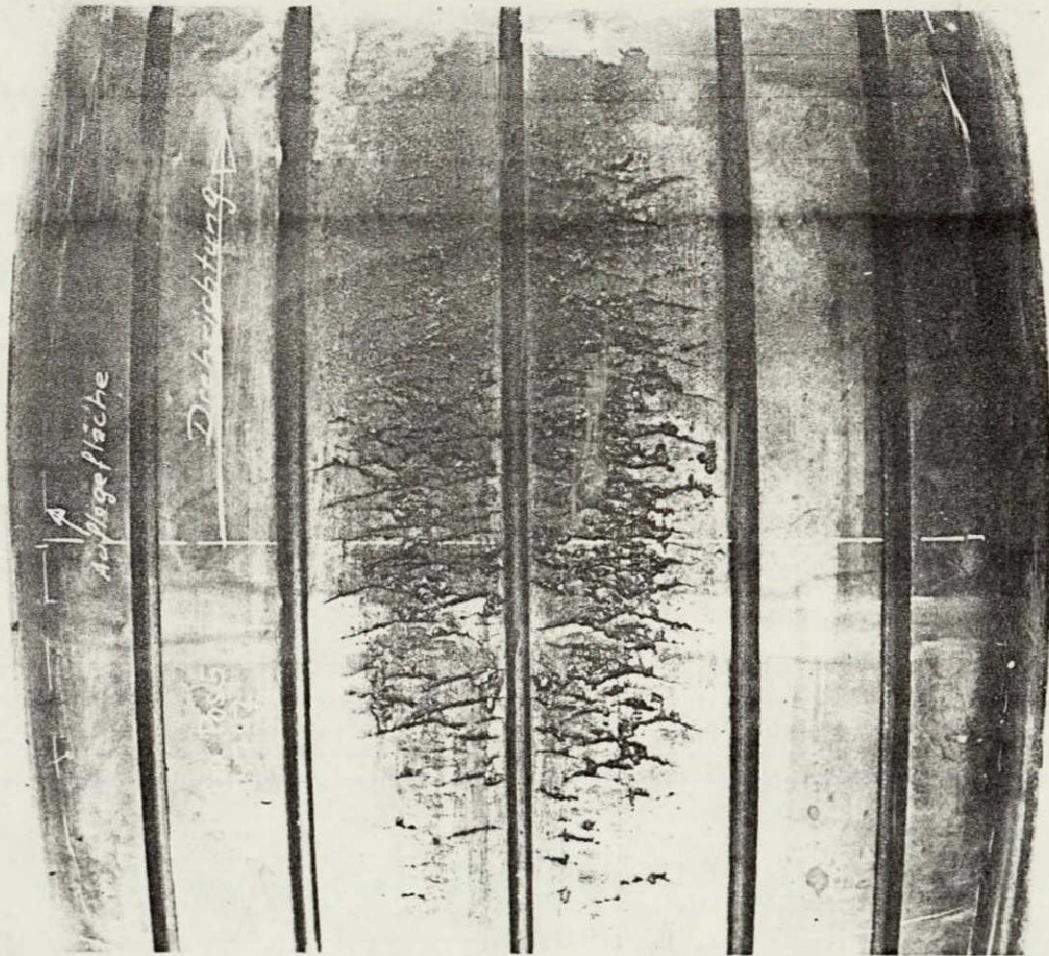


Fig. 3 Chevron Cutting occurs at the touchdown surface when the stationary tire glides over the groove edges.

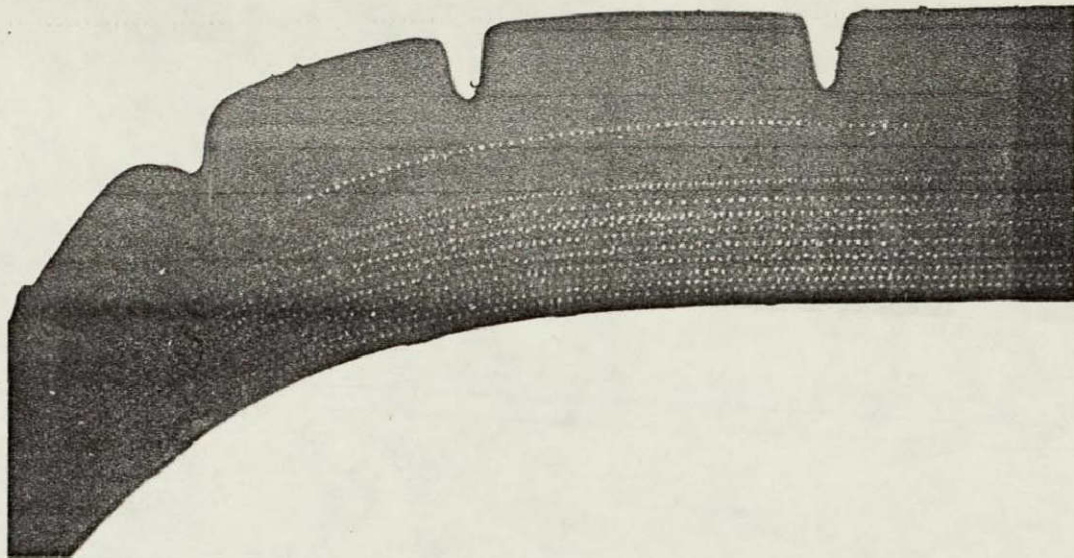


Fig. 4 "Spiral wrap" construction contains cord threads in the running surface rubber which are wound in the direction of the circumference.

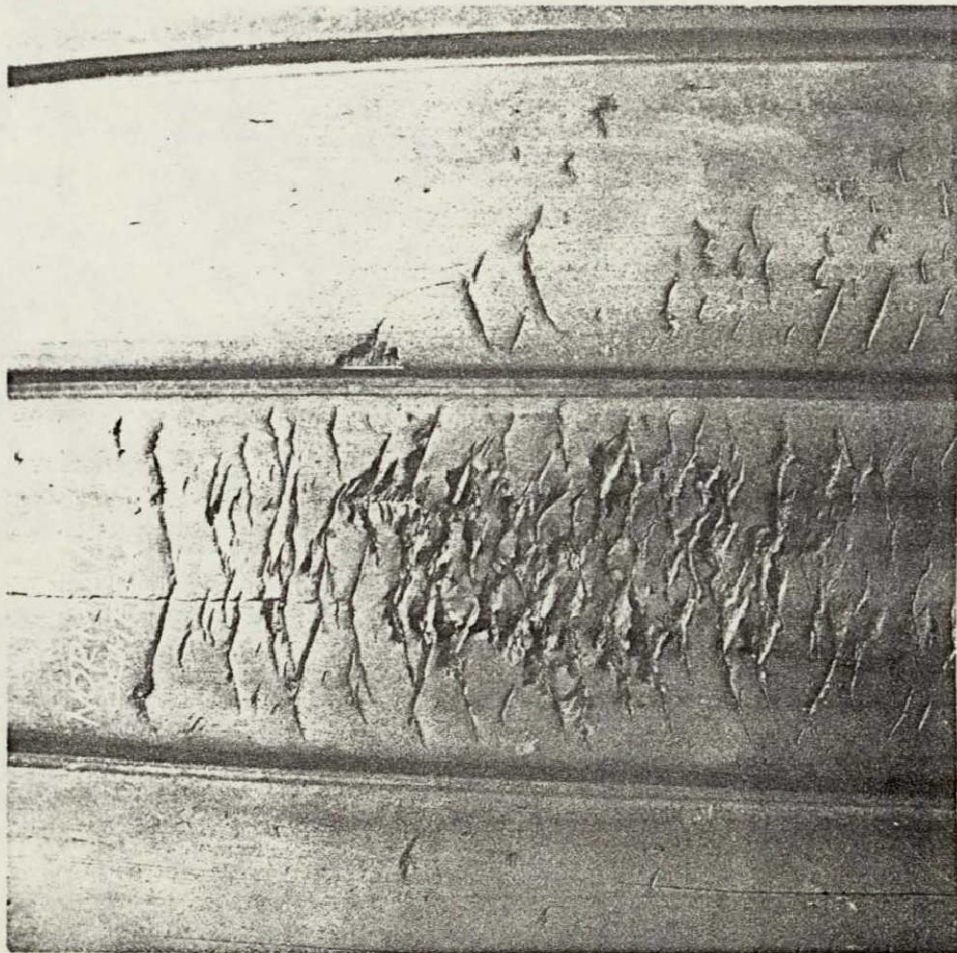


Fig. 5 THOMPSON--normal mixture with typical Chevron Cuts.

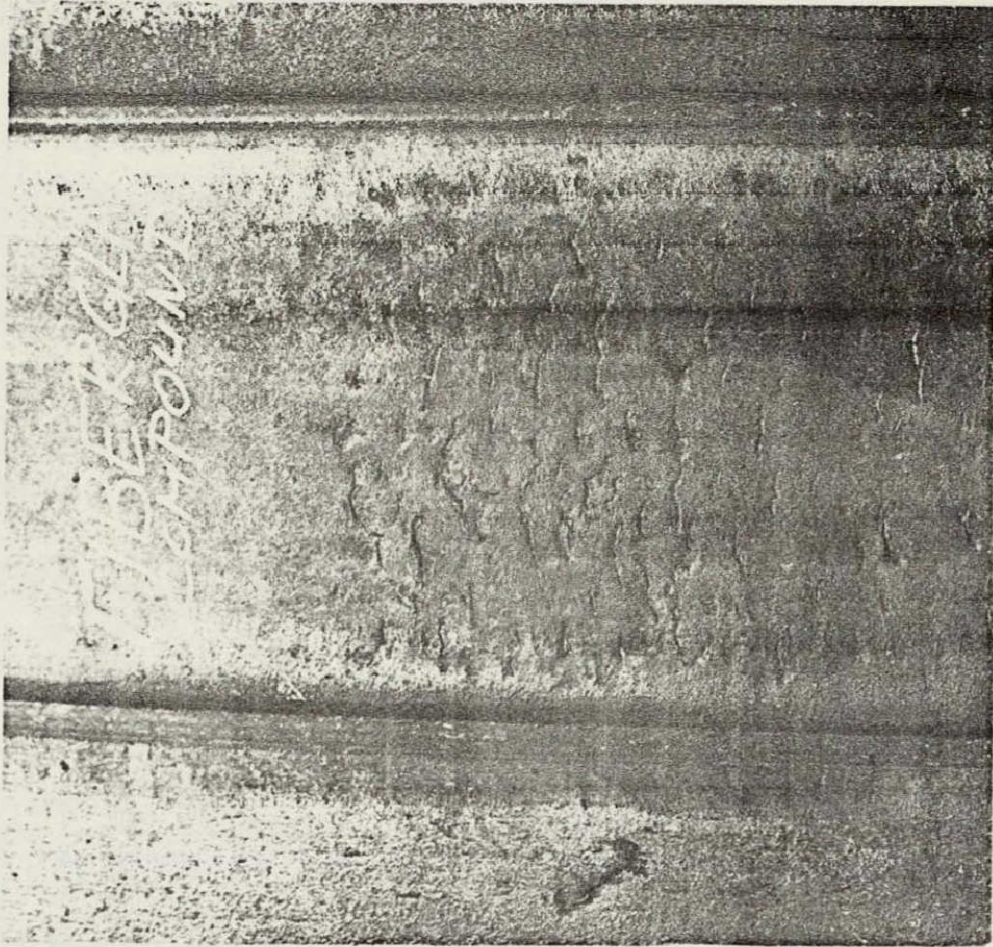


Fig. 6 THOMPSON--Fiberglass compound with typical Chevron Cuts.

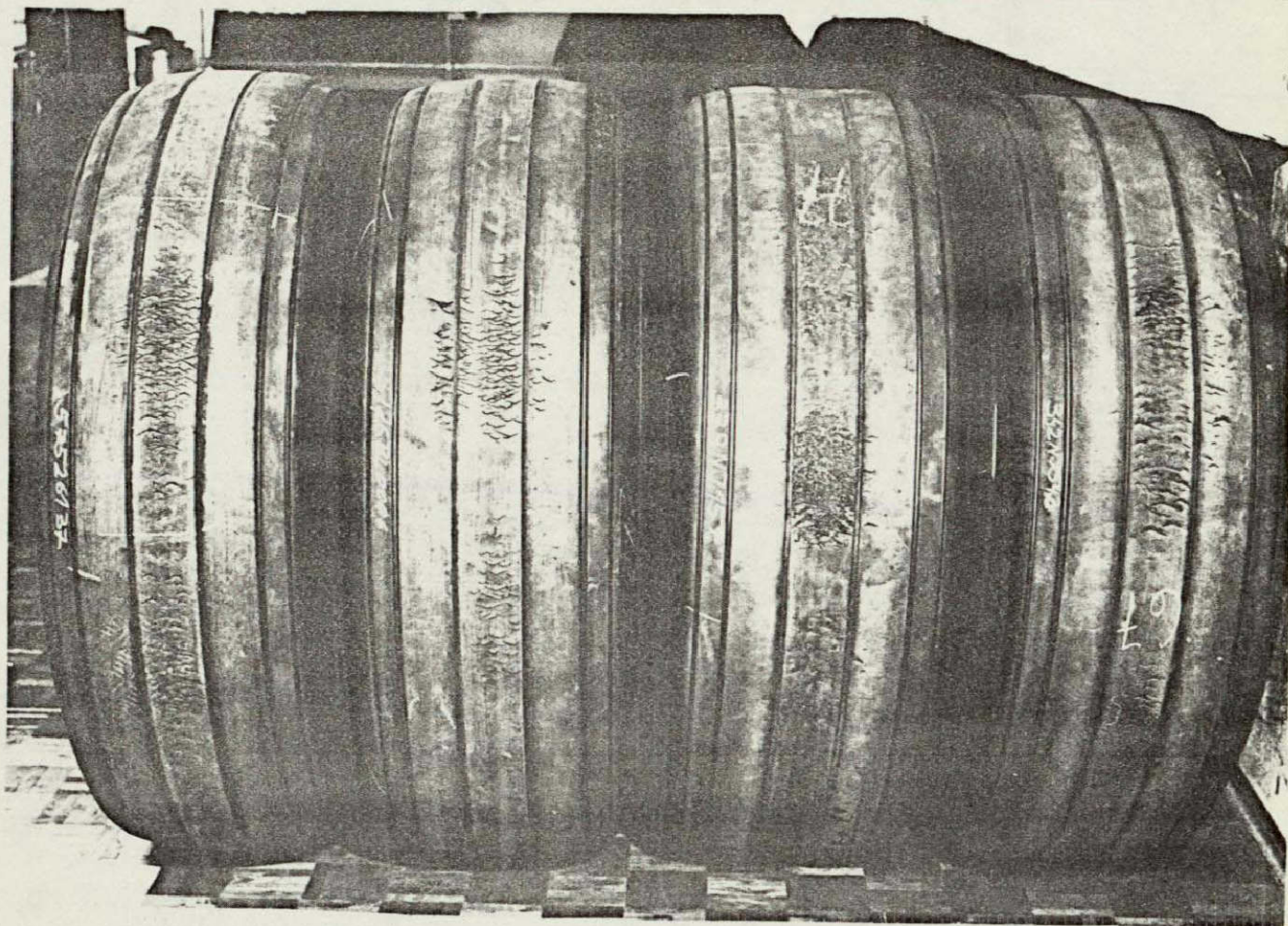


Fig. 7 THOMPSON--Normal mixture typical appearance.

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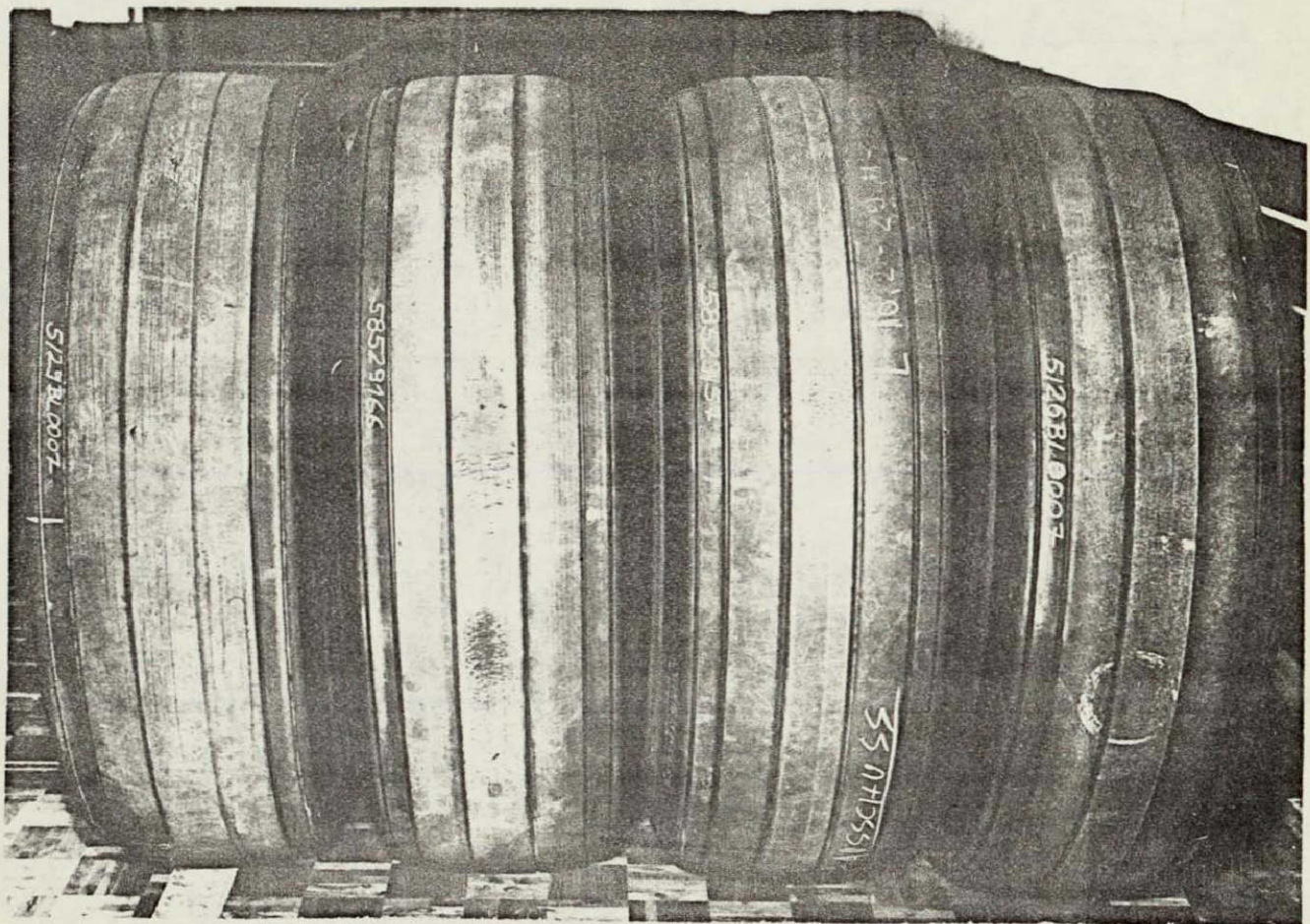


Fig. 8 Fiberglass compound typical appearance.

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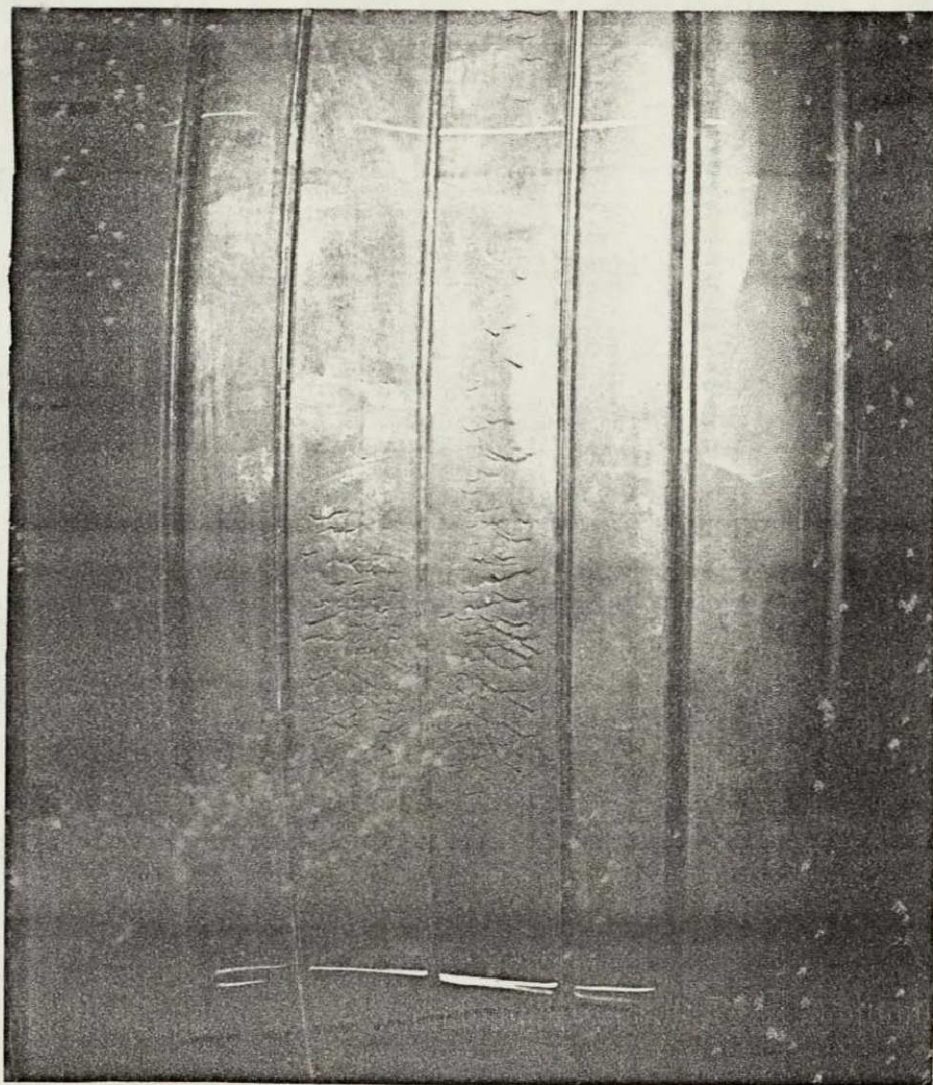


Fig. 9 GOODYEAR--normal construction with typical Chevron Cutting.

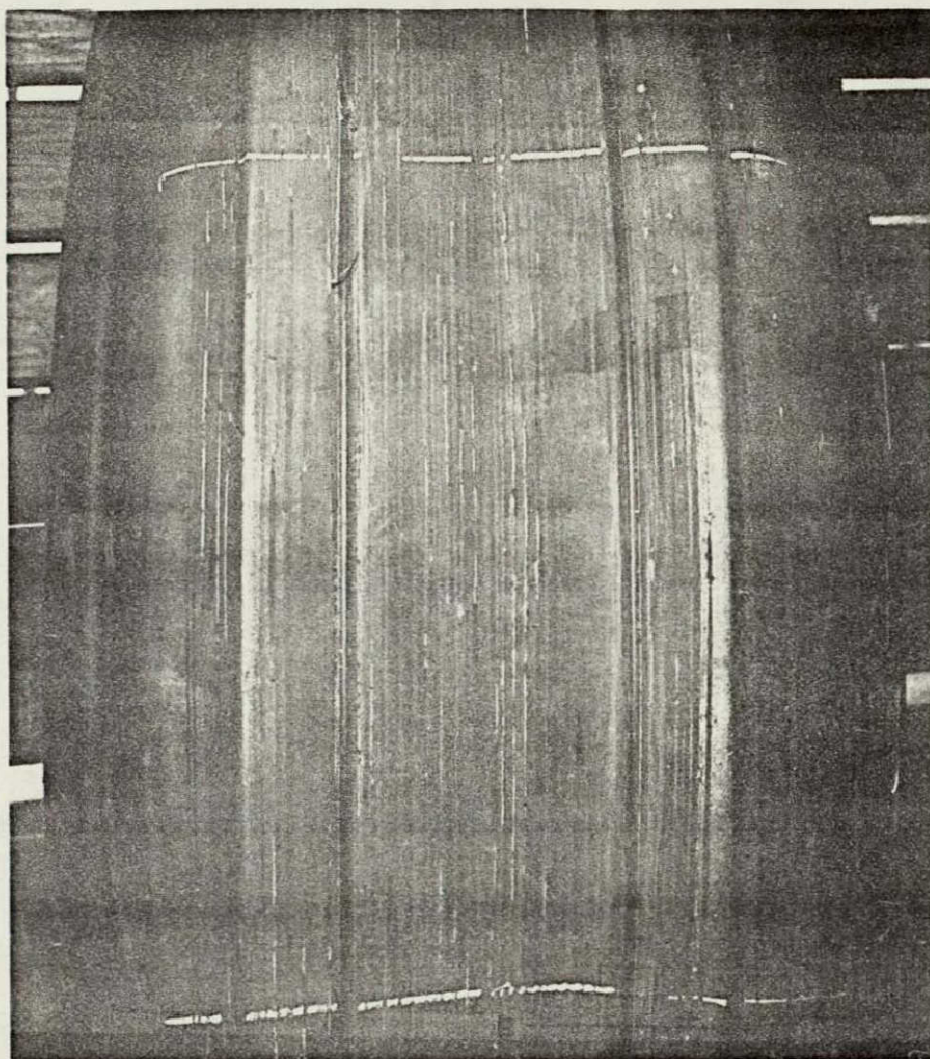


Fig. 10 "Spiral Wrap" construction, typical appearance of a worn-out tire. No Chevron Cutting appears on this tire.

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Fig. 11 MAEDER--normal mixture typical appearance of worn-out tires.

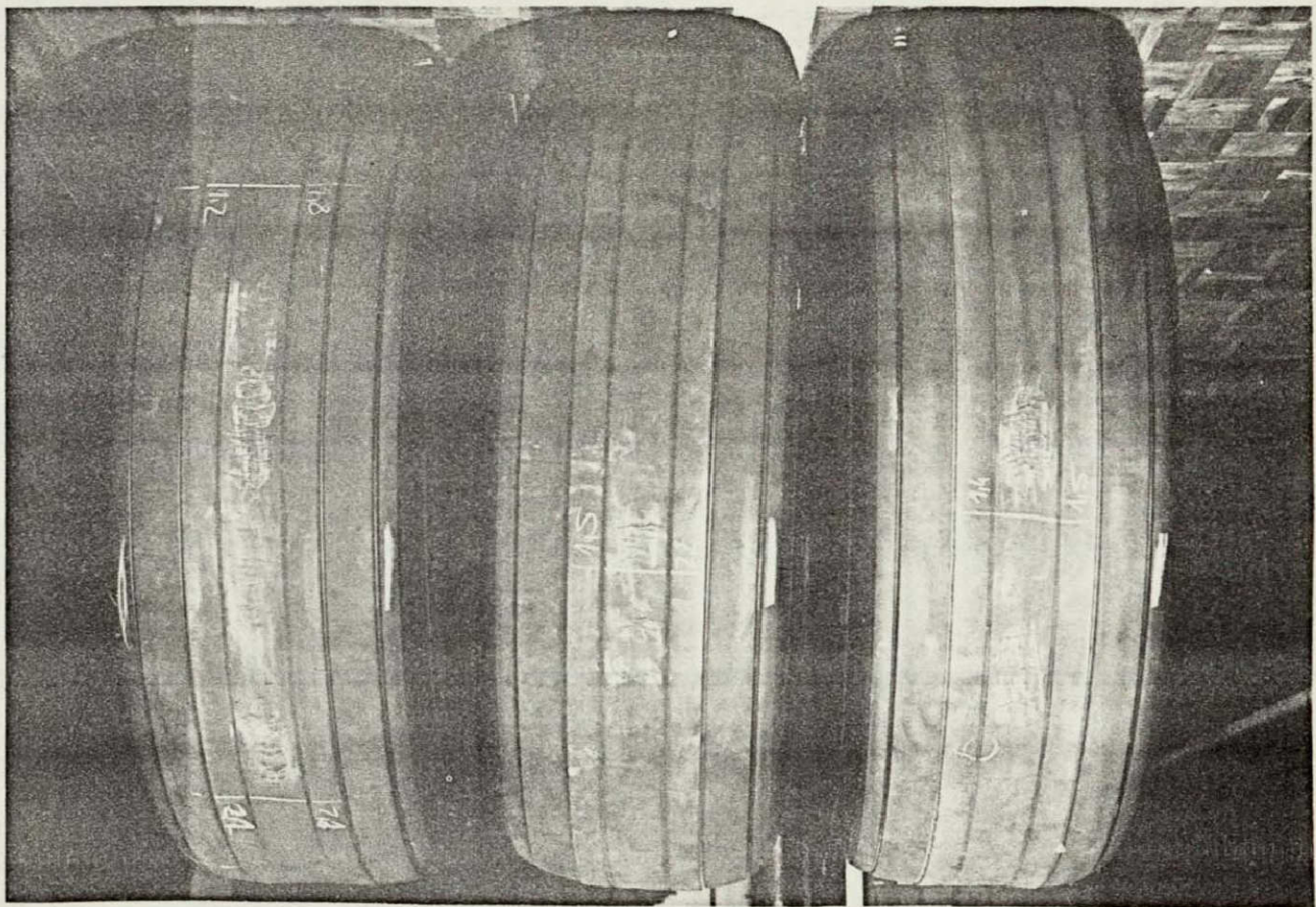


Fig. 12 MAEDER-soft rubber mixture typical appearance of worn-out tires.

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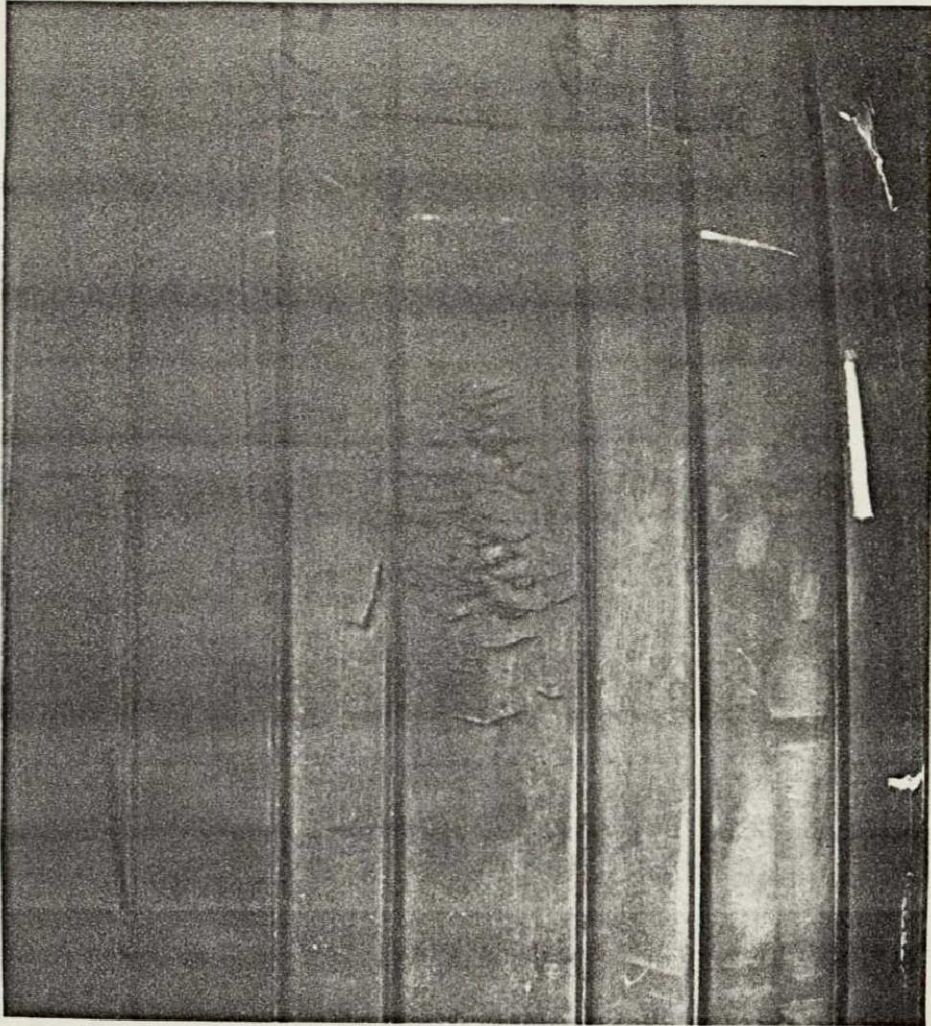


Fig. 13 MAEDER--normal mixture with typical Chevron Cuts.

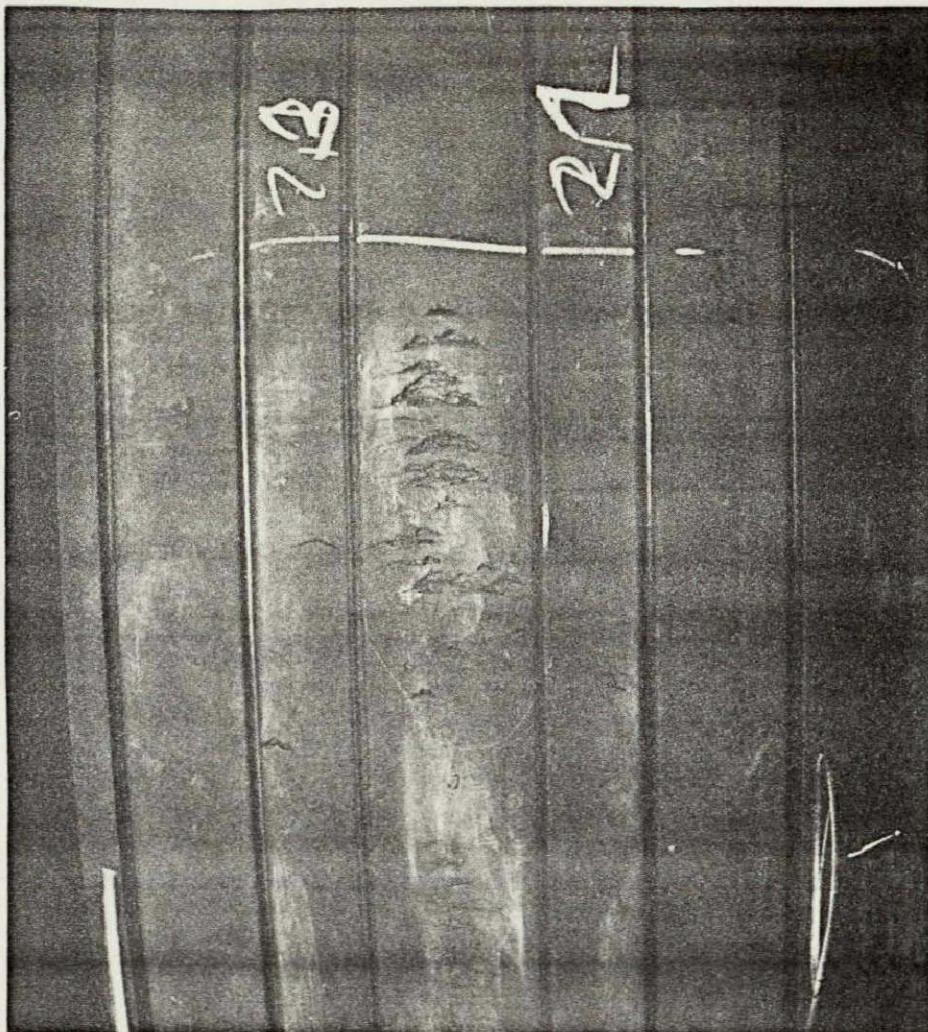


Fig. 14 MAEDER--soft rubber mixture with typical Chevron Cuts.

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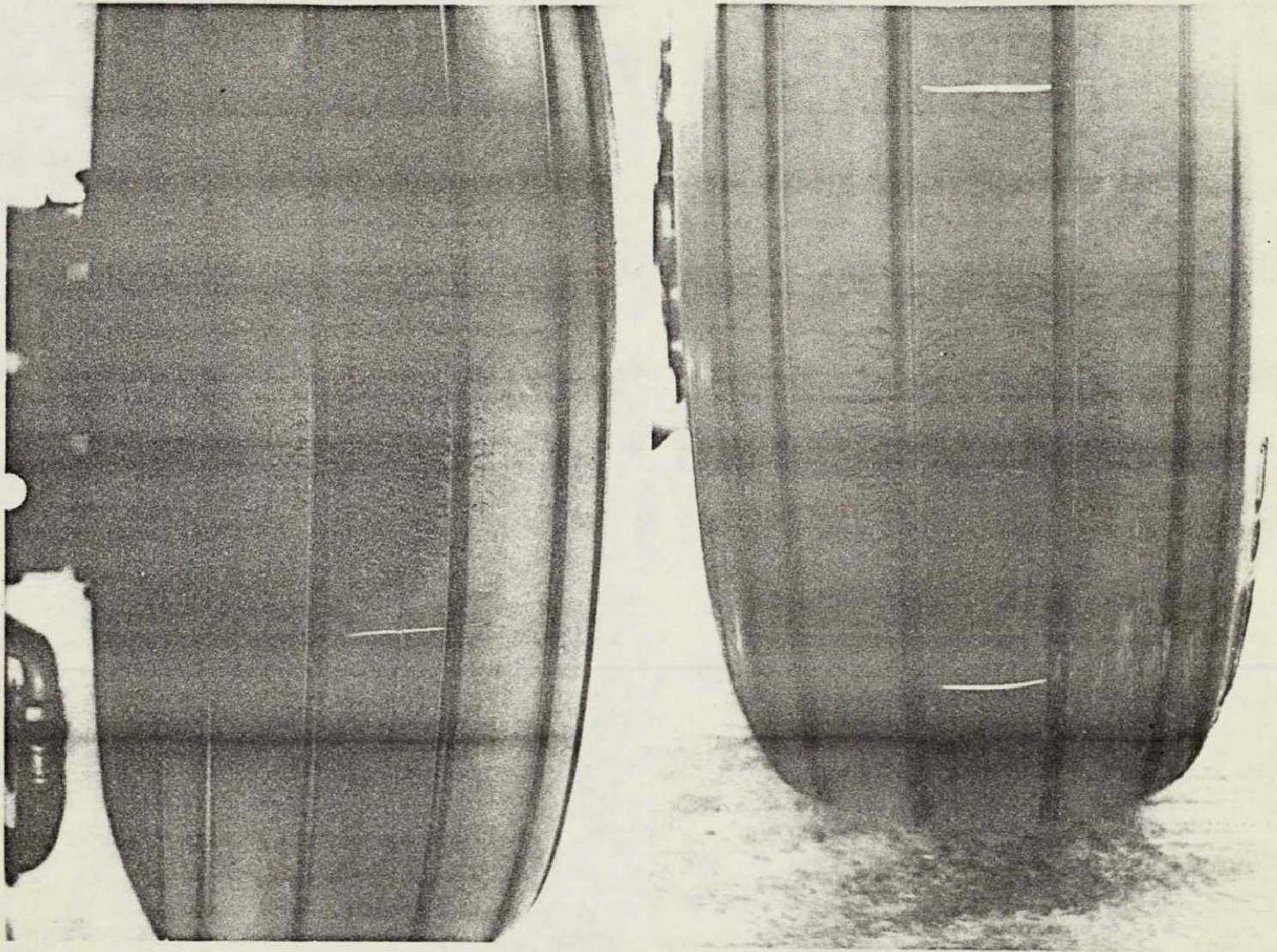
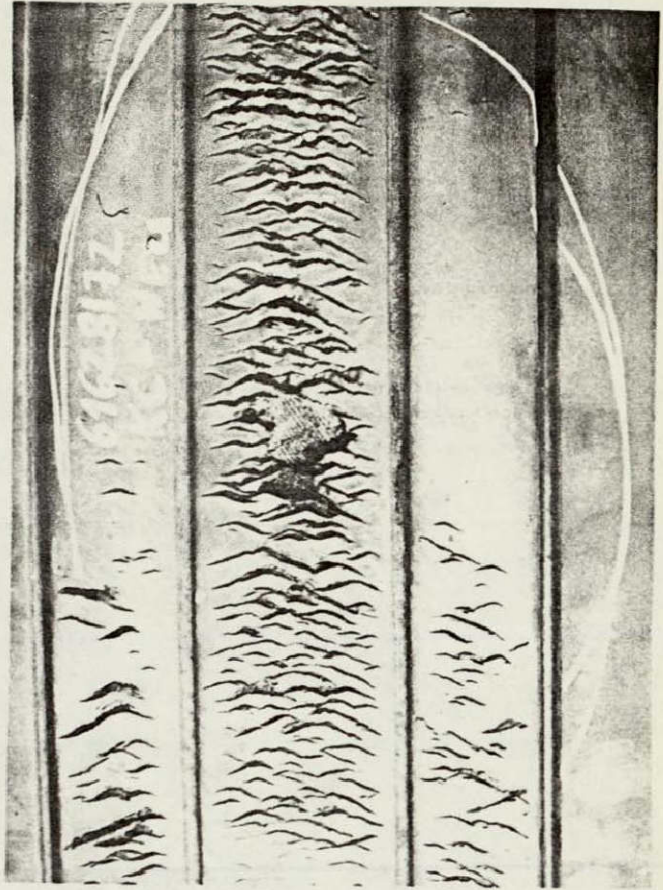
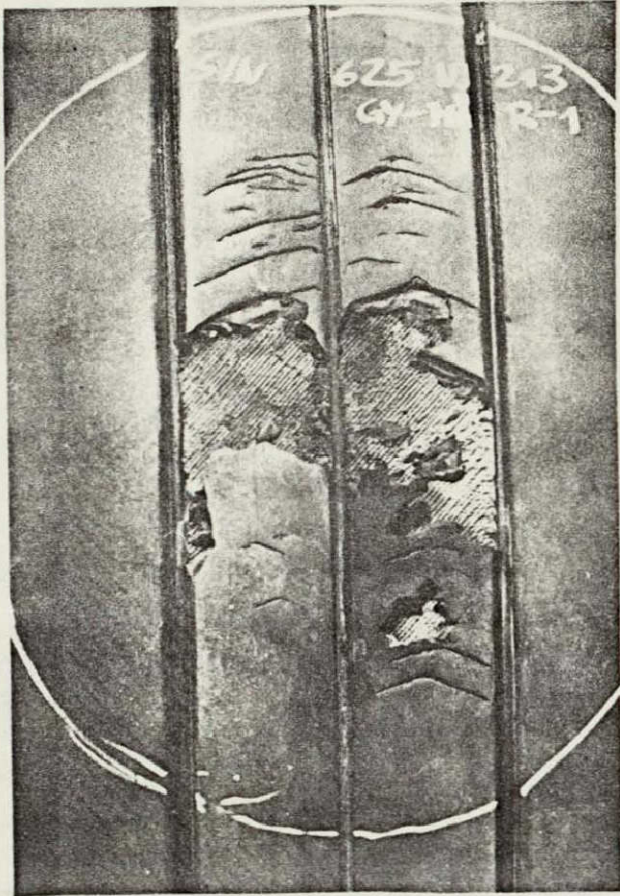


Fig. 15 This form of Chevron Cutting could be observed during the run-in phase of runway 16/34, which had been equipped with a brush-finish surface texture, but only on Thompson cappings.



Rubber breakouts caused by Chevron Cutting

Fig. 16A (DC-10 NLG)

Fig. 16B (B-747)

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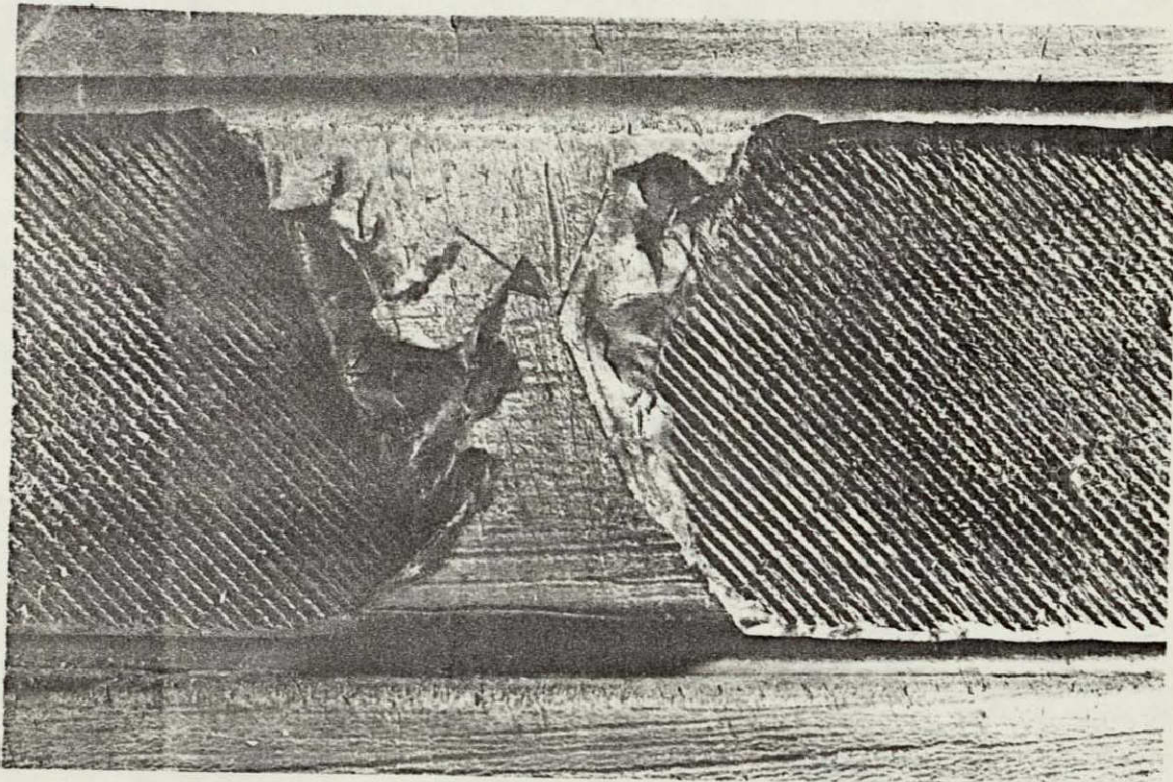


Fig. 16C Chevron Cutting is the point of origin for a rib separation (DC-10 NLG).



Fig. 17 THOMPSON--natural rubber mixture mit shorter breaks.

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