COMMONWEALTH OF AUSTRALIA
PATENTS ACT 1952
CONVENTION APPLICATION FOR A STANDARD PATENT

We, SUMITOMO RUBBER INDUSTRIES, LTD.,
of No. 1-1, Tsutsuicho 1-chome, Chuo-ku, Kobe-shi,
Hyogo, Japan hereby apply for the grant of a standard
patent for an invention entitled:

"TIRE TREAD PATTERN HAVING REDUCED NOISE LEVEL"

which is described in the accompanying complete specification.

DETAILS OF BASIC APPLICATION

Number of Basic Application:- 195079/84
Name of Convention Country in which Basic
Application was filed:- Japan
Date of Basic application:- 17 September 1984
Our address for service is:-
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DATED this SEVENTEENTH day of SEPTEMBER 1985
SUMITOMO RUBBER INDUSTRIES, LTD.

By: Registered Patent Attorney.
HE COMMISSIONER OF PATENTS
SRAILIA
COMMONWEALTH OF AUSTRALIA

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT

In support of the Convention Application made for a patent for an invention entitled:

"TIRE TREAD PATTERN HAVING REDUCED NOISE LEVEL"

1/We x Shizuo Katsurada

of c/o Sumitomo Rubber Industries, Ltd.,
No. 1-1, Tsutsuicho 1-chome, Chuo-ku, Kobe-shi, Hyogo, Japan

do solemnly and sincerely declare as follows:

1. I am/We are the applicant(s) for the patent.

(or, in the case of an application by a body corporate)

1. I am/We are authorised by Sumitomo Rubber Industries, Ltd.

the applicant(s) for the patent to make this declaration on its/their behalf.

2. The basic application(s) as defined by Section 141 of the Act were made

in Japan

on September 17, 1984

by Sumitomo Rubber Industries, Ltd.

3. I am/We are the actual inventor(s) of the invention referred to in the basic application(s).

(respectively)

Kichiro Kakumu

of No. 16-7, Sumiyoshi Yamate 8-chome, Higashinada-ku, Kobe-shi, Hyogo, Japan

is/are the actual inventor(s) of the invention and the facts upon which the applicant(s) is/are entitled to make the application are as follows:

The Applicant is the assignee of the invention from the inventor.

4. The basic application(s) referred to in paragraph 2 of this Declaration were the first application(s) made in a Convention country in respect of the invention as the subject of the application.

Declared at Hyogo, Japan, this 1st day of October, 1985

Shizuo Katsurada

Signature of Declarant(s)
Claim

1. In a pneumatic tire having a block type pattern formed on a tread divided into a central zone (CR) and two shoulder zones (SR) on both sides thereof by two main, continuous, circumferential grooves (G) formed on both sides of an equatorial line of the tire, said shoulder zones comprising a plurality of shoulder transverse grooves 2(N), 2(M) extending from said main circumferential grooves to tread edges, on the other hand, said central zone comprising a plurality of central transverse grooves [3(M), 3(N)] extending from said one circumferential groove or central longitudinal grooves arranged along said equatorial line to adjacent another circumferential groove or extending between said central longitudinal grooves, said shoulder transverse grooves formed in peripheral shoulder zones of outer half tread of the tires set on the outermost wheel incline at an angle $\theta$ of 10° to 35° with respect to the
normal line A drawn from tread edge in parallel with the rotary axis of the tire, on the other hand, said central transverse grooves formed in said central zone incline at an angle $\theta_2$ of $-10^\circ$ to $-35^\circ$ with respect to the normal line B drawn from said circumferential grooves in parallel with the rotary axis of the tire.
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Address of Applicant: No. 1-1, Tsutsuicho 1-chome, Chuo-ku,
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Complete Specification for the invention entitled:

"TIRE TREAD PATTERN HAVING REDUCED NOISE LEVEL"

The following statement is a full description of this invention,
including the best method of performing it known to us
Detailed Description of the Invention

[Industrial Field of the Invention]

This invention relates to a low noise tire and more particularly to a block-pattern radial tire designed to produce less airpumping and impacting noise.

[Prior Art]

With the spread of an expressway network of late, the noise made by motor vehicles traveling at high speed has come to be treated as one of the problems associated with environmental pollution and particularly the tire noise is an important factor causing automotive noise.

The noise caused by the tire is classified into the following according to its sources:

(i) Pattern noise

A space or cut groove formed in the surface of a tread is deformed when the tread touches the ground and its volume is suddenly compressed, whereby the air therein is discharged or sent out with pressure. On the other hand, the volume is sharply increased at the time the space or cut groove is released from touching the ground and it attempts to suck the air in. The air periodically sent into and out of the space or cut groove with pressure produces a continuous pressure wave, that is, sound energy. Accordingly,
there appears the peak of sound energy at the frequency corresponding to the pattern pitch and it becomes the source of noise.

(ii) Resonance noise

This is related with the mass distribution and the elasticity characteristics of a tire and they act to produce noticeably amplified vibration depending on the speed and traveling condition of the tire, causing various parts thereof to vibrate in response to vibration-generating energy given to the tire in repetitive time sequence. Provided that the pattern pitch is so arranged that the resonance frequency of the tire conforms to the peak vibration frequency of the tread pattern, the resonance action thus produced increases the sound.

(iii) Vibration sound due to slipping

This sound is produced when the various portions of a tread slip on the surface of a road.

Attempts have been made to minimize the aforementioned causes of noise and, as for the pattern noise, for instance, there has been adopted the variable pitch method wherein the arrangement of pitch elements providing a basis for repeating the tread design has been improved so as to reducing noise by dispersing the sound energy appearing at a particular frequency throughout a wide
frequency range. In this method, the pitch elements having different lengths are properly arranged in combination and the peak of sound energy periodically generated while the tire is rotated is shifted in terms of timing to lower the peak value by causing a phase difference; this is based on the so-called theory of frequency modulation.

With respect to the resonance noise and what is caused by slipping, it has also been attempted to decrease noise by improving the structure of a tire, the quality of material used for the carcass belt layer, the tread rubber compound and the tread pattern.

[Problems to be Solved by the Invention]

The aforesaid variable pitch method has disadvantages including bringing about the difference between the rigidities of pitch elements, badly affecting vibration characteristics while a tire is rotated, allowing the uneven wear of the tread and causing the life of the tire to be decreased. That method is incapable of reducing sound energy itself but limited in its capability in that the sound energy is only dispersed through a wide frequency range and particularly that the noise produced toward the outside of a motor vehicle is reducible only to some extend.

The present invention is intended to reduce noise by decreasing sound energy itself in place of employing the method of dispersing the frequency of the sound energy and particularly attaching importance to the shape of the tread groove.
[Means of Solution of the Problems]

According to the present invention, in a pneumatic tire having a block type pattern formed on a tread divided into a central zone and two shoulder zones on both sides thereof by two main, continuous, circumferential grooves formed on both sides of an equatorial line of the tire, said shoulder zones comprising a plurality of shoulder transverse grooves extending from said main circumferential grooves to tread edges, on the other hand, said central zone comprising a plurality of central transverse grooves extending from said one circumferential groove or central longitudinal grooves arranged along said equatorial line to adjacent another circumferential groove or extending between said central longitudinal grooves, said shoulder transverse grooves formed in peripheral shoulder zones of outer half tread of the tires set on the outermost wheel incline at an angle $\theta_1$ of $10^\circ$ to $35^\circ$ with respect to the normal line $A$ drawn from tread edge in parallel with the rotary axis of the tire, on the other hand, said central transverse grooves formed in said central zone incline at an angle $\theta_2$ of $-10^\circ$ to $-35^\circ$ with respect to the normal line $B$ drawn from said circumferential grooves in parallel with the rotary axis of the tire.
Referring now to the drawings, an embodiment of the present invention will be described.

In Fig. 1, a tread T is divided by a pair of left- and right-hand main longitudinal grooves G1, G2 into shoulder and central portions SR, CR and the width WSR of the shoulder is normally set within the range of 10% - 30% of the width TW of the tread. There are also formed transverse shoulder grooves in the shoulder portions SR at predetermined intervals in the circumferential direction of the tire, the transverse shoulder grooves 2(M), 2(N) are communicating with the tire end TE through the main longitudinal grooves G1, G2 respectively. In Fig. 1, the outer side of a vehicle in the state of the tires were set on the wheel is shown on the left-hand side together with the outer shoulder SR(M), the transverse shoulder groove 2(M) and the tread edge T(M), whereas the inner side of the vehicle is shown on the right-hand side with (N) added to the reference characters of the respective parts.

Two central grooves GC1 and GC2 extending to the circumference of the tire are formed along the equator C thereof in the central portion CR, equally dividing the central portion CR into three parts. Central transverse grooves 3(N) on the righthand side and central transverse groove 3(M) are formed at predetermined intervals in the circumferential
direction of the tire, the former and the latter respectively communicating with the main longitudinal groove G1 on the right-hand side through the central groove GC1 and the main longitudinal groove G2 on the left-hand side through the central groove GC2, so that the both sides of the central portion are divided into blocks.

Then, said shoulder transverse grooves \(2(M)\) formed on peripheral shoulder regions of outer half tread of the tires set on the outermost wheel of the vehicles incline at an angle \(\theta_1\) of 10° to 35° with respect to the normal line \(A\) drawn from tread edge \(T(M)\) in parallel with the rotary axis of the tire, on the outer hand, said central slant grooves \(3(M)\) formed on said central region of tread incline at an angle \(\theta_2\) of -10° to -35° with respect to the normal line \(B\) drawn from said circumferential grooves in parallel with the rotary axis of the tire.

The transverse grooves on the shoulder regions basically differs in structure from the transverse grooves on the central region in terms of noise generation, the transverse groove \(2(M)\) on the shoulder regions work so as to discharge the compressed air in the groove from the tread edges, on the other hand, the central transverse groove \(3(M)\) work so as to discharge the compressed air.
in the groove toward the central longitudinal grooves GC2, in order to carry on it smoothly to discharge the said compressed air, the transverse groove angle \( \theta_1 \) of the former is set with plus angle and that \( \theta_2 \) of the latter is set with minus angle. Furthermore, the larger the absolute value of angle \( \theta_1, \theta_2 \) of the said transverse groove 2(M) on the shoulder regions and the central transverse groove 3(M), the less the noise generation, but, from the standpoint of the balance of tread pattern rigidity and the prevention of uneven wear, the absolute value of the said angle cannot be set up excessively large. Thus the absolute value of angle \( \theta_1, \theta_2 \) of the shoulder transverse grooves 2(M) and the central transverse grooves 3(M) respectively are set up in the range of 10° to 35° as described above.

Although the tread pattern on the outer side of a vehicle in accordance with the present invention has been described, the same structure is needless to say applicable to the transverse shoulder groove and the central transverse groove on not only outer but also inner side of a vehicle.

Radial tires 205/60 R15 in size with tread patterns shown in Figs. 2 and 3 and transverse shoulder grooves as well as central transverse grooves were prepared by way of trial and their acoustic energy was measured in an anechoic
room with an internal pressure of 2.0 kg/cm² and a load of 400 kg. The acoustic energy was measured in conformity with the tire noise test method as provided for in JASCC 606 and a sound collector microphone was set just beside the tire 50 cm apart from the center of tire width at a height of 15 cm above the surface of the ground touched by the tire.

Fig. 4 is an acoustic pressure waveform chart in the case of a tread pattern having only the horizontal shoulder grooves of Fig. 2. As is obvious from Fig. 4, the acoustic pressure is seen to increase at the time the shoulder portion is released from touching the ground.

In Fig. 5 showing an acoustic pressure waveform chart in the case of a tread pattern having only the central horizontal grooves of Fig. 3, the acoustic pressure is seen to increase at the time the central portion starts touching the ground.

Subsequently, transverse angles θ₁ and θ₂ in the transverse shoulder groove and the central transverse groove respectively were made different mutually to calculate acoustic energy indexes associated with the tread patterns of Figs. 2 and 3. In that case, the acoustic energy E can be calculated according to the following equation using the acoustic pressure P: 

\[ E = \frac{1}{T} \int_0^T (P)^2 dT. \]

The acoustic energy indexes are expressed by Fig. 6 and Fig. 7.
The values shown in Fig. 6 and Fig. 7 attest the fact that the acoustic energy can be reduced by a large margin, and thus it is effective to decrease noise generation, being accompanied with increasing the absolute angles θ₁ and θ₂ of the shoulder transverse groove and the central transverse groove, but the difference between the acoustic energy indexes in the each case of the plus angle and the minus angle is remarkable when the absolute angle is in the range of 10° to 35°, and, in the case of the shoulder transverse angle, its transverse angle is a plus angle in the range of 10° to 35°, on the other hand, the angle of the central transverse groove is a minus angle in the range of -10° to -35°.

Furthermore, if the absolute angle of θ₁ and θ₂ are over 35°, the acoustic energy indexes decreases, but it is not acceptable in view of the rigidity balance of the tread region, the grip performance and the resistance to the uneven wear to set up an angle over 35°.

Fig. 8 shows another embodiment of the invention, this embodiment is the same as that shown in Fig. 1 except that the region between the central longitudinal grooves GC3 and GC4 is divided by the transverse groove 41 into blocks.

Fig. 9 shows another embodiment of the invention. This embodiment is the same as that shown in Fig. 1 except
that the central transverse grooves \(3(M), 3(N)\) are excluded and the central transverse grooves \(51\) are arranged in the region between the longitudinal grooves \(G5\) and \(G6\).

[Effect of the Invention]

As set forth above, the shoulder transverse grooves communicating from the longitudinal main groove to the tread edge and the central transverse grooves communicating from the longitudinal main groove to the central longitudinal groove or another longitudinal groove are provided for the tread pattern according to the present invention and, by arranging said shoulder transverse groove in the outer side of the vehicles at a special range of plus angle with respect to the normal line parallel to the rotary axis, on the other hand, by arranging the central transverse groove at a special range of minus angle, the compressed air in the grooves can be expelled smoothly, which has effect on the suppression of air pumping and impacting sound.

4. Brief Description of the Drawings

Fig. 1 is a partial plane view of the tread of a tire according to the present invention.

Figs. 2 and 3 are schematic view of tread patterns of a tire.

Figs. 4 and 5 are graphs representing acoustic pressure waveform charts while the tire is rotated.
Figs. 6 and 7 are graphs representing the relations between acoustic energy and control transverse groove angle and shoulder transverse groove angle respectively.

Figs. 8 and 9 show another embodiments according to the present invention.

Reference characters:
G1, G2, G3, G4, G5, G6 ... longitudinal main grooves,
GC1, GC2 ... central longitudinal grooves,
2(M), 2(N), 21(M), 21(N) ... shoulder transverse grooves,
3(M), 3(N), 31(M), 31(N) ... central transverse grooves,
T(M), T(N) ... tread edges,
CR ... tread central region,
SR(M), SR(N) ... tread shoulder regions.
The claims defining the invention are as follows:

1. In a pneumatic tire having a block type pattern formed on a tread divided into a central zone (CR) and two shoulder zones (SR) on both sides thereof by two main, continuous, circumferential grooves (G) formed on both sides of an equatorial line of the tire, said shoulder zones comprising a plurality of shoulder transverse grooves 2(N), 2(M) extending from said main circumferential grooves to tread edges, on the other hand, said central zone comprising a plurality of central transverse grooves [3(M), 3(N)] extending from said one circumferential groove or central longitudinal grooves arranged along said equatorial line to adjacent another circumferential groove or extending between said central longitudinal grooves, said shoulder transverse grooves formed in peripheral shoulder zones of outer half tread of the tires set on the outermost wheel incline at an angle $\alpha_1$ of 10° to 35° with respect to the normal line A drawn from tread edge in parallel with the rotary axis of the tire, on the other hand, said central transverse grooves formed in said central zone incline at an angle $\alpha_2$ of -10° to -35° with respect to the normal line B drawn from said circumferential grooves in parallel with the rotary axis of the tire.
DATED this SEVENTEENTH day of SEPTEMBER 1985
SUMITOMO RUBBER INDUSTRIES, LTD.

Patent Attorneys for the Applicant
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ACOUSTIC ENERGY INDEX

![Graph showing acoustic energy index with positive and negative values.]

FIG. 6

ACOUSTIC PRESSURE

![Graph showing acoustic pressure over time.]

FIG. 4

ACOUSTIC PRESSURE

![Graph showing acoustic pressure over time.]

FIG. 5

ACOUSTIC ENERGY INDEX

![Graph showing acoustic energy index with positive and negative values.]

FIG. 7

CONTACT WITH GROUND

RELEASE FROM GROUND

FIG. 4

FIG. 5

FIG. 6
FIG. 8

G4  GC4  GC3  G3
21(M)  31(M)  31(N)  21(N)

FIG. 9

OUTSIDE
G6
G5
51
51