

PATENT SPECIFICATION

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(54) RESILIENT SUPPORT PAD

(71) We, CATERPILLAR TRACTOR CO., a corporation organized and existing under the laws of the State of California, United States of America, of 100 N.E. Adams Street, Peoria, Illinois 61629, United States of America, 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:-

Heretofore utilized resilient support pads, particularly those utilized as bogie support pads in crawler vehicles, were generally made of rubber and had an operational life less than desirable. After considerable research, it was discovered that the configuration of the undeflected bogie pad was a determining factor in its life period.

During use of the bogie pads, internal triaxial stresses are subjected onto the pad. It has been discovered that these stresses could be moved within and eliminated from the bogie pad by changing the configuration of the bogie pad.

Bogie pads are subjected to a great deal of abuse, adverse conditions, and extremely heavy impacts. It is desirable to provide a bogie pad which can withstand these adverse operating conditions while maintaining operable for longer periods of time.

According to the present invention, a resilient support pad is formed by a solid block of resilient material constituted by a base portion, an intermediate portion, and a cap portion each having cross sections perpendicular to a nominal upright axis of the block with continuously rounded peripheries, the base portion having a peripheral wall surface which is substantially parallel to the upright axis and which intersects and is substantially perpendicular to a base surface of the block, the intermediate portion having a peripheral wall surface which tapers from an intersection with the peripheral wall surface of the base portion to an intersection with the surface of the cap portion which is of generally domed configuration, and the peripheral surface of the intermediate portion and the surface of the cap portion, as seen in axial section, extending away from the direction of the peripheral surface of the base portion at inclinations which do not decrease relatively to the axis.

The invention also includes a crawler vehicle comprising a frame; at least one bogie assembly including a bogie arm pivotally connected at one end to the frame and having track rollers rotatably mounted at the other end; and at least one bogie support pad in accordance with the invention connected at its base portion to one of the frame and bogie arm at a location between the frame and bogie arm.

Some examples of bogie support pads constructed in accordance with the invention, and of crawler vehicles fitted with such pads, are illustrated in the accompanying drawings, in which:-

- Figure 1 is a diagrammatic view of a portion of one crawler vehicle;
Figure 2 is a diagrammatic frontal view of a bogie pad in an unload position;
Figure 3 is a diagrammatic top view of a bogie pad in an unload position;
Figure 4 is a diagrammatic frontal view of a bogie pad system;
Figure 5 is a diagrammatic frontal view of a bogie pad in a partially loaded condition;
Figure 6 is a diagrammatic frontal view of a bogie pad in a fully loaded condition;
Figure 7 is a bogie pad system in a partially loaded condition;
Figure 8 is a bogie pad system in a fully loaded condition; and
Figure 9 is a load-deflection curve of the bogie pad.

Referring to Figure 1, a crawler vehicle 10, for example a crawler tractor, has continuous track 12 for locomotion. The vehicle 10 has a frame 14 and at least one bogie assembly 16

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associated with each track 12. The bogie assembly 16 includes a bogie arm 18 pivotally connected at one end to the frame and has a track roller system 20 connected at the other end. The arm 18 is pivotally movable relative to the frame for supporting the associated track 12 with the rollers 20 during movement of the track 12 toward and from the frame 14, as is well known in the art.

By the term frame 14, as used herein, it is meant any supporting structure suitable that is maintained at a preselected location relative to the vehicle 10.

At least one unitary bogie pad 22 is fixedly connected to the bogie arm 18, as shown in bogie assembly 16 or to the frame 14 as shown in bogie assembly 16'. The bogie pad 22 extends outwardly from the connecting structure 14 or 18 and is positioned at a location between the frame 14 and bogie arm 18 and is of a size sufficient for contacting the other structure 14 or 18 in response to pivotal movement of the bogie arm 18 toward the frame 14 for controllably damping the movement of said arm 18.

Referring to Figures 2 and 3, the bogie pad 22 has a base portion 24, an intermediate portion 26, and a cap portion 28 merging into one another. Each of the portions 24, 26, 28 are of a general round horizontal cross sectional configuration, as can be seen in Figure 3, with said configurations preferably being circular.

The base portion 24 has a base surface 25 connected to a respective frame 14 or bogie arm 18. The base surface 25 can be directly connected to the frame 14 or bogie arm 18 by bonding in any suitable manner or can be indirectly connected to the frame 14 or bogie arm 18 by bonding the bogie pad 22 to a supporting plate 30 and connecting the supporting plate 30 to said frame 14 or bogie arm 18 by any suitable fastening means 32, as shown in Figure 4.

The intermediate portion 26 has outer annular walls 34 which slope generally inwardly forming a frustrum in the undeflected condition of the pad 22. The cap portion 28 is of a general domed configuration and has a general arcuate outer surface.

Lines "a" and "b" have been found designated on Figure 2 to indicate the lines of demarcation between the various portions, 24, 26, 28.

Referring to Figure 4, a bogie pad system 36 is shown wherein a bogie pad 22', 22" is positioned on a respective frame 14 and bogie arm 18 at locations where one bogie pad 22' contacts the other adjacent bogie pad 22" during pivotal movement of the bogie arm 18. In the bogie pad system 36, the pads 22', 22" are of a configuration and are positioned at locations sufficient for initially contacting one another at locations between the centre "c" of each pad and outer edge 22 of the cap portion 28 in response to pivoting of the bogie arm 18. This construction of a pad 22 and positioning is also maintained where only a single pad 22 is utilized, as shown in Figure 1. The initial contact point of the pad is likewise spaced from the centre "c" and the outer edge portion 38 of the cap portion 28.

By so locating the initial contacting point, the operational life of the pad 22 is markedly increased by assuring against the introduction of additional shear stresses in the pad in response to initially contacting an intermediate portion 26 of the pad 22 or the outer edge portion 38 of the cap portion 28. As set forth above, the bogie arm 18 is pivotally movable and the pad pathway is arcuate. Therefore, during design of the pad 22, the radius of the arc must be taken into consideration in order to assure the preselected initial contacting point of the pad 22.

The outer surface of the dome shaped cap portion 28 of the bogie pad 22 can be defined by an arc of a single radius, as in pad 22' or of a plurality of radii, as in pad 22".

The base portion 24 of the bogie pad 22 has a preselected base surface 25 area based upon the total weight of the vehicle 10. The total area of each pad 22 is defined by the expression

$$\text{Area} = \frac{T}{C}$$

where

C = The normal compressive stress of the rubber in the range of about 3500 to about 8300 Kilo pascals.

T = Total weight of vehicle upon which pad is expected to be used.

A pad 22 of greater area is undesirable owing to the facts that material and space on the vehicle will be wasted. A pad 22 of lesser area is undesirable owing to the facts that undesirable pressures will be subjected onto the pad 22 and the operational life of the resultant pad 22 will be less than desirable.

At a nominal compressive stress "C" less than about 3500 Kilopascals the bogie pad is undesirably large in size and wastes space on the vehicle and causes associated equipment to be unnecessarily large which also represents waste. At a "C" greater than 8500 Kilopascals the bogie pad is subjected to stresses of a sufficiently high magnitude as to cause the operational life of the resultant pad to be undesirably short.

The base portion 24 also should be constructed with a height "H_b" in the range of about 2 to about 15mm. At lesser heights of the base portion 24, the pad will undesirably hinge at a location within the intermediate portion 26 which will introduce undesirable stresses in the pad 22 and result in an undesirable operational life. At greater heights of the base portion 24,

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the pad will undesirably hinge within the base portion 24 which will introduce undesirable stresses in the pad 22 and result in an undesirable operation life.

With a base height maintained as set forth in the above-cited question, the hinging of the pad will be maintained at the connection of the base surface 25 to frame 14 or bogie arm 18.

The overall height of the pad 22 is based on the compression of the pad. It is preferred that the bogie pad have a maximum dynamic compression value for the intended use in a range of about 1/2 inch to about 3 inches. Maximum compression values less than about 1/2 inch are undesirable because the bogie arm will not have sufficient damped travel. Maximum compression values greater than about 3 inches are undesirable because the vehicle will have undesirable working tool stability. The maximum compression value is preferably about 1-1/2 inches. The overall height of the bogie pad is constructed so that the maximum compression travel under dynamic loading is in the range of 20% to 40% of the overall height H.

Referring to Figures 5 and 7, the pad or pads 22 are preferably of a dimension sufficient for deflection of substantially the entire cap portion 28 to a substantially planar surface in the installed position of the pads 22 on a standing vehicle with said pads supporting the vehicle weight. Under these stable load conditions, it will be noticed that the base portion 24 has hingedly moved outwardly i.e. so that its peripheral wall surface is frusto conical, and that the intermediate portion 26 has moved outwardly.

Referring to Figures 6 and 8, the pad or pads 22 are subjected to the maximum expected load and the base and intermediate portions 24, 26 are further outwardly extending.

The pads 22 are preferably formed of natural rubber having carbon black therein and being substantially free of reinforcing elements of other material. By the term reinforcing elements of other materials it is meant mechanical reinforcing materials such as wire, cords, meshes, and the like, and does not refer to chemical reinforcing elements such as the carbon black and other chemical binders used in the forming of rubber.

Referring to Figure 9, it can be seen that the pad 22 of the above described construction has load deflection properties at which the load-deflection curve of the pad at maximum expected load is substantially vertical.

In the example pad, hereinafter described, the static load on the pad is about 20,000 lbs. and the maximum expected load is 160,000 lbs. It should be noticed that the deflection of the pad between the static and maximum load is about 1 inch with a 1-1/2 inch maximum compression.

This is particularly significant where it is realized that the unique construction of the pad of this invention minimizes load stresses within the pad to the extent that the pad has unexpected operational life while being subjected to 40% and greater deflection. Heretofore utilized pads of other construction would experience drastically reduced operational life at such heavy loads and great deflections.

The following is a preferred example bogie pad 22 of this invention

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PREFERRED MATERIAL**FORMULATION**

5	PREFERRED INGREDIENT	BRAND NAME AND SOURCE	PARTS (BY WEIGHT)	5
	No. 1 Ribbed Smoked Sheet	-----	100.0	
10	FEF Carbon Black	STATEX M - COLUMBIAN CARBON CO.	70.0	10
	PROCESS OIL	CIRCO LIGHT RUBBER PROCESS OIL - SUN OIL CO.	10.0	
15	STEARIC ACID	STEARIC ACID C.P. HALL CO.	2.0	15
	ZINC OXIDE	PROTOX 166 NEW JERSEY ZINC CO.	5.0	
20	SULFUR	SPIDER BRAND OLIN-MATHLESON CO.	2.75	20
	ANTIOXIDANT	OCTAMINE UNIROYAL CHEMICAL DIV.	1.0	
25	ANTIOZONANT	FLEXZONE 3C UNIROYAL CHEMICAL DIV.	1.0	25
	ACCELERATOR	SANTOCURE MOR MONSANTO CO.	0.90	
30	PRE-VULCANIZATION INHIBITOR	SANTOGARD PVI MONSANTO CO.	0.25	30
35				35

PROCESSING

40	A. MIXING		40
	1. 0.5 PARTS PEPTIZER ENDOR - E.I. DU PONT PER HUNDRED RUBBER FOR PREMASTICATION.		
	2. NO OILS OR PROCESSING AIDS EXCEPT AMOUNT OF OIL SHOWN IN FORMULATION.		
	3. COMPOUNDING INGREDIENTS ARE WELL DISPERSED.		
45	4. A TWO STAGE MIXING PROCEDURE. ALL INGREDIENTS EXCEPT CURATIVE (SULFUR, SANTOCURE MOR, AND SANTOGARD ARE MIXED INTO THE PREMASTICATED RSS NO. 1 AND COOLED. THE CURATIVE ARE ADDED IN A SECOND STEP IN A MIXER.		45
50	B. MOONEY VISCOSITY AND SCORCH TIME OF MIXED STOCK PRIOR TO MOLDING:		50
	VISCOSITY - ML1 + 4 - 100°C (212°F)	65	
55	SCORCH - (ML) 135°C (275°F) TIME TO 5 POINT RISE	15 MINUTES	55

C. RHEOMETER CURED CHARACTERISTICS (ASTM D2084)

1. PLATEN TEMPERATURE -
148°C (298°F)OSCILLATION - 1.67Hz (100 cpm)
CHARTMOTOR - 60 MIN.
PREHEAT TIME - 0 SEC.1. M_L (MIN. TORQUE)

1.0 Nm (8.4 LB. IN)

2. M_H (MAX. TORQUE)

4.7 Nm (41.6 LB. IN)

3. T_2 (SCORCH TIME)

8.7 MINUTES

4. T_{C95} (CURE TIME)

20.1 MINUTES

2. PLATEN TEMPERATURE -
162°C (324°F)OSCILLATION - 1.67 Hz (100 cpm)
CHARTMOTOR - 60 MINUTES
PREHEAT TIME - 0 SEC.1. M_L (MIN. TORQUE)

0.9 Nm (8.1 LB. IN)

2. M_H (MAX. TORQUE)

4.4 Nm (39.2 LB. IN)

3. T_2 (SCORCH TIME)

3.7 MINUTES

4. T_{C95} (CURE TIME)

8.6 MINUTES

PROPERTIES

1. HARDNESS (ASTM D2240)

70 SHORE A

2. TENSILE STRENGTH (ASTM D412)

18.6 MPa (2700 PSI)

3. ELONGATION (ASTM D412)

325%

4. 100% MODULUS (ASTM D412)

4.8 MPa
(700 PSI)

5. 300% MODULUS (ASTM D412)

18.6 MPa
(2700 PSI)

6. TEAR STRENGTH ASTM (D624-DIEC)

525 N/cm
(300 LB/IN) MIN.7. COMPRESSION SET
(ASTM D395 - METHOD B)

25% MAXIMUM

ASTM BUTTONS CURED
30 MIN. AT 148°C
298°F SET AFTER
22 HOURS AT 70°C (158°F)8. COMPRESSIVE MODULUS ASTM (D575)
-METHOD A) AT 25% DEFLECTION2.9 MPa
(425 PSI)

9. SPECIFIC GRAVITY

1.165

AIR OVEN AGING (ASTM D573 - 70 HOURS AT 70°C (158°F))

1. HARDNESS CHANGE

+10 MAXIMUM

2. TENSILE CHANGE

±20%

3. ELONGATION CHANGE

-25%

4. SURFACE CONDITION

NO CRACKS

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PREFERRED DIMENSIONS

1.	BASE DIAMETER	14.20 IN.
2.	TOTAL OVERALL HEIGHT H_t	2.25 IN.
3.	CROWN HEIGHT H_c	.50 IN. (22% of H_t)
4.	HEIGHT OF BASE H_b	.20 IN. (9% of H_t)
5.	ANGLE ϕ	55°

The subject example pad has been tested with 160,000 pound load. The test example bogie pad has presently been compressed to the maximum design compression through 2,000,000 cycles and remains in operating condition.

WHAT WE CLAIM IS:-

1. A resilient support pad formed by a solid block of resilient material constituted by a base portion, an intermediate portion, and a cap portion each having cross sections perpendicular to a nominal upright axis of the block with continuously rounded peripheries, the base portion having a peripheral wall surface which is substantially parallel to the upright axis and which intersects and is substantially perpendicular to a base surface of the block, the intermediate portion having a peripheral wall surface which tapers from an intersection with the peripheral wall surface of the base portion to an intersection with the surface of the cap portion which is of generally domed configuration, and the peripheral surface of the intermediate portion and the surface of the cap portion, as seen in axial section, extending away from the direction of the peripheral surface of the base portion at inclinations which do not decrease relatively to the axis.
2. A pad according to claim 1, wherein the intermediate portion is a frusto cone.
3. A pad according to claim 1 or claim 2, wherein, in axial section, the substantially domed configuration of the cap portion presents an arcuate outer edge.
4. A pad according to claim 3, wherein the arcuate outer edge is an arc of a single radius.
5. A pad according to claim 3, wherein the arcuate outer edge is defined by a plurality of arcs.
6. A pad according to any one of the preceding claims, wherein each of the base, intermediate, and cap portions has a circular cross section perpendicular to the upright axis.
7. A pad according to any one of the preceding claims, wherein the base portion has a height of between 2 and 15mm.
8. A pad according to any one of the preceding claims, which is formed of rubber containing carbon black and is substantially free of reinforcing elements of other material.
9. A pad according to any one of the preceding claims, in which the base surface is bonded to a plate.
10. A pad according to any one of the preceding claims, in which, when an axial loading is initially applied to the pad, the peripheral wall surface of the base portion swings outwards about its intersection with the base surface into a frusto conical configuration.
11. A pad according to any one of the preceding claims, in which the base portion has a height of substantially 9%, and the cap portion a height of substantially 22%, of the total height of the base, intermediate, and cap portions.
12. A pad according to claim 1, substantially as described with reference to any one of the examples illustrated in the accompanying drawings.
13. A crawler vehicle comprising a frame; at least one bogie assembly including a bogie arm pivotally connected at one end to the frame and having track rollers rotatably mounted on the other end; and at least one bogie support pad according to any one of the preceding claims connected at its base portion to one of the frame and bogie arm at a location between the frame and bogie arm.
14. A crawler vehicle according to claim 13, wherein the base portion has a cross sectional area defined by the expression " $\text{Area} = \frac{T}{C}$ " wherein:
C = a constant in a range of between 3500 and 8300 Kilopascals; and,
T = total weight of crawler vehicle.
15. A crawler vehicle according to claim 13 or claim 14, wherein the bogie support pad is so constructed that substantially the entire domed configuration of the cap portion is deflected to a substantially planar surface at the installed position of the pad of the standing vehicle.
16. A crawler vehicle according to any one of claims 13 to 15, wherein the bogie pad has a load deflection characteristic such that the load deflection curve of the pad at maximum expected load is substantially vertical.
17. A crawler vehicle according to any one of claims 13 to 16, wherein the maximum compression travel of the bogie support pad under dynamic loading, in use, is between range



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PREFERRED DIMENSIONS

	1. BASE DIAMETER	14.20 IN.	
5	2. TOTAL OVERALL HEIGHT H_t	2.25 IN.	
	3. CROWN HEIGHT H_c	.50 IN. (22% of H_t)	5
	4. HEIGHT OF BASE H_b	.20 IN. (9% of H_t)	
10	5. ANGLE ϕ	55°	10

The subject example pad has been tested with 160,000 pound load. The test example bogie pad has presently been compressed to the maximum design compression through 2,000,000 cycles and remains in operating condition.

WHAT WE CLAIM IS:-

- 15 1. A resilient support pad formed by a solid block of resilient material constituted by a base portion, an intermediate portion, and a cap portion each having cross sections perpendicular to a nominal upright axis of the block with continuously rounded peripheries, the base portion having a peripheral wall surface which is substantially parallel to the upright axis and which intersects and is substantially perpendicular to a base surface of the block, the intermediate portion having a peripheral wall surface which tapers from an intersection with the peripheral wall surface of the base portion to an intersection with the surface of the cap portion which is of generally domed configuration, and the peripheral surface of the intermediate portion and the surface of the cap portion, as seen in axial section, extending away from the direction of the peripheral surface of the base portion at inclinations which do not decrease relatively to the axis. 15
2. A pad according to claim 1, wherein the intermediate portion is a frusto cone. 25
3. A pad according to claim 1 or claim 2, wherein, in axial section, the substantially domed configuration of the cap portion presents an arcuate outer edge. 25
4. A pad according to claim 3, wherein the arcuate outer edge is an arc of a single radius. 30
5. A pad according to claim 3, wherein the arcuate outer edge is defined by a plurality of arcs. 30
6. A pad according to any one of the preceding claims, wherein each of the base, intermediate, and cap portions has a circular cross section perpendicular to the upright axis. 35
7. A pad according to any one of the preceding claims, wherein the base portion has a height of between 2 and 15mm. 35
8. A pad according to any one of the preceding claims, which is formed of rubber containing carbon black and is substantially free of reinforcing elements of other material. 40
9. A pad according to any one of the preceding claims, in which the base surface is bonded to a plate. 40
10. A pad according to any one of the preceding claims, in which, when an axial loading is initially applied to the pad, the peripheral wall surface of the base portion swings outwards about its intersection with the base surface into a frusto conical configuration. 45
11. A pad according to any one of the preceding claims, in which the base portion has a height of substantially 9%, and the cap portion a height of substantially 22%, of the total height of the base, intermediate, and cap portions. 45
12. A pad according to claim 1, substantially as described with reference to any one of the examples illustrated in the accompanying drawings. 50
13. A crawler vehicle comprising a frame; at least one bogie assembly including a bogie arm pivotally connected at one end to the frame and having track rollers rotatably mounted on the other end; and at least one bogie support pad according to any one of the preceding claims connected at its base portion to one of the frame and bogie arm at a location between the frame and bogie arm. 50
14. A crawler vehicle according to claim 13, wherein the base portion has a cross sectional area defined by the expression "Area = $\frac{W}{C}$ " wherein: 55
- 55 C = a constant in a range of between 3500 and 8300 Kilopascals; and, 55
- T = total weight of crawler vehicle. 55
15. A crawler vehicle according to claim 13 or claim 14, wherein the bogie support pad is so constructed that substantially the entire domed configuration of the cap portion is deflected to a substantially planar surface at the installed position of the pad of the standing vehicle. 60
16. A crawler vehicle according to any one of claims 13 to 15, wherein the bogie pad has a load deflection characteristic such that the load deflection curve of the pad at maximum expected load is substantially vertical. 60
17. A crawler vehicle according to any one of claims 13 to 16, wherein the maximum compression travel of the bogie support pad under dynamic loading, in use, is between range 65

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20% and 40% of the total height of the base, intermediate and cap portions of the pad.

18. A crawler vehicle according to any one of claims 13 to 17, wherein the bogie pad cap portion has a centre and an outer edge and the bogie pad is of a configuration and positioned at a location so as to be contacted by the other of the frame and bogie arm at a location on the cap portion spaced from the centre and from the outer edge of the cap portion in response to pivoting of the bogie arm.

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19. A crawler vehicle according to any one of claims 13 to 17; wherein there are at least two bogies pads each fixed to a respective one of the frame and bogie arm at locations such that one of the bogie pads contacts the other in response to pivoting of the bogie arm.

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20. A crawler vehicle according to claim 19, wherein each bogie pad cap portion has a centre and an outer edge and the bogie pads are of a construction and location such that the cap portions of the two bogie pads contact one another at locations spaced from their respective centre and respective outer edge in response to pivoting of the bogie arm.

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21. A crawler vehicle according to any one of claims 13 to 20, including a base element bonded to the base surface of the bogie support pad; and means connecting the base element to the respective one of the frame and bogie arm.

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22. A crawler vehicle according to claim 13, substantially as described with reference to any one of the examples illustrated in the accompanying drawings.

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