Final Report

Concept Feasibility Study

LIGHTWEIGHT, HIGH MOBILITY TRACK

Contract DAAE07-67-C-3847

Army Tank Automotive Command

Ordnance Management Structure Code No.
5521.12.26900

Department Of The Army Project No.
1-M-5-21801-D-263

9 FEBRUARY 1968

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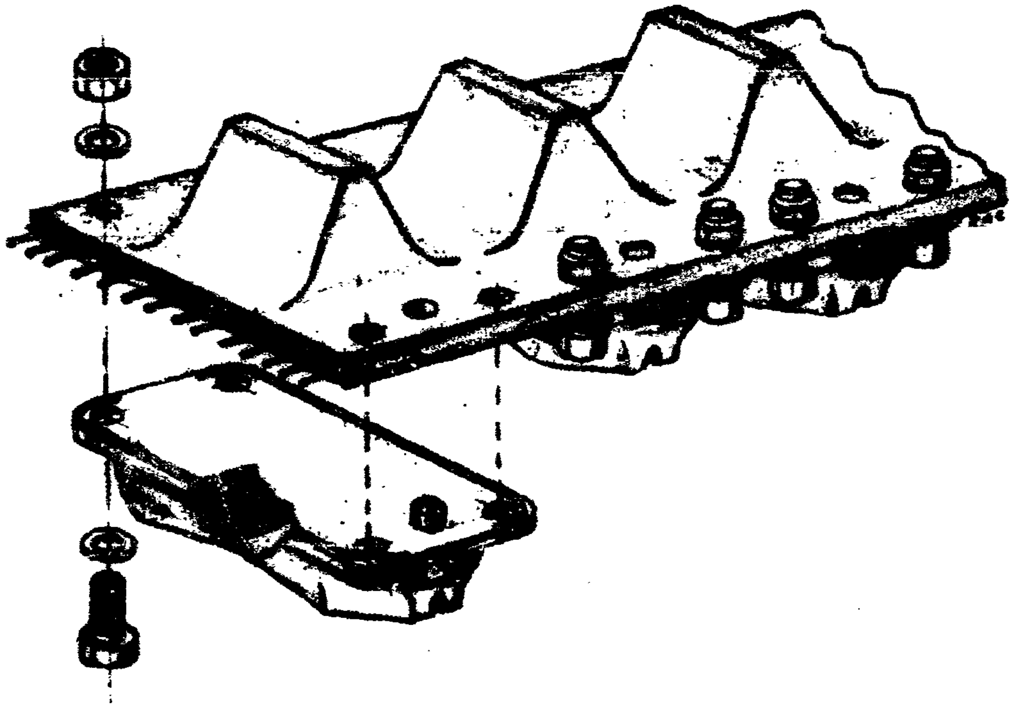
Detroit, Michigan P.O. Box 757 Detroit, Mich., 48231

ABSTRACT

This report presents Chrysler's concept feasibility study of the Lightweight High Mobility Track, performed under Contract DAAE07-67-C-3847, effective 10 May 1967. The subject track consists of a fiber glass reinforced belt with guide tooth projections on its inside surface and pneumatic pads on its outside surface. This particular track was intended for use on a vehicle with a gross weight of 3000 pounds. The resultant concept is 12 inches wide, weighs 9.83 pounds per foot, and is 110.7 percent buoyant. In addition, the inherent advantages of the design include a smooth roadwheel path, the ability to absorb road shocks, quiet operation, and expected long life.

The concept was analyzed from a number of standpoints including weight, buoyancy, tensile strength, and feasibility of manufacture. It was concluded that the concept is feasible and that it would be applicable to lightweight cargo and reconnaissance vehicles. Recommendations for future activity on this project are also presented.



LIGHTWEIGHT HIGH MOBILITY TRACK

TYPE	BUOYANT RUBBER BELT WITH PNEUMATIC ROAD PADS
WIDTH	12 INCHES
HEIGHT	2.75 INCHES (ROADWHEEL TO GROUND)
PITCH	6 INCHES
MAIN TENSION MEMBER	FIBER GLASS CORDS
WEIGHT PER FOOT	9.83 LB
BUOYANCY	110%

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1.0 INTRODUCTION

This report presents a concept feasibility study of the Lightweight High Mobility Track conducted under Contract DAAE07-67-C-3847, which became effective on 10 May 1967. The scope of work included the development and definition of the track concept and its drive sprocket and the analyses necessary to establish feasibility.

The project originated as a result of Chrysler's proposal in response to Request for Quotation DAAE07-67-Q-0072, which was issued on 12 October 1966 by the U. S. Army Tank Automotive Command. The technical requirements of this RFQ were formulated by the Mobility Systems Laboratory at ATAC, which also provided technical administration for the feasibility study. Chrysler proposed a buoyant track consisting of a continuous fiber glass-reinforced belt with rubber guide teeth on its inside surface and pneumatic track pads on its outer surface. This unique approach was adopted because of requirements for buoyancy, light weight, shock absorption, and smoothness of operation.

The requirement that the track be buoyant enough to support itself in water was perhaps the most difficult, especially in light of the other requirements. The first tracks concepted in preparing the proposal were much more conventional, having pins or bands, and compartments to increase volume and buoyancy. Each of these concepts achieved buoyancy only by increasing weight in comparison to existing track designs. Furthermore, these concepts were quite unwieldy and subject to easy damage from a number of standpoints.

It thus became evident that the desired track must be unique in many respects. First, a buoyant track would require that metallic parts be held to an absolute minimum. Second, to provide a truly "satisfactory" cushion against road shock, vibration, and noise would require a degree of material flexibility more typical of elastomers than of metals.

The idea of eliminating metallic parts as much as possible was reinforced by an amendment to the RFQ, dated 14 October 1966. The amendment indicated that the track should be applicable to a vehicle with a gross weight of 3,000 to 9,000 pounds. Chrysler interpreted this as indicative of a desire for a track of extremely light weight.

Following a review of the technical requirements for the track, this report discusses the concept investigation and presents a description of the resulting concept. The various analyses used to determine feasibility and compatibility with the specifications are then presented, as well as conclusions and recommendations.

2.0 TECHNICAL REQUIREMENTS

The following technical requirements were listed in the RFQ, and the concept presented in the proposal was directed toward meeting them. These requirements were also stated in the feasibility study contract under Section B, Description or Specifications. The track was to have the following capabilities:

1. High flotation ability sufficient to make it better than self-supporting in water.
2. Capability of traversing the following terrain spectrum at the average indicated speeds.

		PERCENT	REQUIRED MPH	DESIRED MPH
(a)	Dry, hard cross country	16.6	35	50
(b)	Dry, mild cross country (including level cultivated field and tall grass)	33.6	20	28.5
(c)	Dry, rough cross country (including uncultivated land, small trees, brush, and steep grades)	16.6	12	17
(d)	Wet, marginal cross country (including mud, paddies, swamp, muskeg, and snow)	16.6	17.5	25
(e)	Inland waterways (including river, lakes, and canals containing sharp obstacles and steep banks)	16.6	7	12

3. Capability of negotiating a 60 percent dry cross country grade, a 40 percent dry side slope, and climb wet, soft 60 percent slopes at the water's edge.

4. The track shall be easily maintained in the field.

5. High reliability of operation for a life of 5,000 miles (long range goal 8,000 to 10,000 miles) at low cost per vehicle mile.

6. A satisfactory cushion against vibration, road shock, and noise.

7. Operational capability within an ambient temperature range of -65°F to ±125°F.

8. Low propulsive power loss throughout the operating speed range and terrain spectrum.

9. Maximum use of, but not limited to, commercially available materials. Proposed use of promising new materials to obtain the desired efficiency, economy, and life is desirable.

In addition to the above requirements, the contract listed target goals and parameters, which were formulated by ATAC and agreed to by Chrysler during contract negotiations:

(a) Target Track Width - 12 inches

(b) Gross Vehicle Weight (GVW) - 3,000 lbs.

(c) Curb Weight - 2,000 lbs.

(d) Target Track Weight - 12.0 lbs/ft. maximum

(e) Target Buoyancy - 100 percent minimum

3.0 CONCEPT INVESTIGATION

This section describes the concept investigation and the evolution of the design from its inception to its final form. A review of the functional requirements for each part is also given to further explain the selection of certain design characteristics.

3.1 Reinforced Belt

3.1.1 Functional Requirements

It is essential that the belt possess the following characteristics in order for it to function properly:

a. Adequate strength in tension

b. Provide smooth roadwheel path

c. Lateral stability

d. Torsional stability

e. Low weight

f. Suitable for attachment of road pads

g. Provide guiding surfaces

h. Provide driving and braking surfaces

i Minimum stretch under tension

3.1.2 Concept Development

The belt portion of the track initially proposed was 20 inches wide, one-half inch thick, and had two rows of teeth for guiding on the outboard edges of the roadwheels, as shown in Figure 3-1, page 3-2. A segmented construction was envisioned as the best approach rather than an endless construction. The

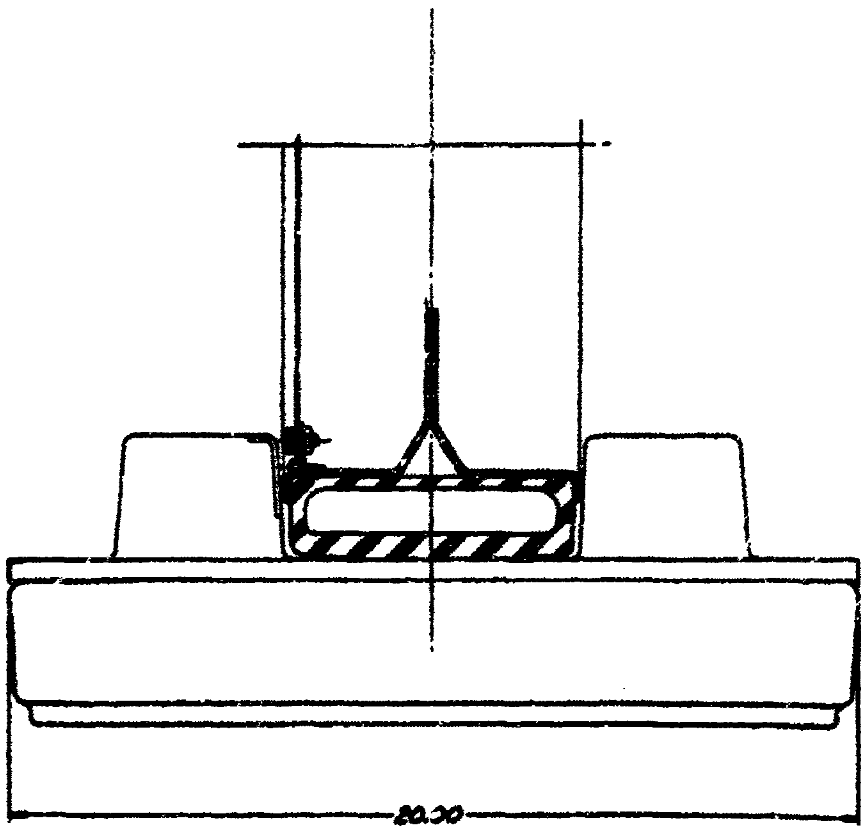

Figure 3-1 Proposal Concept – Front View

belt was reinforced only by the fiber glass cord. Meetings with ATAC personnel and the establishment of target parameters indicated that the concept would have to be altered at the beginning of the feasibility study. First, the width of the belt was changed to 12 inches. Second, it was recommended that a center guide/center drive arrangement be used instead of the double row of guide teeth.

The investigation began with layout studies to determine the overall configuration of the concept based upon the target specifications. Simultaneously, the strength requirements for the belt were determined and research on reinforcing materials was begun. The properties of fiber glass were examined, and it was concluded that this material would make an excellent reinforcement for carrying belt tension loads. Specific properties which support this conclusion include the following (1):

- High tensile strength: 250,000-315,000 psi
- Complete recovery from strain up to about three percent
- Not affected by age
- Not affected by moisture
- Not attacked by most acids, weak alkalies, or organic solvents
- Compatible with track operating temperature requirements
- Not attacked by micro-organisms

Discussion with manufacturers of fiber glass confirmed these properties. In addition, it was recommended that the fiber glass not be loaded in shear, but only in tension. For this reason, it was decided to make the belt an endless construction rather than attempting to segment it. This construction eliminates

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Numbers in parentheses indicate references listed on page 7-1.

shear loads introduced by attaching one segment to another and offers the greatest strength capability in tension. It provides an uninterrupted path for the roadwheels and allows uniform sprocket engagement at any point on the belt. A weight savings is also realized in the endless construction.

The restriction on shear loading for the fiber glass indicated that, by itself, it would not furnish a suitable base for attachment of road pads. Therefore, some other type of internal belt reinforcement would be required in addition to the fiber glass. A fabric such as nylon or rayon was selected because of success in similar applications and because it is extremely tough. In addition to providing strength in the attachment area, the fabric increases the torsional and lateral stability of the track. It was decided to place the layer of fabric between the fiber glass and the inner (roadwheel) surface of the belt, closest to the point of attachment load application (Figure 3-2, page 3-5). In this location, the fabric also protects the fiber glass from impact loads caused by the interaction of the roadwheels with debris on the inner surface of the belt. This "cushioning" effect occurs because the fabric has a high ultimate elongation and thus can deform locally to distribute concentrated loads. In this way, the material converts impact energy into strain energy which is in part dissipated by internal friction or stored and subsequently released as the material regains its original shape. The study of internal reinforcements for the belt revealed that the belt thickness could be reduced from one-half inch to three-eighths inch, thereby reducing the weight of the flat portion of the belt by 25 percent.

Following the recommendation for a center guide/center drive arrangement for the track guide teeth, a preliminary design for the teeth was concepted on

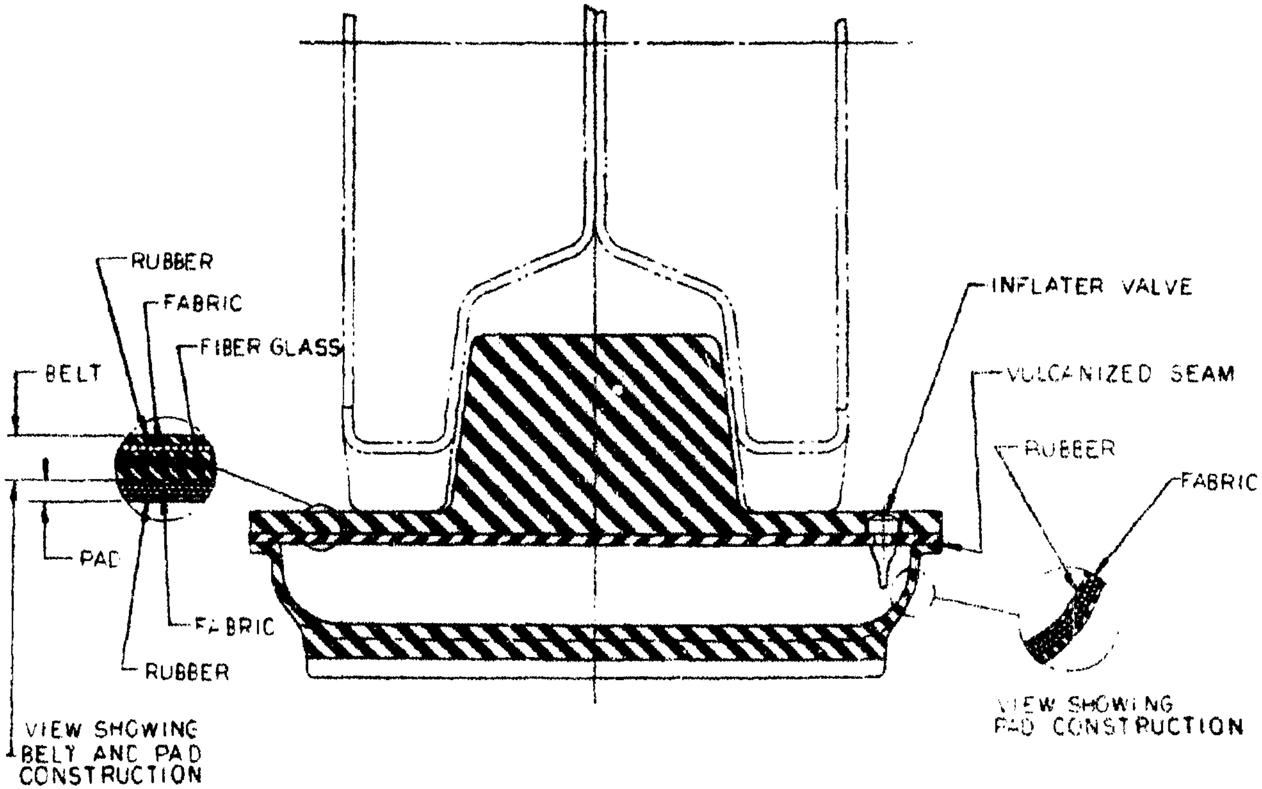

Figure 3-2 Lightweight High Mobility Track – Lateral Cross-Section

layout drawings. An attempt was made to provide the teeth with the largest bases possible within reason in order to produce adequate strength to withstand guiding, driving, and braking loads. The front and rear surfaces of the teeth were then developed by a layout study in which the belt was graphically wrapped and unwrapped around the sprocket. A tooth height of three inches was considered adequate for guiding purposes, especially in view of the large area of the tooth sides (Figure 3-3, page 3-7). For roadwheels greater than 14 inches in diameter, at least two teeth are in contact with a roadwheel at all times.

3.1.3 Manufacturing Techniques

In order to establish the feasibility of the belt, it was necessary to determine the problems inherent to its manufacture and if, indeed, it could be manufactured. During the initial stages of the investigation, handbooks on rubber products and processes were first reviewed to provide background information in preparation for discussions with suppliers. A basic method for manufacturing the belt was also formulated. Following the changes in the concept prompted by the contract target specifications, a number of suppliers with experience in manufacturing fiber glass reinforced belts were contacted. Some of the discussions which followed prompted minor changes in the belt concept. Chrysler's original ideas on manufacturing were also generally confirmed, with the addition of details in nomenclature, processes, and sequence of operations. The paragraphs below describe three methods of manufacturing and the advantages of each.

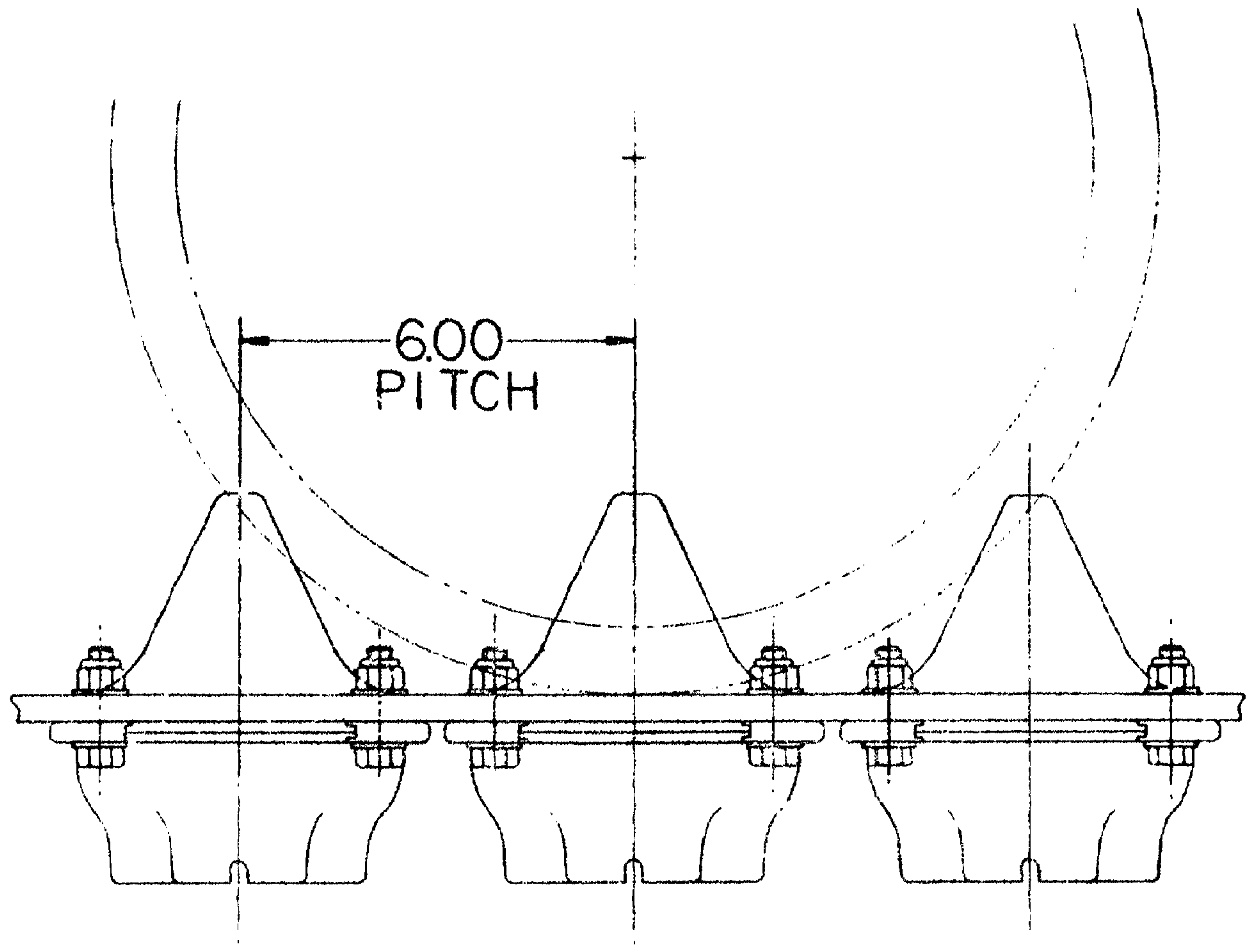

Figure 3-3 Lightweight High Mobility Track - Side View

3.1.3.1 Open-Side Press

This process is suggested as the least expensive method for producing prototype belts in small quantities. Uncured sheet rubber stock is first laid over a round mandrel. The inside diameter of the rubber on the mandrel is equal to the length of the inside surface of the finished track. The fiber glass tension member is wound around the mandrel while under tension. Another sheet of uncured rubber is then laid over the tension member and secured with a curable adhesive. The "raw" belt is suspended on two rollers, one on each side of the press. A mold in the press is loaded with uncured rubber stock which has been pre-cut to the approximate shape of the guide teeth. The belt is put under tension by a hydraulic cylinder which is connected to one of the rollers. The press is then closed upon the belt, subjecting it to heat and pressure. Thus, the belt is cured (vulcanized) in increments (typically 3-5 feet) and is indexed when the cure of one increment is complete. The control of temperature and temperature gradients along the portion being cured is extremely important to prevent overcure or undercure in overlap areas between increments. This method may be used to cure a belt of any anticipated length, but a specific mandrel is required for a given belt length.

3.1.3.2 Positive-Drive Type Circular Mold

Like the open-side press method, the circular mold method requires a mandrel for establishing the belt length. The raw belt is placed in an autoclave which contains a circular mold. Pressure is applied by a sleeve and a bag which is pressurized with steam which surrounds the belt and the mold. When the bag is pressurized, the belt is pressed against the mold. The production rate of this process is approximately 6-7 times that of the open side press method, but a specific mold is required for a given belt length. The mold would be much more costly than that required for the open-side press. The circular mold process would, therefore, be best suited for production of large quantities of belts of a specific length and would offer a maximum production rate in comparison to other methods.

3.1.3.3 Roto-Cure

As with the above processes, the roto-cure method requires a mandrel for a specific belt length. Rather than curing in increments or in one step, the roto-cure machine feeds the raw belt through a series of rollers, one of which is a heated mold. Pressure is applied by a stainless steel band which is also wrapped around the rollers. The use of this steel band requires that one side of the belt be smooth. A singular advantage of this process is that it can cure belts of various lengths, provided the width, pitch, etc. are the same. The roto-cure process is not as fast as the circular mold process, but it is expected that two belts could be handled per machine, thus showing an advantage over the open-side press.

All of the above processes can be applied to an endless belt construction, wherein the tension members do not have to be spliced or connected mechanically. This type of construction is considered essential for maximum belt life and strength. It was, therefore, concluded that all of these processes could be used to manufacture the belt portion of the lightweight track, with a reasonable probability of success, owing to the previous experience of suppliers with similar items.

3.2 Road Pad

3.2.1 Functional Requirements

The following characteristics were considered of major importance in the design of the pneumatic road pads:

a. High buoyancy
b. Low weight
c. Longitudinal flexibility
d. Satisfactory cushion against road shocks
e. Non-directional tread to avoid necessity of right- and left-hand parts
f. Low "footprint" pressure
g. Adequate heat dissipation
h. Adequate attachment strength
i. Resistance to penetration
j. Valve requiring a minimum of time and effort to fill air chamber

3.2.2 Concept Development

The initial road pad design was rectangular in shape, tapering slightly toward the bottom surface. The attachment to the belt was made by four studs, the heads of which were inside the air cell cavity (Figure 3-4, page 3-11). The air valve was integral with one of the studs. The road contact surface was chevron-shaped.

At the outset of the feasibility study, the road pad concept was first reduced in width from 20 inches to 12 inches. The first area to be investigated was the attachment to the belt. Various types of reinforcements were concepted for the interior of the air cavity. The overall pad design was also discussed with rubber companies, and it was decided that major changes would be necessary

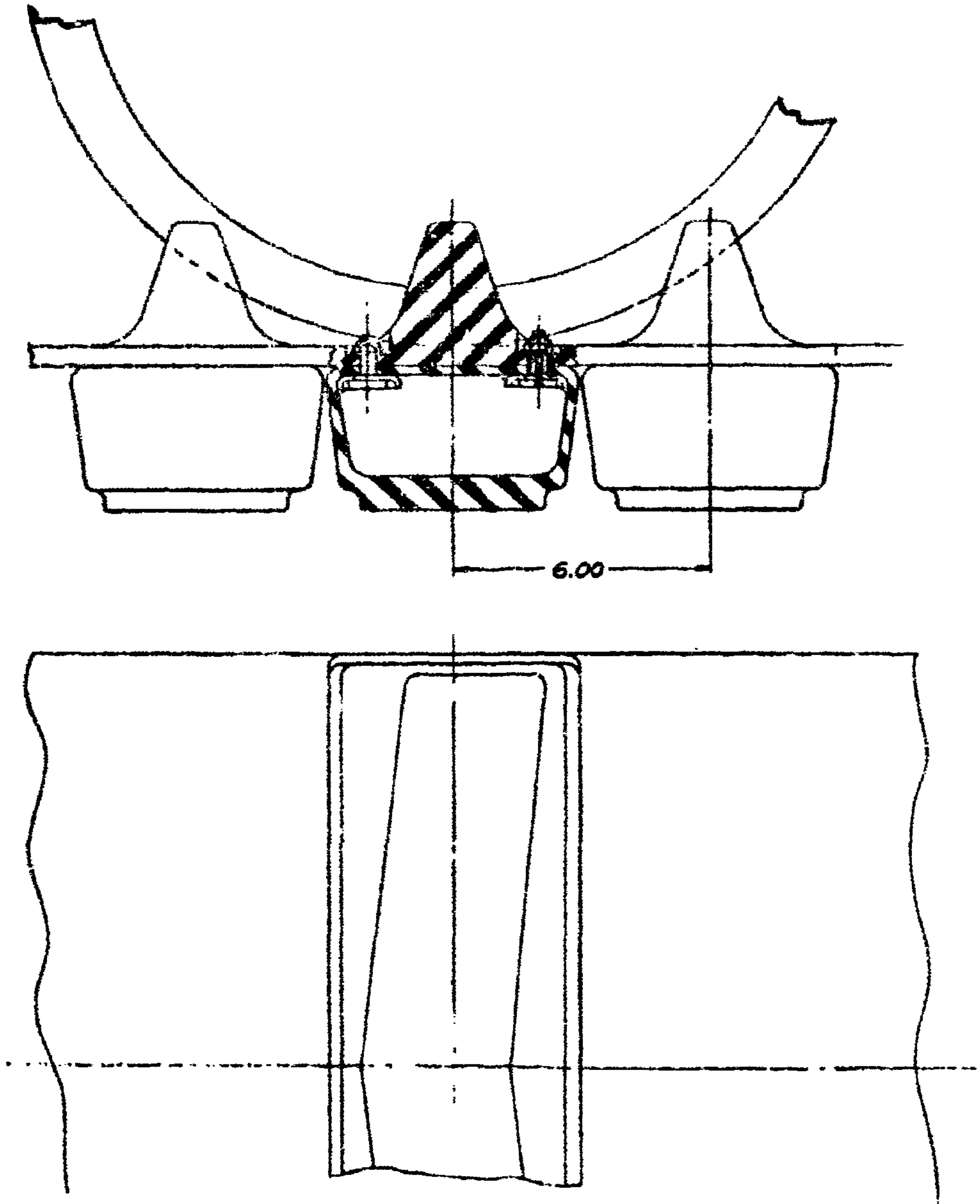

Figure 3-4 Proposal Concept - Side and Bottom Views

to facilitate manufacturing. First, having the attaching studs enter the air cavity presented sealing problems as well as manufacturing problems. Second, placing reinforcements inside the cavity required that access to the cavity be provided. The overall shape of the pad also made it extremely difficult to place fabric reinforcements in the cavity walls, and the pad would not flex properly because its walls were straight-sided and had rather sharp corners. Thus, it became evident that a complete redesign would have to be made to overcome these problems.

A basically oval shape was selected to allow the placement of the fabric reinforcements and to allow flexing by eliminating corners. The top surface of the pad remained rectangular. The pad would consist of a rectangular upper (belt sida) piece and an oval-shaped lower piece containing the air cavity. The lower piece would have a flange matching the periphery of the upper piece. The two pieces would be joined by applying heat and pressure to the flange area. A heat-sensitive cement would be used in the joining process. Prior to joining, each piece would be molded separately and partially vulcanized in the flange area. Vulcanization would be completed in the joining process.

Following the above approach, the configuration for the road pad concept was re-established. Detailed study of certain areas and discussions with suppliers established the correct corner radii, draft angles, and material thickness.

The attachment area was further investigated once the basic configuration of the pad had been established. In addition to facilitating closure of the air cell during manufacturing, the flange around the top of the pad provided a means of making the attachment without violating the air cell cavity. The corners of the flange offered an excellent place to make the attachment with three-eighths (3/8) bolts and flat washers. As with the belt, a steel sleeve was used to line the bolt hole to aid in distributing the lateral attaching loads and to prevent the threads of the bolt from working against the rubber (Figure 3-5, page 3-14). The sleeve also prevents the rubber from being compressed due to bolt tension. The front and rear edges and corners of the pad flange were also reinforced with steel clips. These clips protect the edges from tearing and keep the top of the pad flat against the track.

The decision to make the attachment with bolts outside the air cavity eliminated the idea of using one of the bolts as a valve. A review of the pad design indicated that the valve should be located in the top portion of the pad, where the surface is subjected to a minimum of flexing and where the valve would receive the least abuse during operation. A small valve such as used with tubeless tire rims was first considered. The valve would extend from the top of the pad through a hole in the track. Since these valves are designed for mounting in metal wheel rims, it was decided to reinforce the hole in the top of the pad with a steel ring as shown in Figure 3-6, page 3-15. This ring would be bonded to the rubber and would provide a sealing surface against which the body of the valve could expand following insertion. It would also prevent localized flexing in the area of the valve. This type of valve requires a cap which prevents the build-up of debris around the valve stem and aids in sealing. The placement of this valve is critical because

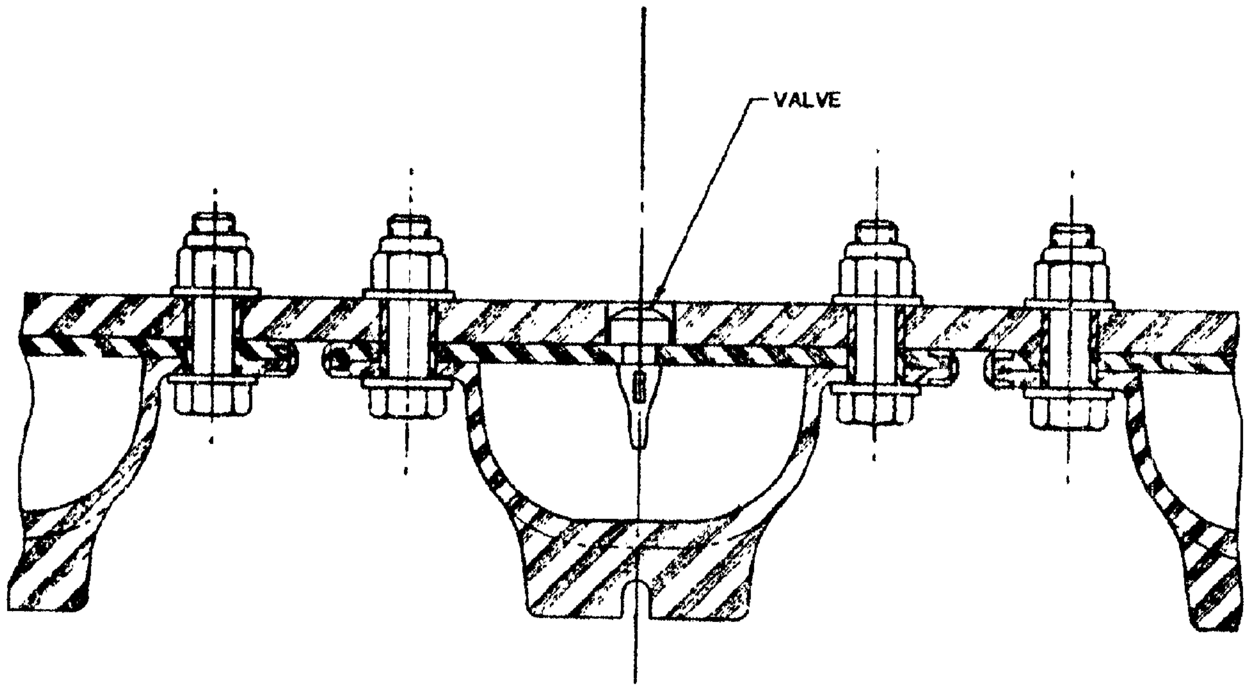

Figure 3-5 Lightweight High Mobility Track - Cross-Section Through Attachments and Valvo

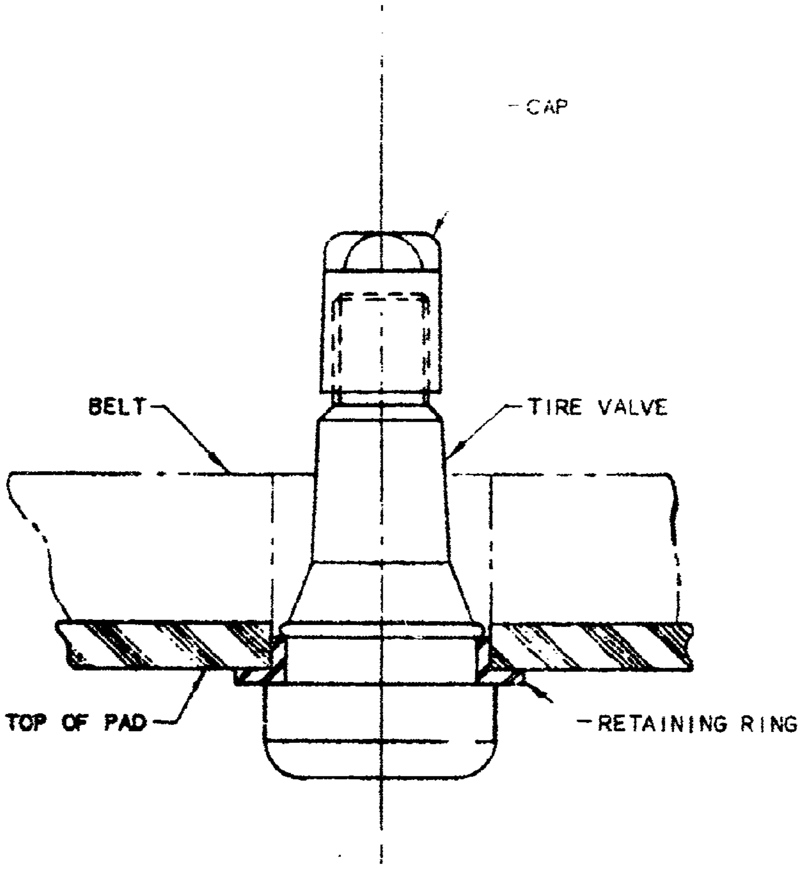

Figure 3-6 Tire Valve Mounting

it places a limitation on roadwheel width, the roadwheel must pass between the guide teeth and the row of valves. The valve is also quite vulnerable due to the fact that it projects from the inside surface of the track close to the outboard edge.

When the above problems became evident, a search for a valve requiring less complexity, weight, space, and effort to use was initiated. Since this is a low pressure application (approximately 11 psi static), other types of valves typically used for low pressures were examined. It was found that the valves commonly used in footballs, basketballs, etc. would meet the requirements. These valves are commonly called "inflaters" or "needle valves" because they are filled with a hollow needle.

This type of valve has several advantages over the tire valve originally selected. The weight of the inflater is almost negligible (approximately 1.9 grams); no cap is required; the valve will not extend beyond the inner surface of the belt and, therefore, will not be as vulnerable (Figure 3-5, page 3-14). In addition, the time required to fill the pad with this valve is expected to be less, and a pre-set air pressure source may be used to great advantage. It is also expected that the valve may be inserted directly into the top portion of the pad and bonded with an adhesive, thus eliminating the metal sealing ring required with the tire valve.

In developing the pneumatic pad concept, the idea of a chevron-shaped grouser was carried over from the proposal concept. With a grouser of this shape and the fact that the valve would have to be located near the outboard edge of the pad, it would have been necessary to have left- and right-hand pads for use on opposite sides of the vehicle. Also, the area of contact of this pad on the ground was rather small. Therefore, an attempt was made to design a grouser which would be non-directional and provide a large "footprint" area to reduce the unit pressure on the rubber for greater wear and to lower the pad inflation pressure requirement.

The grouser finally selected gives maximum protection and support to the pad air cell. It also presents gripping edges in both longitudinal and lateral directions (Figure 3-7, page 3-18). A lateral slot in the grouser prevents excessive stiffness when bending around the roadwheels and sprocket. The thickness of the grouser was established as 5/8 inch, based upon weight and buoyancy requirements.

3.3 Sprocket

3.3.1 Functional Requirements

Because of the somewhat unorthodox design of the track and its rubber guide teeth, it was necessary to design a sprocket specifically suited to this application. The following characteristics were considered in the development of the concept:

a. Smooth engagement and disengagement with track guide teeth

b. Light weight

c. Self-cleaning

d. Ease of manufacture

e. Adequate support of track

f. Ease of attachment to final drive hub

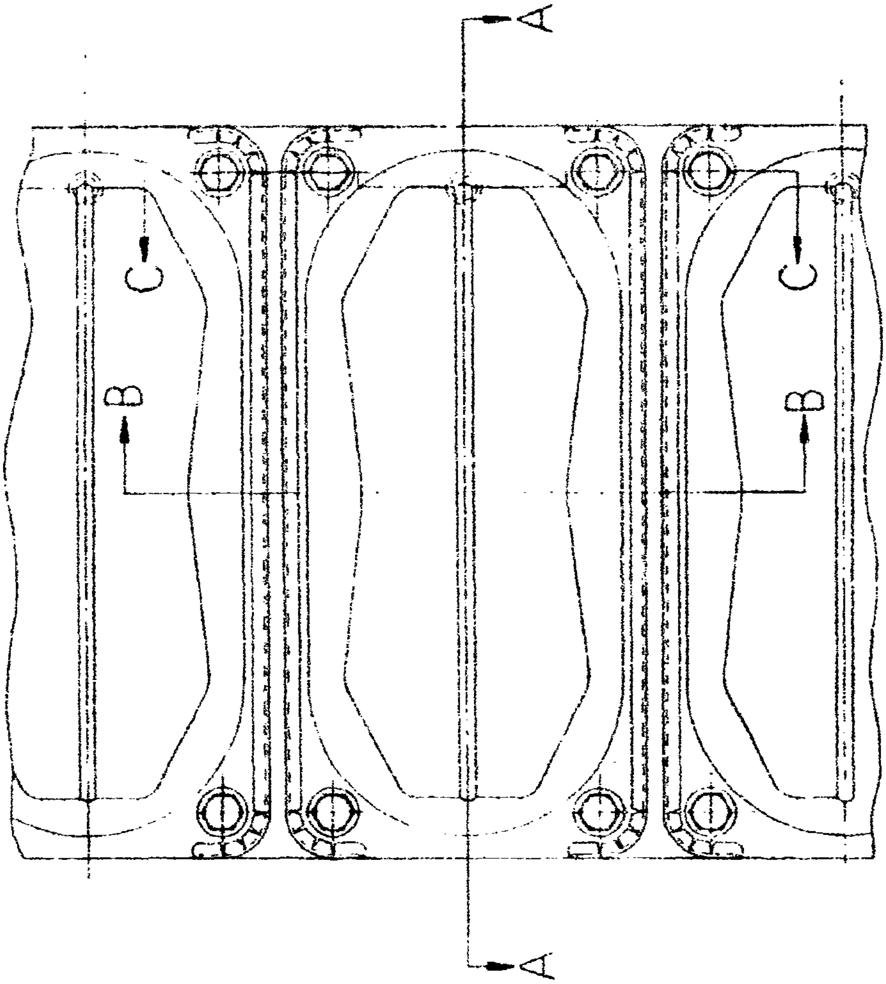

Figure 3-7   Lightweight High Mobility Track - Bottom View

3.3.2 Concept Development

The sprocket concept presented in the proposal consisted of twelve hollow steel drive pins welded on each end to circular plates. In view of the changes made to the track concept at the outset of the feasibility study, it was necessary to revise the sprocket concept and provide additional detail to agree with the track and the hypothetical vehicle application.

Beginning with the basic idea of a pin-type sprocket, it was first decided to reduce the number of pins to ten in order to reduce size and weight. This was considered advisable because the vehicle application envisioned was extremely light. The first step in designing the sprocket was to determine the correct location of the drive pins. This was done by considering the inside surface of the belt as the pitch line of the track and arranging the drive pins to be tangent to the inside of a diameter consisting of ten arc lengths of 6.00 inches. The pitch diameter, therefore, was found to be 19.10 inches (Figure 3-8, page 3-20).

With the diametral locations of the drive pins established, attention was next centered on providing support for the pins while allowing clearance for the track guide teeth. It was also desired to support the track belt outboard of the pins. Two identical deep-dish formed sections were thus developed to the desired shape. It was reasoned that this method would facilitate manufacturing and would minimize the number of parts required (Figure 3-9, page 3-21).

The formed sections were then perforated to cradle the pins prior to welding. In this way, accurate positioning of the pins was assured. Additional

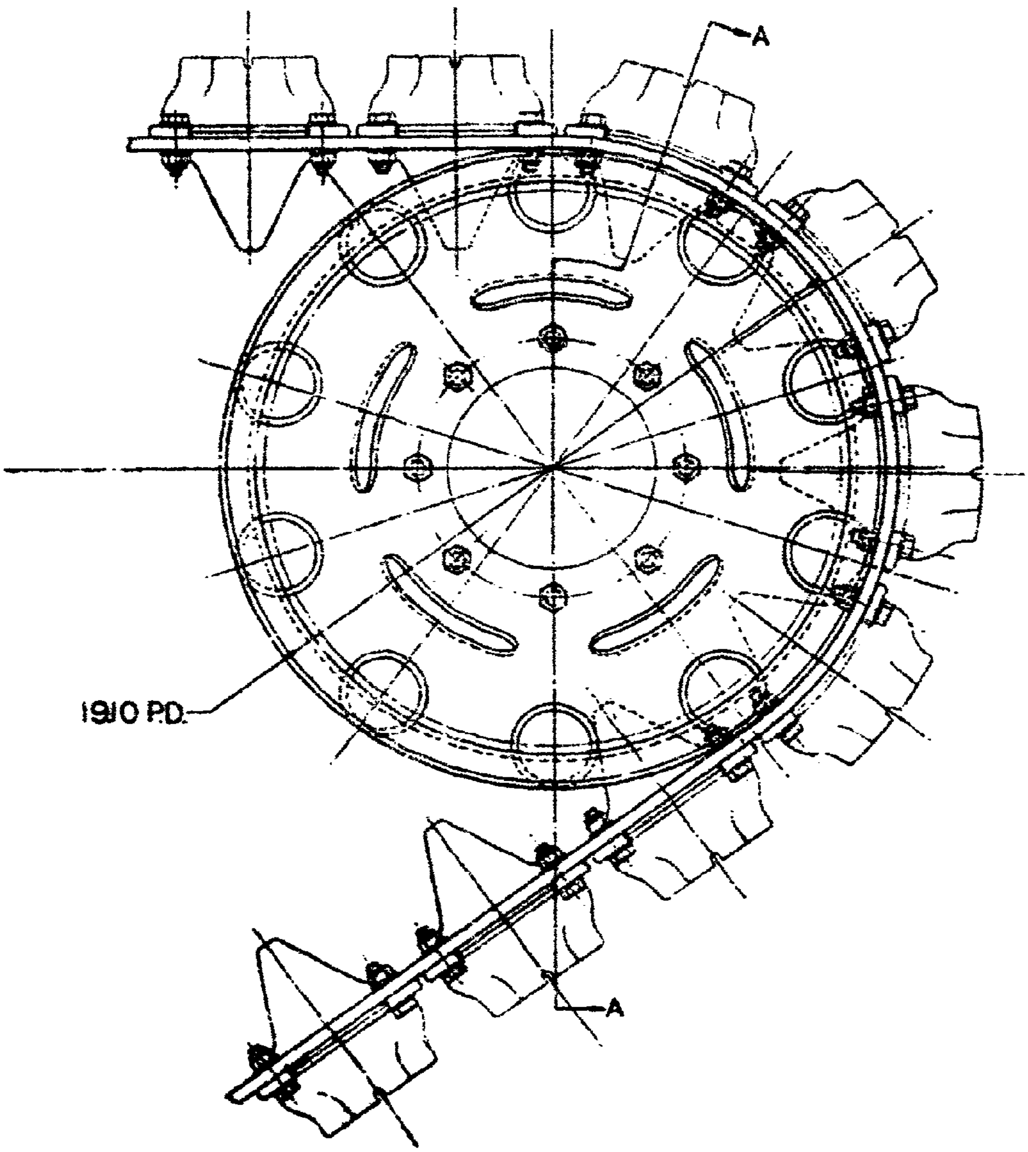

Figure 3-8   Sprocket - Side View

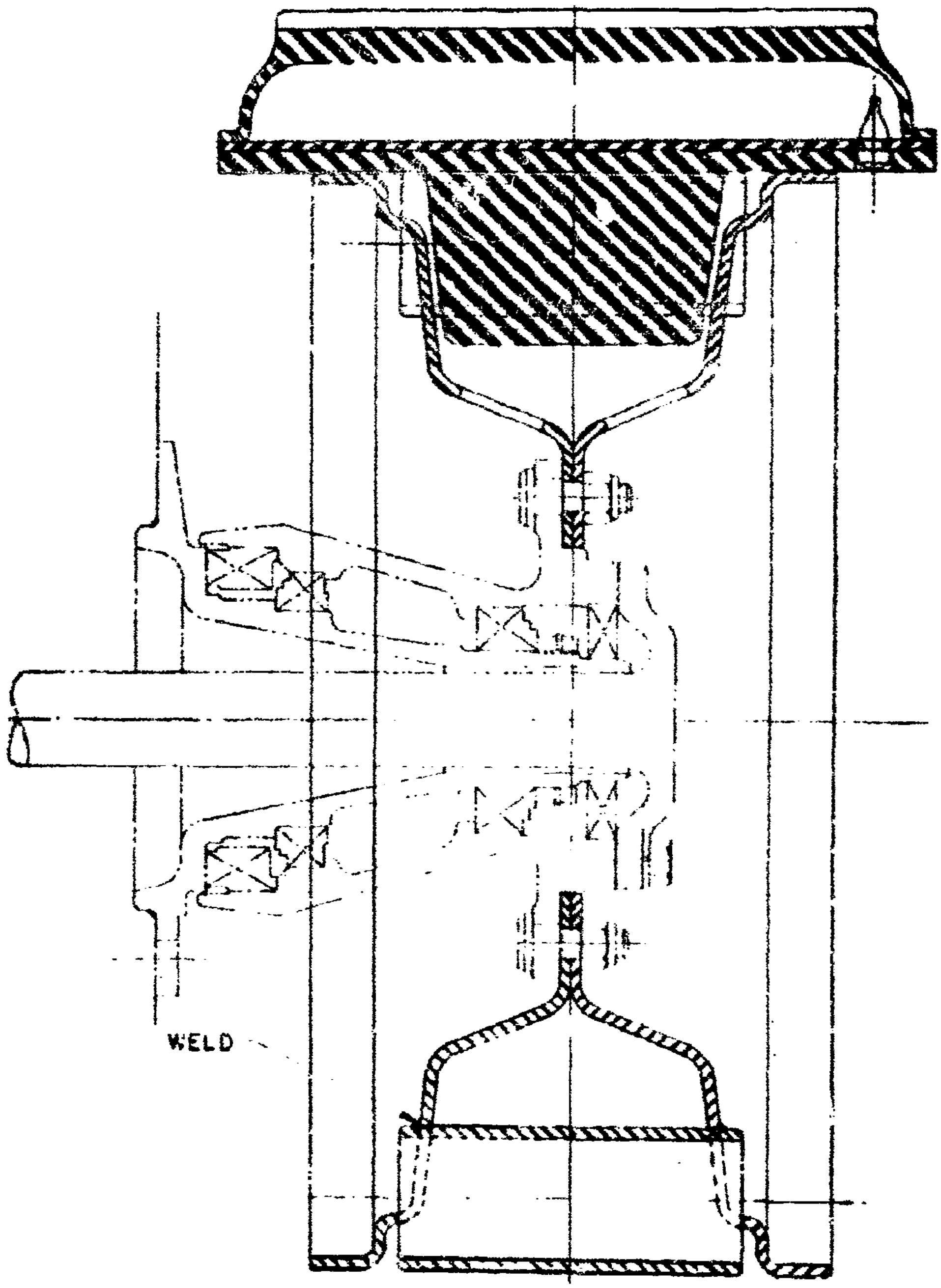

Figure 3-9   Sprocket - Cross-Section

perforations were included to allow debris to fall free of the sprocket and to reduce weight.

The attachment of the sprocket to the final drive hub was the next area to be investigated. In the absence of definition in this area, an M116 final drive hub was used as a guide. The various parts including bearings, drive shaft, hub, and support housing were rearranged and revised to suit the new sprocket design without changing the basic concept. Since final drive hub definition was beyond the scope of this project, no further study was performed in this area. A hole in the center of the sprocket assembly was made to pilot on a diameter of the final drive hub, and the sprocket was held in place by studs and by nuts, in a manner similar to automobile wheel mounting.

4.0 CONCEPT DESCRIPTION

4.1 General

The Lightweight High Mobility Track is essentially an endless reinforced rubber belt having guide teeth molded to its inner surface and rubber pneumatic road pads bolted to its outer surface. The track is 12 inches wide and has a "pitch" of 6 inches. One guide tooth and one road pad are located on each pitch. Due to the flexibility of this track, the term "pitch" takes on implications different from the same term applied to pin-type tracks or conventional band tracks using rigid shoes; as the track travels around roadwheels, sprocket, and return rollers, it will bend sufficiently to partially conform to these objects rather than forming distinct chords.

The track weighs approximately 9.83 pounds per foot and is 110.7 percent buoyant in water. The envelope length envisioned for the theoretical vehicle application is 22.5 feet, and each track will weigh 210 pounds. Each pitch of track displaces .0874 cubic feet of water when submerged.

The sprocket engages the guide teeth on the inside surface of the belt. The sprocket teeth are cylindrical hollow pins which are welded to two deep-dish formed wheel sections which bolt to the sprocket hub. The formed sections are perforated to prevent the collection of debris around the pins and are shaped to guide the track by forming a groove for the guide teeth. The track is supported outboard of the pins by flanges on each of the formed wheel sections.

4.2 ·inforced Belt

The reinforced rubber belt section of the track resembles a cogged positive-drive belt, except that the teeth do not extend across the entire width. The thickness of the belt is 3/8 inch and the guide teeth extend three inches from the inside surface. The teeth serve not only as driving surfaces, but also as track guides; the dual roadwheels straddle the teeth and are presented with a smooth, uninterrupted path.

The tension members of the track are located in the thin belt section. Tension loads are carried by strands of fiber glass cord. The ultimate tensile strength of the belt is expected to be approximately 66,000 pounds. The fiber glass cord consists of one strand wrapped many times around the track envelope and located at the center of the 3/8 inch thick section. This reinforcement extends across the full width of the belt (Figure 3-2, page 3-5). Only one layer of the cord is required. Two or more layers could not be used in this application because of the rigidity of the fiber glass cord in tension. Bending around a roadwheel or sprocket could set up enough stress in the cord to cause failure of the rubber or of the cord itself.

The fiber glass cord is made from continuous filaments grouped into strands. The strands are twisted together to produce the cord. It is important that the direction of twist be reversed at the center of the belt. For example, the portion of the belt from the longitudinal centerline to the right edge would contain cord with a right or left-hand twist. The portion of the belt on the opposite side of the centerline would contain cord of the opposite twist. This arrangement eliminates the tendency for the belt to twist under tension.

individual fibers are treated with an organic or inorganic lubricant which keeps them apart and minimizes the abrasive action of glass on glass. Without this lubricant, the fibers would scratch each other and cause fracture. The selection of the lubricant largely depends upon its compatibility with the rubber in which the cord will be encased. The lubricant is permanent because it is completely enclosed in rubber and not subject to dilution or attack by environmental influences. The fiber glass cord to be used will be similar to that described in MIL-Y-1140 E, Yarn, Cord, Cloth and Tape-Glass, Section 3.3.2, page 5, 30 December 1963.

In addition to the fiber glass cord, the belt is reinforced with one ply of nylon or rayon fabric, located between the fiber glass cord and the inside surface of the belt. The fabric reinforcement gives lateral and torsional strength to the track and increases the shear strength of the belt for the road pad attachment. The fabric material has a much lower modulus of elasticity than the fiber glass and a higher ultimate elongation. Therefore, the fabric does not carry normal belt tension loads, but serves to protect the fiber glass from concentrated shear or point loads. It also adds to the overall toughness of the belt section.

The guide teeth on the inner surface of the belt are integral with the belt and are molded from the same rubber as the belt. They are prismoidal in shape, tapering on all sides toward the top. Large radii are located at the junction of the front and rear surfaces of the tooth and the inner surface of the belt. The sprocket pins engage the teeth at these radii. The area of the base of each tooth is quite large in order to provide adequate shear strength to withstand driving and guiding loads.

The road pads are located on the outer surface of the belt and each is held in place by four bolts. The belt has four steel-reinforced holes per pitch to accommodate the attaching bolts (Figure 4-1, page 4-5). This steel reinforcement allows the attachment to be made without locally compressing the belt as the nut is tightened and helps distribute lateral forces to the belt during operation. Access to the road pad air valve is through an additional hole in the belt, located near its outside edge.

4.3 Road Pads

The pneumatic road pads serve two primary purposes in addition to providing tractive surfaces: they add buoyancy and serve to absorb shocks. Each pad consists of a pressurized air cell and a rubber grouser which is integral with the cell. The air cell is oval-shaped (Figure 3-7, page 3-18) and is constructed of two pieces. The upper piece is a flat sheet of rubber which is reinforced with fabric. This piece is adjacent to the outside surface of the belt when the pad is installed. The lower piece contains the air cell cavity. The two pieces are joined at a flange which encompasses the upper surface of the pad assembly. The leading and trailing edges of this flange are reinforced with steel clips to prevent tearing of the rubber during operation. The attaching bolts extend through the flange at the corners, and the holes for the bolts are reinforced with steel sleeves.

The flat upper surface of the pad contains an inflater, a valve similar to those used in athletic equipment. A "needle" is used to fill or deflate the air cell. This type of valve has no moving parts and is made entirely of a highly resilient grade of rubber. Due to this resiliency, the hole for the "needle" closes and forms a seal when the needle is not inserted.

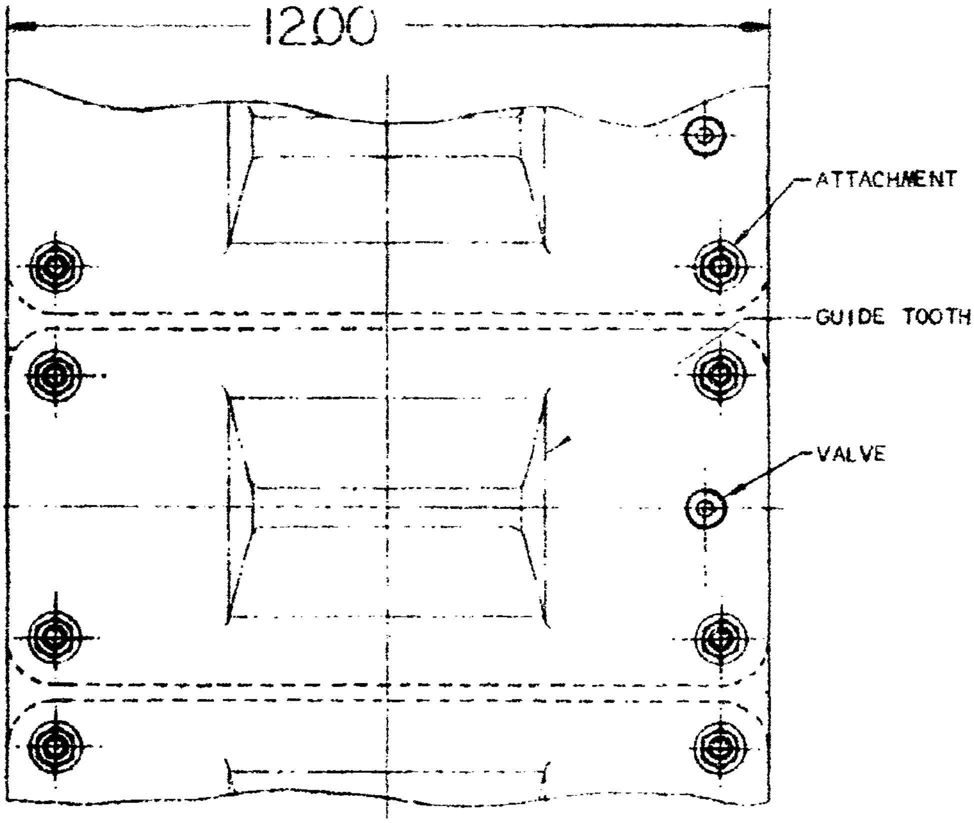

Figure 4-1 Lightweight High Mobility Track – Plan View

The lower portion of the pad is reinforced with two plies of fabric along the sides and above the grouser. The fabric gives the pad lateral and longitudinal stability as well as resistance to penetration. It also provides strength in the area of the attachment. The grouser is non-directional and has an area of 32.9 square inches. A lateral slot in the grouser aids in bending around the roadwheels and sprocket.

4.4 Sprocket

The sprocket is a fabricated construction consisting of ten hollow cylindrical pins and two formed sections similar to an automotive wheel. The pins are welded to these sections at each end (Figure 3-8, page 3-20, and Figure 3-9, page 3-21).

The pins engage the guide teeth on the track for driving and braking. The track is supported as it travels around the sprocket by the pins and by flanges on the outboard edges of the formed wheel sections. The driving and guiding interfaces are all rubber to metal, providing quiet operation. The sprocket is self-cleaning because the formed sections are perforated to permit the expulsion of debris. The pitch diameter of the sprocket is 19.10 inches; the overall width is 8.65 inches.

The sprocket is attached to the final drive hub by studs and nuts. The studs are pressed into the hub mounting flange. A pilot diameter on the hub guides the formed sections of the sprocket to assure accurate mounting.

5.0 FEASIBILITY ANALYSES

Throughout the duration of the concept feasibility study, it was necessary to evaluate the lightweight track from several standpoints at each stage of the concept evolution. These evaluations not only provided increased concept definition, but in many cases also indicated areas for improvement of the designs. This section presents the analyses used to determine certain design requirements and to evaluate the final concept.

5.1 Track Tension Requirements

Since the ability of the track to carry axial loads is extremely important, the first analysis was performed to determine the magnitudes of these loads. The calculations (page A-2) were based upon the hypothetical vehicle application having a gross weight of 3000 pounds. Maximum operating tension was determined by considering the vehicle operating on a surface with a traction coefficient of 0.80, thus making this tension equal to 40 percent of the gross weight or 1200 pounds.

Maximum potential tension is usually based upon sprocket torque data. In the absence of these data, however, ATAC recommended that the maximum potential tension be equal to the gross vehicle weight multiplied by 1.25 or 3750 pounds.

Studies of the properties of fiber glass and discussions with suppliers of fiber glass-reinforced belts indicated that the ultimate strength of the belt should be 15 to 20 times as great as the maximum operating tension. It was also noted that such belts are currently being manufactured with strengths of approximately 6000 pounds per inch of width. With a track width of 12 inches, less a total of one inch to allow for attachments, it was found that the belt portion of the track could be manufactured with an ultimate strength of 66,000 pounds. The strength potential of the belt, therefore, far exceeded the suggested ultimate strength; the ultimate strength of the belt could be as high as 55 times the maximum operating tension and 17.6 times as high as the maximum potential tension, as shown on page A-3.

5.2 Weight and Buoyancy

An analysis of the weight and buoyancy of the concept was performed as soon as the final configuration was determined. In performing the analysis, the material and displaced volumes were computed for each geometrical section of the belt and the pneumatic road pad, as shown in the calculations beginning on page A-4. The specific weight of rubber used was 0.0415 pounds per cubic inch, as provided by suppliers. This figure was found to agree with other data on rubber (2). It was assumed that the effective specific weights of the fiber glass cord and fabric would be the same as that of rubber. The weights of attachments were either calculated or, when possible, determined directly with a scale. The analysis showed that the track would weigh 9.83 pounds per foot and would have a buoyancy in water of 110.7 percent. The weight of the sprocket was calculated to be 56.2 pounds (page A-7).

5.3 Length Change due to Temperature Variation

Dimensional stability, especially in the longitudinal direction, is extremely important for all tracks. Large variations in length could cause the track to become "overpitched" or "underpitched" with respect to the sprocket and could also affect static track tension. The total length change the track could be expected to undergo was, therefore, calculated using the specified minimum and maximum operating temperatures of -65 to +125 degrees Fahrenheit. The calculations on page A-8 show that the change in length would be only 0.114 percent or .3078 inches for an envelope length of 22.5 feet. It was assumed that the fiber glass cord, being the main tension member, would govern the length change of the track; the effects of the rubber and fabric were neglected.

5.4 Road Pad Inflation Pressure

The development of a pneumatic pad and the selection of an air valve requires some knowledge of the inflation pressures which will be required. In calculating the static inflation pressure (page A-9), it was assumed that the pressure inside the pad would have to be equal to the "footprint" pressure on the grouser due to static roadwheel load. Therefore, it could be said that, when a roadwheel is directly above a road pad, only that particular pad supports the wheel and no vertical load is transmitted into any other pads. This was considered to be a safe assumption since, in practice, a certain amount of load will be carried by adjacent pads because of deflections. In addition, it was assumed that the walls of the pad do not contribute to the support of the grouser area. The calculations showed that the required inflation pressure would be 11.4 psi and that the average "footprint" pressure for all grousers would be 3.91 psi.

5.5 Grouser Wear Rate

Another factor typically relating to ground pressure is the wear rate of a rubber road pad. Most road pads are rigidly backed and cannot deflect to an appreciable extent when experiencing concentrated loads. The pneumatic pad for the lightweight track, however, provides a flexible backing for the rubber grouser. In attempting to estimate the wear rate and expected life of the grouser, it is possible to draw certain conclusions based upon data from existing tracks.

A survey conducted by Chrysler under another contract (3) indicated that a definite relationship existed between road pad wear rate and the ground pressure on a road pad calculated by dividing the pad area per pitch of track by the average static roadwheel load. In addition, a similar relationship was shown to exist between wear rate and the average pressure on all pads in contact with the ground. The curves on the following pages represent the results of the survey. The curves were extrapolated for low pressures because of a lack of data in this area. Another factor which limits the ability to predict wear rates for the Lightweight Track road pads is their flexibility. It would be expected that a flexible road pad would have a lower wear rate than a rigidly-backed pad because of its ability to deflect and distribute concentrated loads over an increased area. In addition, examination of conventional road pads indicates that they may be subject to damage by bruising, wherein a concentrated load causes a breakdown of the rubber as it is pinched between a small road irregularity and the rigid backing material. The pneumatic track pad will greatly reduce this tendency.

Based upon maximum "footprint" pressure, the curve for band tracks indicates a wear rate of approximately 4560 miles per inch of wear. Using an average "footprint" pressure of 3.91 psi, the appropriate graph indicates a wear rate in excess of 4600 miles per inch of wear. No attempt has been made to extrapolate this curve beyond 4600 miles. Assuming a wear rate of 4500 miles per inch, a life of approximately 2880 miles is indicated for the 5/8-inch thick

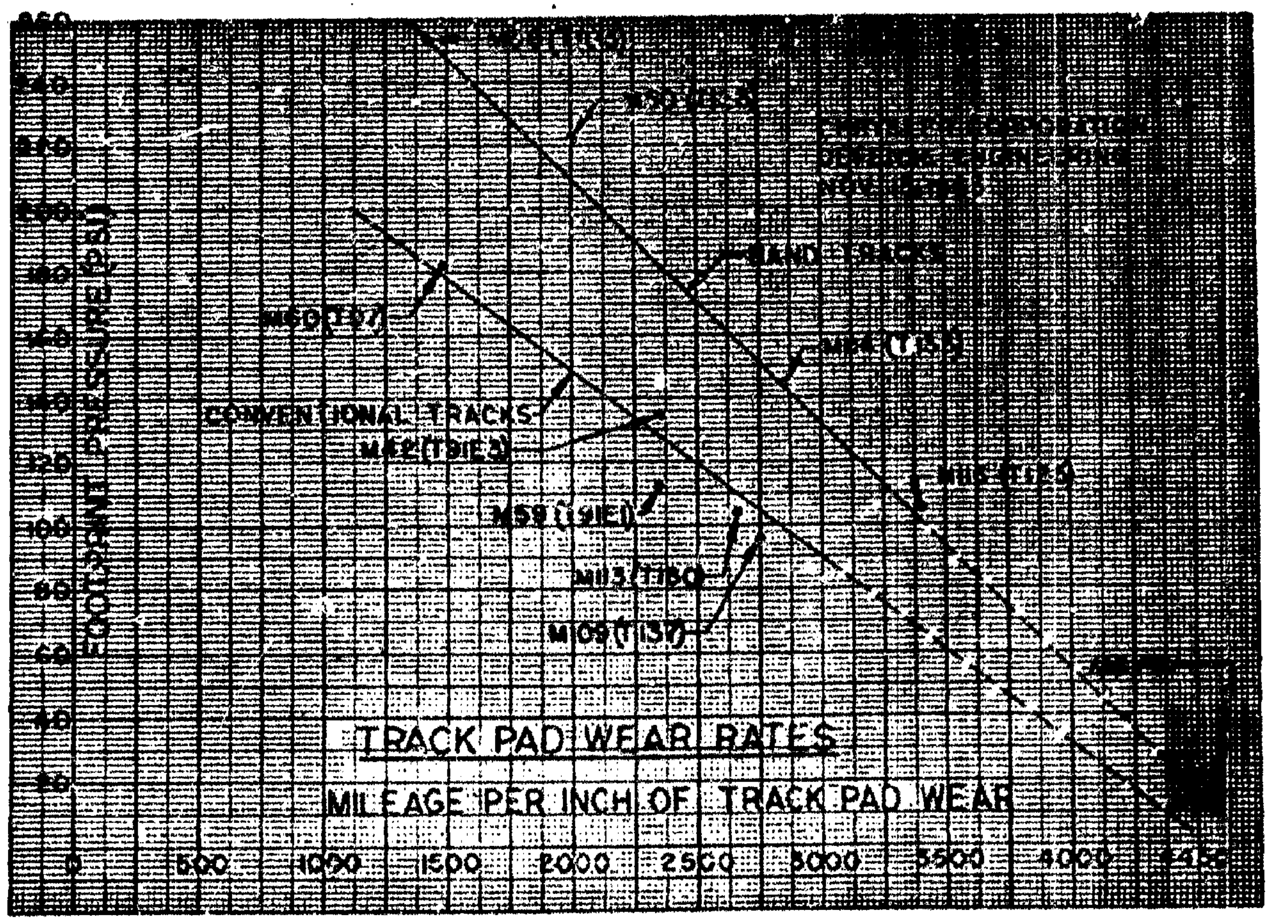

Figure 5-1 Track Pad Wear Rates Versus Footprint Pressure

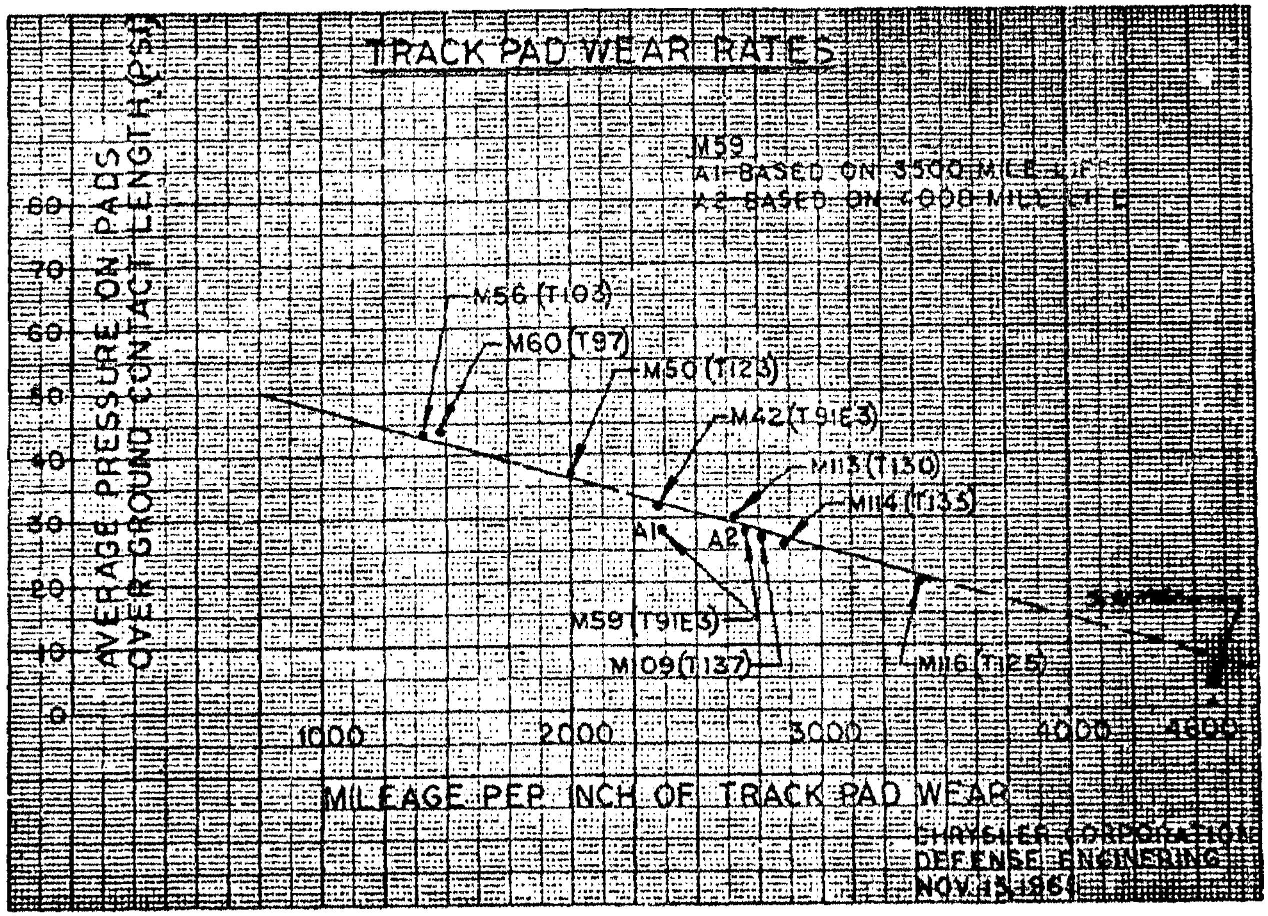

Figure 5-2 Track Pad Wear Rates Versus Average Footprint Pressure

grouser. It should be noted that the pad could still function for a limited time, even with the grouser completely worn away.

5.6 Maintenance Requirements

The Lightweight High Mobility Track has been designed to require a minimum of maintenance. Once the track has been installed and the initial tension adjustment made, no further tension adjustment will be necessary. The track will not take a "set" due to the nature of the fiber glass tension members. It is expected that maintenance will consist only of replacing worn or damaged road pads and an occasional restoration of inflation pressure during long periods of inactivity.

Depending upon the nature of road pad damage, it will be possible to make repairs without removing the pad from the track belt. For example, a simple puncture may be repaired in the same manner as a tubeless tire; a plug is inserted into the puncture and sealed with an adhesive. In order to inflate the pads, it will be necessary to lubricate the inflater needle before inserting it. To inflate all of the pads in a minimum time, an air supply which has been pre-set to the desired pressure would be advantageous. In the field, the pads could be inflated with a simple hand-operated pump. Little physical effort would be required, owing to the low pressure and the small volume to be filled.

The replacement of a road pad requires only two wrenches. One would be used to tighten or loosen the locking nut, while the other would be required to hold the bolt. Locking nut torque will not be critical. For normal operation, replacement of road pads will be required at intervals of approximately 2800 miles.

Because the Lightweight Track is continuous, its installation will require a procedure which is quite different from those used to install conventional pin or band-type tracks. Most tracks are laid flat on the ground while the vehicle is rolled onto them. Installation of the Lightweight Track will require that one or both sides of the vehicle be raised until the roadwheels are approximately six inches above the ground. The track will then be positioned under the roadwheels and suspended over the idler and return rollers. In order to place the track over these members, the tension adjustment must be in the relaxed position, and the sprocket should be removed. The sprocket would be reinstalled with the track suspended on it, followed by the adjustment of track tension.

5.7 Effects of Damage

Because of the severe loads a track must withstand, one of the most frequent causes of vehicle immobilization is track failure. However, overdesign of conventional pin and band-type tracks with respect to forseeable operating loads usually involves penalties in several areas, including weight and power consumption. A pin-type track is subject to a disabling failure if only one pin is overstressed. A similar condition exists with sectionalized band tracks, especially where sections are joined together. The rigidity of conventional tracks places severe demands upon the tension carrying members because loads cannot be distributed through deformation. In this area, the flexibility of the Lightweight Track and the fact that the load-carrying members are distributed across the entire width of the belt present certain advantages. First, the pneumatic road pads serve to distribute concentrated vertical loads caused by road surface irregularities. Second, because the track is designed to carry many times the expected maximum operating tension, the failure of a significant percentage of the fiber glass tension members will not cause total track failure.

Although the pneumatic road pads are essential to track buoyancy and serve other important functions, failure of several or all of the pads will not affect the structural integrity of the belt. Similarly, although operation could not be sustained with a number of damaged guide teeth adjacent to each other, several isolated failures could be tolerated to provide a "get home" capability. For the above reasons, a vehicle equipped with the Lightweight Track could sustain considerable track damage before being immobilized.

5.8 Comparison with Track used on XM571 Vehicle

The XM571 is an articulated tracked vehicle consisting of two powered units joined by a special universal joint/propeller shaft. The gross weight of this vehicle is approximately 8000 pounds, with the front unit slightly heavier than the rear unit. Each unit, then, has a gross weight close to 4000 pounds. which is very similar to the hypothetical vehicle application of the Lightweight Track (4). At present, the XM571 track is the lightest track made for any vehicle above a 3000 pound gross weight. The objectives of the Lightweight Track included concepting a track which is not only lighter, but which will surpass other aspects of the XM571 track such as reliability, durability, and buoyancy. In view of this, a brief examination of the XM571 track was conducted, resulting in the comparison table shown below. It must be pointed out, however, that the Lightweight Track is at present merely a concept and has not had the benefit of testing.

TABLE I COMPARISON OF LIGHTWEIGHT TRACK AND XM571 TRACK

DATA	UNITS	LIGHTWEIGHT TRACK	XM571 TRACK
Width	Inches	12.00	18.00
Pitch	Inches	6.00	4.75
Weight	Pounds/Foot	9.83	14
Volume	Cubic Feet/Foot	0.1748	.0416
Buoyancy	Percent	110.7	21.6
Grouser Height	Inches	2.38 (Pad)	1.59

5.9 Amphibious Operation

The most significant features of the track which favor amphibious operation are its light weight and buoyancy. Unlike conventional tracks, this track will help to support the vehicle in the water without a serious weight penalty. It will, therefore, be possible to provide a given vehicle with greater freeboard and/or amphibious load-carrying capacity.

Certain specialized vehicles, such as landing craft, have made use of tracks specifically designed for maximum water propulsion. A number of these tracks employ vane-shaped shoes or appendages and feature an "open" construction which allows water to flow from the inside of the track envelope to the outside. Shrouds have been used to cover the returning portion of the track to eliminate thrust in the direction opposite to that of the vehicle. The Lightweight High Mobility Track, due to its road pad appendages, will provide some thrust in the water, but it is not expected to equal the efficiency of tracks designed specifically for water propulsion. It would be necessary to cover the returning portions of the tracks with shrouds for the reason mentioned previously. For certain vehicle applications, however, the buoyancy of the track may make it possible to have the returning portion of the track above or close to the surface of the water for maximum efficiency from the standpoints of thrust and power consumption. Any meaningful estimate of water speed would require data defining the appropriate features of the vehicle application. In view of the absence of these data, no numerical estimate of water speed has been made.

5.10 Cross-Country Speed Capability

The requirements listed in Section 2 include descriptions of terrain conditions ranging from dry hard cross-country to wet marginal cross-country. The Lightweight High Mobility Track has no known features which would limit operating speed on these various types of terrain. On the other hand, experience has shown that speed limitations are more often related to the ability of the vehicle driver and crew to withstand severe vibration inputs or the ability of the vehicle power train to provide the necessary power and control. Other factors which must be considered are associated with the overall vehicle configuration, including ground clearance, driver field of vision, and length/width ratio. Even with a complete vehicle definition available, an estimate of cross-country speed capability is extremely difficult to make.

Given two identical vehicles - one with the Lightweight Track and the other with a conventional band track of the same width and weight - it is expected that the vehicle equipped with the Lightweight Track would be able to attain greater cross-country speeds. The reasons for this include low power consumption and the inherent ability to absorb shocks.

5.11 Overall Performance Summary

The overall performance of the Lightweight High Mobility Track is expected to provide certain advantages which have been heretofore unattainable with existing track designs. The longitudinal flexibility and lack of a definite "pitch" will provide extremely smooth operation with minimum power consumption. The cushioning effect of the pneumatic road pads will serve to reduce vibration caused by small surface irregularities and may ease suspension requirements for small vehicles. The fact that no metal-to-metal contact is present anywhere in the track interfaces between roadwheels, idlers, and sprockets will assure that noise will be held to a minimum. The low weight and high buoyancy of the track will allow better amphibious operation and an increased cargo capacity in comparison to gross vehicle weight.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The outcome of this investigation is a concept of the Lightweight High Mobility Track and Drive Sprocket. The track consists of a reinforced rubber belt with guide teeth on its inner surface and removable pneumatic road pads on its outer surface. The adoption of this concept was originally prompted by requirements for positive buoyancy, light weight, smooth operation, low power loss, long life, and ability to absorb shocks. The analyses performed to determine feasibility centered mainly upon weight, buoyancy, tensile strength, and manufacturing. The resulting concept is 12 inches wide, has a pitch of 6 inches, weighs 9.83 pounds per foot, and is 110.7 percent buoyant.

6.2 Conclusions

The analyses indicate that the Lightweight High Mobility Track Concept is feasible and that it will definitely meet or surpass most of the requirements. Due to the unusual nature of this concept, however, a meaningful evaluation of some of its characteristics such as belt life, power losses, and road pad wear rate can best be performed by laboratory and on-vehicle testing.

A number of features of the Lightweight Track represent improvements over conventional pin or band tracks. The fact that the roadwheel path is smooth and continuous will eliminate the vibration caused by roadwheels traveling over individual shoes. The elimination of metal-to-metal contact throughout the track and its interfaces with suspension components will provide extremely quiet operation. The longitudinal flexibility of the track and the lack of rigid pitches will serve to reduce vibration and power losses. The ability of the pneumatic road pads to absorb road shocks will attenuate low amplitude suspension inputs. The buoyancy of the track will allow greater freeboard or load-carrying capacity for amphibious vehicles.

Although the track concept developed during this study was intended for a vehicle with a gross weight of 3,000 pounds, it is expected that various similar concepts would be applicable to cargo and reconnaissance vehicles currently using conventional band tracks. In general, the track seems best suited for lightweight, high-speed vehicles. Variations of the basic concept could probably be used on vehicles up to about 20,000 pounds gross weight, with similar advantages.

6.3 Recommendations

In view of the feasibility of the Lightweight High Mobility Track and the inherent advantages of the concept, it is recommended that additional programs be undertaken with the ultimate goal of placing this track into service on future or existing lightweight vehicles. The following programs are presented as a plan involving the least cost and risk, preliminary to on-vehicle testing.

6.3.1 Concept Definition and Test Plan Program

An essential phase of a future development program would be the production of a full complement of detail drawings for the track and the sprocket complete with all necessary specifications regarding materials and performance. These drawings and specifications would be based upon the concept presented in this report and full use of the experience gained during the feasibility study would be assured.

Chrysler is currently involved in the design and fabrication of the Pitchless Band Track Test Machine to be installed at ATAC (Contract DAAE07-67-C-4181). It is further recommended that a plan be devised for testing the Lightweight Track on this machine. In order to accomplish this, detail drawings for a roadwheel and other hardware for use on the machine would have to be provided. The test plan would be directed toward determining endurance, durability, and power consumption factors as related to speed, vibration, tension, and application of dynamic loads.

6.3.2 Material Procurement and Test

Upon completion of the above program, action would be initiated to procure all material required for testing. Necessary modifications to the test machine would be made and testing accomplished with technical assistance provided by Chrysler personnel.

7.0 REFERENCES

The following list presents references for data included in the report. Each reference is referred to by number in the report text.

(1) Modern Plastics Encyclopedia, Vol. 34 #1A, 1956, New York, page 518.

(2) Handbook of Molded and Extruded Rubber, Second Edition, Goodyear Tire & Rubber Co., Akron, Ohio, 1959, page 9.

(3) Pitchless Band Track, Concept and Feasibility Study, Army Tank Automotive Command, Contract DA-20-113-AMC-07701(T), Chrysler Corporation, Defense Operations Division, Defense Engineering, 11 February 1966, pages 3-3 to 3-6.

(4) Final Report of Engineering Test of Carrier, Utility, Articulated, XM571, Aberdeen Proving Ground, Aberdeen, Maryland, USATECOM Project No. 1-3-5550-01-D, Report No. DPS-1462, October 1964, page 8.

(5) Burington, Richard S., Handbook of Mathematical Tables and Formulas, Handbook Publishers, Inc., Sandusky, Ohio, 1958, page 15.

(6) Trends in Designing with Reinforced Plastics (pamphlet), Pittsburgh Plate Glass Co., October 1964.

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APPENDIX

CONTENTS

7102 0164

CHRYSLER DEFENSE ENGINEERING

SHEET 2 OF ___

DESIGN CALCULATIONS

SUBJECT:

TRACK TENSION [illegible]

MAXIMUM OPERATING TRACK TENSION

$$TENSION_{MAX\ OP} = \frac{VW}{2} \times 0.8 = 1500\ LB \times 0.8$$

$$= 1200\ LB$$

THE ABOVE TENSION COULD OCCUR IF THE VEHICLE WEIGHT WERE EQUALLY DIVIDED BETWEEN THE TWO TRACKS ON A SURFACE WITH A TRACTION COEFFICIENT OF 0.8

MAXIMUM POTENTIAL TRACK TENSION

$$TENSION_{MAX\ POTENT} = VW \times 1.25 = 3000\ LB \times 1.25$$

$$= 3750\ LB$$

THIS METHOD FOR DETERMINING MAXIMUM POTENTIAL TRACK TENSION IS USED IN THE ABSENCE OF SPROCKET TORQUE DATA. THE ABOVE CONDITION COULD OCCUR IF THE VEHICLE WEIGHT WERE CONCENTRATED ON ONE TRACK ON A SURFACE WITH AN APPARENT COEFFICIENT OF FRICTION OF 1.25

WORK DONE BY D A YOUNG 5-17-67 REVIEWED BY ______
DATE DATE

7106-0164

CHRYSLER DEFENSE ENGINEERING

SHEET 1 OF 1

DESIGN CALCULATIONS

SUBJECT: BELT SECTION STRENGTH

(a) RATIO OF ULTIMATE BELT STRENGTH TO MAX. OPERATING TENSION

(b) RATIO OF ULTIMATE BELT STRENGTH TO MAX. POTENTIAL TENSION

ULTIMATE BELT STRENGTH = 6000 LB/INCH OF WIDTH

EFFECTIVE BELT WIDTH = 12.00 IN. − 2 X .500 IN. FOR ATTACHMENTS = 11.00 IN

∴ ULTIMATE TENSILE STRENGTH = $11.00\,IN \times 6000\,\frac{LB}{IN} = 66{,}000\,LB$

(a) $\frac{\text{ULT. TENS. STRENGTH}}{\text{MAX. OP. TENSION}} = \frac{66{,}000\,LB}{1200\,LB} = 55.0$

(b) $\frac{\text{ULT. TENS. STRENGTH}}{\text{MAX. POTENT. TENSION}} = \frac{66{,}000\,LB}{3750\,LB} = 17.6$

WORK DONE BY D.A. Young 10-6-67 DATE REVIEWED BY ____________ DATE

7106-0164

CHRYSLER DEFENSE ENGINEERING

SHEET 1 OF 4

DESIGN CALCULATIONS

SUBJECT: WEIGHT AND BUOYANCY ANALYSIS

IN THE FOLLOWING ANALYSIS, THE BASIC TRACK AND ROAD PADS ARE TREATED SEPARATELY. CALCULATIONS ARE FOR ONE PITCH (6 INCHES).

BASIC TRACK

BELT SECTION

$$\text{VOL} = 6 \times 12 \times 3/8 = 27.00 \text{ IN}^3$$

TOOTH SECTION

$$\text{VOL} = \frac{1}{2}\left[(5 \times 3.56) + (4.25 \times .62) + 4\,(4.625 \times 2.09)\right]$$

$$= 29.55 \text{ IN}^3$$

BASIC TRACK VOL./PITCH = 56.55 IN^3 (ALSO EQUALS DISPLACED VOLUME)

WEIGHT/PITCH = $56.55 \text{ IN}^3 \times .0415 \text{ LB/IN}^3 = 2.347 \text{ LB}$

PNEUMATIC PAD

UPPER SECTION

$$\text{VOL} = \left\{5.75 \times 12.00 - \left[1.50^2 - \pi(.75)^2\right]\right\}\frac{5}{32}$$

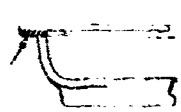
$$= 10.71 \text{ IN}^3 \text{ (MAT'L \& DISPLACED VOL)}$$

LIP BELOW UPPER SECTION

DISP. VOL = 10.71 IN^3, SAME AS ABOVE

$$\text{MAT'L VOL} = 10.71 - \frac{5}{32}\left[\pi(2.375)^2 + (4.75 \times 6.25)\right]$$

$$= 3.30 \text{ IN}^3$$



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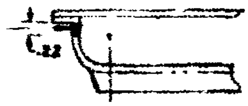
CHRYSLER DEFENSE ENGINEERING

DESIGN CALCULATIONS

SUBJECT:

LIP TO LOCUS OF RADIUS

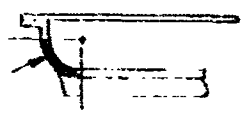


DISP. VOL. = $.22\left[\pi(2.56)^2 + 5.12\times6.25\right]$
$= 11.57 \text{ IN}^3$

MAT'L. VOL. = $11.57 - .22\left[\pi(2.375)^2 + 4.75\times6.25\right]$
$= 1.15 \text{ IN}^3$

RADIUS

BY PAPPUS' THEOREM (5):

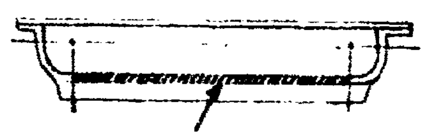


DISP. VOL. = $\frac{\pi}{4}(1.25^2)\times\left[\pi(1.28+.66)+6.25\right]$
$= 15.15 \text{ IN}^3$

MAT'L. VOL. = $15.15 - \frac{\pi}{4}(1.00)^2\times\left[\pi(1.38+.42)+6.25\right] - \left\{1.00(.094)\times\left[2\pi(1.28+.047)+12.50\right]\right\}$
$= 3.82 \text{ IN}^3$

BOTTOM OF AIR CELL TO LOCUS OF RADIUS

DISP VOL = $1.25\left[\pi(1.28^2)+(2.56)(6.25)\right]$
$= 26.40 \text{ IN}^3$



MAT'L. VOL. = 5.29 IN^3

WORK DONE BY D.A.YOUNG 11-7-67 DATE REVIEWED BY ______ DATE

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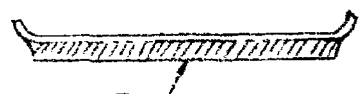
CHRYSLER DEFENSE ENGINEERING

DESIGN CALCULATIONS

SUBJECT:

GROUSER



$$\text{MAT'L \& DISP. VOL} = \frac{5}{8}(32.91) - 11.00\left[\frac{\pi}{4}\left(\frac{1}{8}\right)^2 + \frac{1}{4}\left(\frac{3}{16}\right)\right]$$
$$= 20.55 - .796$$
$$= 19.75 \text{ IN}^3$$

SUMMARY

FOR ONE PITCH:

	DISP. VOL. (IN³)	MAT'L VOL. (IN³)	MAT'L. WT (LB.)	DISP. WT. (LB.)
BELT SECTION	27.00	27.00	1.120	.974
TOOTH SECTION	29.55	29.55	1.225	1.067
PAD	94.29	44.02	1.827	3.404
ATTACHMENTS	——	——	.310	——
STEEL CLIPS	——	——	.430	——
TOTALS			4.912	5.445

WT./FOOT = 4.912 LB x 2 = 9.824 LB/FT

$$\text{PER CENT BUOYANCY} = \frac{5.445}{4.912} \times 100\% = 110.7\%$$

WORK DONE BY D.A.Young 11-7-67 DATE REVIEWED BY ________ DATE

7106-0164

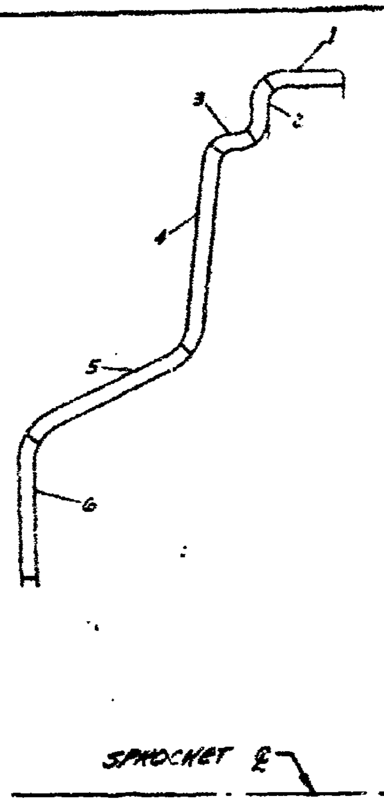
CHRYSLER DEFENSE ENGINEERING

SHEET 4 OF 4

DESIGN CALCULATIONS

SUBJECT: SPROCKET WEIGHT ESTIMATE

VOLUMES



STEEL WHEEL SECTION

BY PAPPUS' THEOREM (5):

(1) $2\pi(9.43)\,.187(1.0) = 11.22$
(2) $2\pi(9.03)\,.187(.85) = 9.13$
(3) $2\pi(8.62)\,.187(.50) = 5.13$
(4) $2\pi(7.10)\,.187(2.85) = 24.08$
(5) $2\pi(5.37)\,.187(2.25)$ 14.40
(6) $2\pi(3.95)\,.187(1.87)$ 8.79

72.75 IN³

LESS CUTOUTS FOR DRIVE PINS:

$$.187\left[\frac{\pi(1.25^2)}{2} + .50(2.50)\right](10) = 6.94\ IN^3$$

LESS OTHER CUTOUTS:

$$.187\left[3.30(1.50) + \pi(.75^2)\right](5) = 6.30\ IN^3$$

VOL OF WHEEL SECTION = 59.5 IN³
2 SECTIONS/SPROCKET = 119.0 IN³

DRIVE PINS

$$10\pi\,(1.25^2 - 1.06^2)\,5.75 \cdot 79.5\ IN^3$$

TOTAL VOL OF SPROCKET = 198.5 IN³

WEIGHT = $198.5\ IN^3 \times .283\ \frac{LB}{IN^3} = 56.2$ LB

WORK DONE BY D.A.YOUNG 11-7-67 DATE REVIEWED BY ________ ________ DATE

7106-0164

CHRYSLER DEFENSE ENGINEERING

SHEET 1 OF 1

DESIGN CALCULATIONS

SUBJECT: CALCULATE LENGTH CHANGE OF BELT DUE TO AMBIENT TEMPERATURE CHANGE

AMBIENT TEMPERATURE RANGE = -65°F TO +125°F

TEMPERATURE DIFFERENTIAL = 190°F

ASSUME TOTAL LENGTH OF TRACK ENVELOPE = 22.5 FT

(6) COEFFICIENT OF THERMAL EXPANSION OF FIBER GLASS = $6 \times 10^{-6} \frac{IN}{IN\ °F}$

SINCE THE FIBER GLASS CORD IS THE MAIN TENSILE MEMBER, THE EFFECT OF THE RUBBER IS NEGLECTED

$$\text{LENGTH CHANGE} = \frac{6 \times 10^{-6}\ IN}{IN\ °F} \times \frac{22.5\ FT}{ENVELOPE} \times \frac{12\ IN}{FT} \times 190°F = 0.3078\ IN$$

$$\text{PER CENT LENGTH CHANGE} = \frac{.3078\ IN.}{270\ IN.} \times 100\% = 0.114\ \%$$

WORK DONE BY D.A. YOUNG 6-7-67 DATE REVIEWED BY ______ ______ DATE

CHRYSLER DEFENSE ENGINEERING

DESIGN CALCULATIONS

SUBJECT: ROAD PAD INFLATION PRESSURE

AVERAGE STATIC ROADWHEEL LOAD = $\frac{3000\ LB}{8\ WHEELS}$ = 375 LB

GROUSER CONTACT AREA = 32.9 IN^2

GROUND PRESSURE ON GROUSER = $\frac{375\ LB}{32.9\ IN^2}$ = 11.4 PSI

INFLATION PRESSURE = 11.4 PSI

AVERAGE PRESSURE ON ALL GROUSERS = $\frac{\text{GROSS VEHICLE WT}}{\text{TOTAL AREA OF GROUSERS ON GROUND}}$

NUMBER OF GROUSERS ON GROUND = $\frac{\text{WHEELBASE} \times 2}{\text{PITCH}}$ = $\frac{140}{6}$ = 23.33

TOTAL AREA OF CONTACT = $\frac{32.9\ IN^2}{\text{GROUSER}} \times 23.33$ = 768 IN^2

AVERAGE PRESSURE = $\frac{3000\ LB}{768\ IN^2}$ = 3.91 PSI

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LIGHTWEIGHT, HIGH MOBILITY TRACK

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report

5. AUTHOR(S) (First name, middle initial, last name)

David A. Young
Defense Operations Division
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	U.S. Army Tank-Automotive Command Track, Research & Engineering Section Warren, Michigan 48090

13. ABSTRACT

This report presents Chrysler's concept feasibility study of the Lightweight High Mobility Track, performed under Contract DAAE07-67-C-3847, effective 10 May 1967. The subject track consists of a fiber glass reinforced belt with guide tooth projections on its inside surface and pneumatic pads on its outside surface. This particular track was intended for use on a vehicle with a gross weight of 3000 pounds. The resultant concept is 12 inches wide, weighs 9.83 pounds per foot, and is 110.7 percent buoyant. In addition, the inherent advantages of the design include a smooth roadwheel path, the ability to absorb road shocks, quiet operation, and expected long life.

The concept was analyzed from a number of standpoints including weight, buoyancy, tensile strength, and feasibility of manufacture. It was concluded that the concept is feasible and that it would be applicable to lightweight cargo and reconnaissance vehicles. Recommendations for future activity on this project are also presented.

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Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Milita[illegible] [illegible]spension Systems-Tracks						
Lightweigh[illegible] [illegible]nt, All-Rubber Track						
Pneumatic Road Pads						
Fiber glass Cable Cords						

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Pneumatic Road Pads						
Fiber glass Cable Cords						