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ATV Flotation Tires

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THE PURPOSE OF THIS PAPER is to discuss flotation tires for all-terrain vehicles (ATV), including the history, development, performance, design, and trends for the future of this specialized line of tires. Current vehicle applications and their success have established flotation tires as a permanent new line of tires throughout the industry.

PRESENT ATV MARKET

People are constantly looking for something new and different in entertainment. With the rapid increase in population, especially in and around the metropolitan areas, causing congestion of highways, parks, and other long established sources of recreation, the ATV has offered something new and exciting in exploring remote wilderness areas and thrills of riding over rough unimproved fields and trails (Fig. 1).

The ATV fills a requirement also for the military where special circumstances and terrain require the maximum in mobility to transport personnel and supplies to remote areas (Fig. 2).

Commercial needs in construction and maintenance of power lines, gas pipe lines, and exploration for new oil fields have made use of the ATV equipped with flotation tires (Fig. 3).

In each application and type vehicle, the primary requirement has been for flotation tires to provide the ultimate in off-the-road mobility over all types of terrain (Fig. 4).

HISTORY OF FLOTATION TIRES

Interest in an extra wide, low inflation pressure flotation tire increased when, in 1951, William Albee of California became interested in developing a tire similar to the inflated seal-skin bladder used by Eskimos to roll their heavy boats over rough ground. These primitive pneumatic rollers supported the load and conformed to ground irregularities, providing a rolling pillow that reduced the effort of moving boats over rocks and snow covered beaches (Fig. 5).

The initial tire design consisted of lightweight square woven rubberized fabric tied into a small bead which clamped onto a steel axle (Fig. 6). The tire was held underneath the vehicle by means of a yoke and was loaded and powered through a roller on top of the tire.

Several test vehicles were built for the purpose of demonstrating the capabilities of flotation tires over various types of ground conditions and for testing the durability of the tires (Fig. 7). In 1953 the military converted several trucks to ultrawide flexible flotation tires and conducted extensive tests to evaluate tire performance over all types of ground conditions. Included were areas of Greenland on snow and ice. Later the suspension system was modified to the conventional axle drive and axle loaded (Fig. 8). The design of the axle suspension was simplified and power loss was reduced by direct drive to the axles. This was the beginning of the present ATV flotation tire.

ABSTRACT

Flotation tires on all-terrain vehicles (ATV) are an essential component for good, overall off-the-road mobility. Water displacement by the large volume tires provide additional buoyancy for amphibious vehicles. The large contact area of the

deflected tire provides low ground pressure for flotation on soft ground. ATV tires are a special breed of tires with design features for better mobility such as carcass flexibility, wide tire section, and special tread design.



Fig. 1 - Ruppster car—recreation

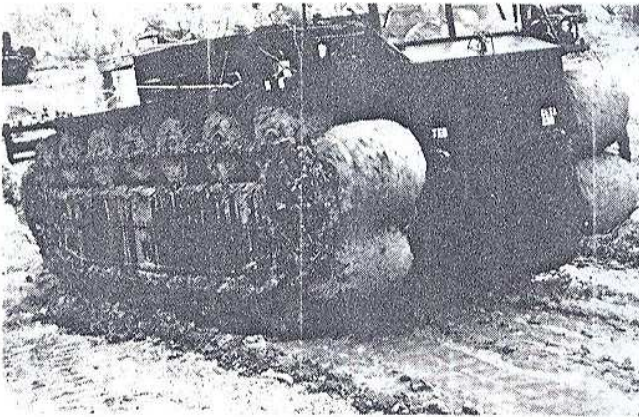


Fig. 2 - Marginal terrain vehicle (experimental)

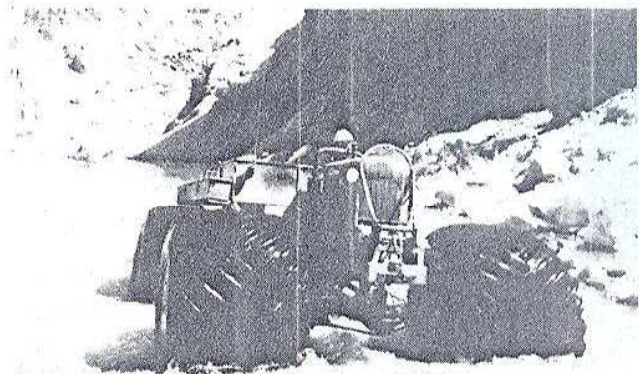


Fig. 3 - Swamp buggy exploration

Tire configuration was changed from the extra wide flotation tire that was clamped to the axle and the tire width was greater than the overall diameter, to a tire section width equal to or slightly less than the overall tire diameter. The tire bead diameter was also increased to fit standard rims and to allow producing tires on current manufacturing equipment.

PRESENT FLOTATION TIRE DESIGN

There are presently three basic tire constructions available to cover the various vehicle applications and types of service.



Fig. 4 - Log skidding tractor

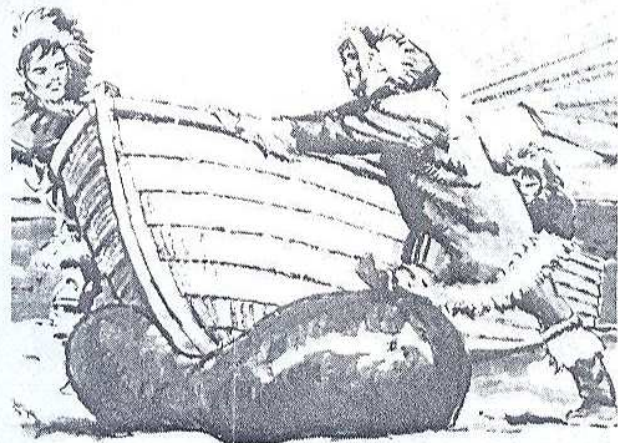


Fig. 5 - Artist sketch of Eskimo use of bladder tire

1. All rubber tire (no fabric plies) which is cured directly to the wheel. Maximum inflation pressure is 5 psi, overall tire diameter is 20 in and width is 12 in (Fig. 9).

2. Minimum bias ply fabric construction designed for rated inflation pressure of 5 psi. The tire size is approximately the same as the all rubber described above (Fig. 10).

3. All other ATV tires are of the conventional bias cord fabric construction and range from 2-12 ply rating. Beads are designed to fit standard size and type rims. Available tread designs cover the complete range of tread types needed for good tire performance over unimproved surfaces. Tread designs range from smooth and minimum tread voids for reduced tire imprints on golf greens, to directional heavy lug tread for traction in mud (Fig. 11).

The tire size designation of flotation tires differs from the conventional tires by describing the complete nominal dimensions of the tire. The numbers are in order of tire diameter,

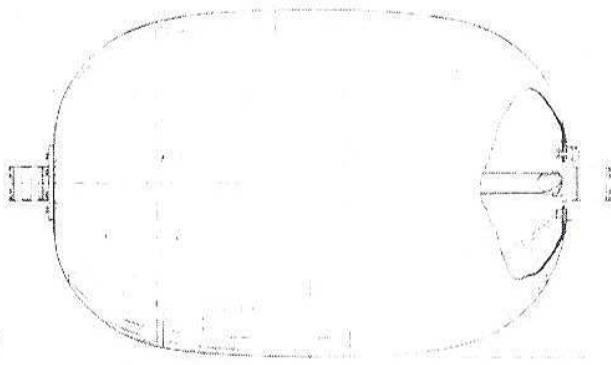


Fig. 6 - Sketch of first bladder tire (flexible flotation cylinder and driving roller (42 in in diameter, 60 in wide)

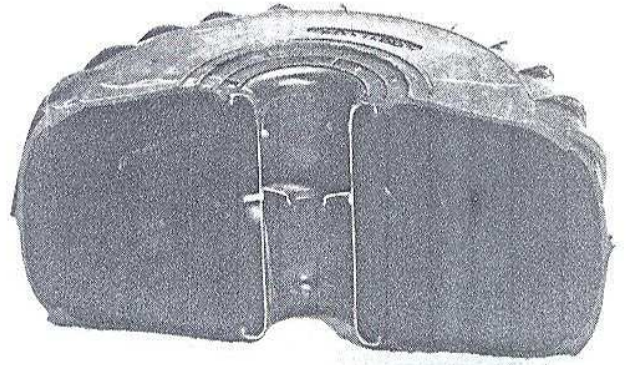


Fig. 9 - Section of an all-rubber tire



Fig. 7 - Experimental rolligon truck



Fig. 10 - Extra low pressure tire

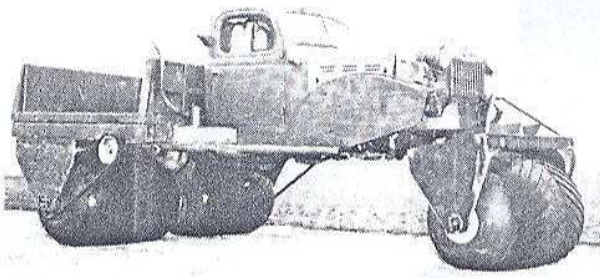


Fig. 8 - Experimental truck with bladder tire converted to axle drive

Fig. 11 - Composite photo of flotation tire tread designs (from left to right—rib, super terra grip, rawhide, xtra traction, power rib, and compass)



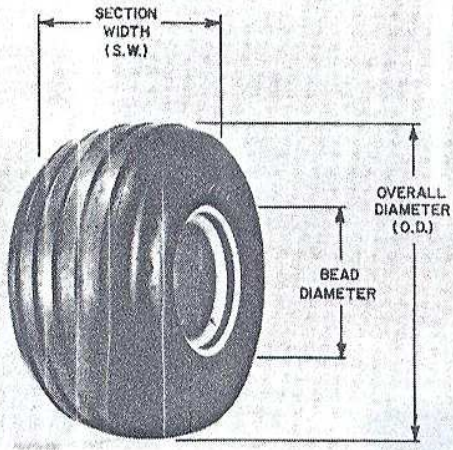


Fig. 12 - Sketch of tire size designation—example size: 18 x 9.50-8; OD-18 in, S.W.-9.50 in, and bead diameter-8 in

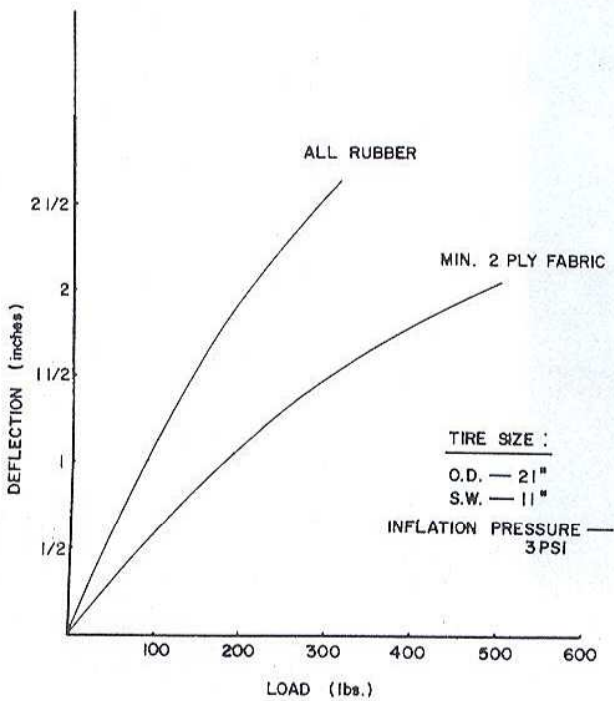


Fig. 13 - Graph of tire load deflection

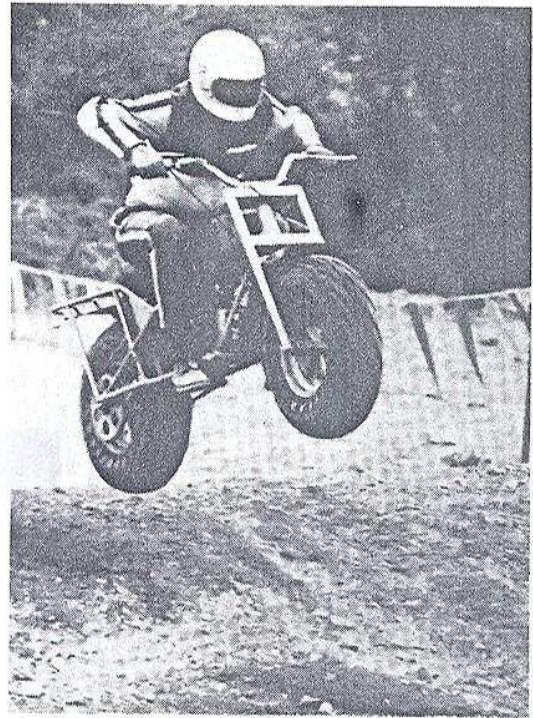


Fig. 14 - Motorcycle—two tires



Fig. 15 - Tricart—three tires

section width, and bead diameter. For example, the popular 18 x 9.50-8 golf car tire has an overall diameter of 18 in, section width of 9.50 in, and bead diameter of 8 in (Fig. 12).

CHARACTERISTICS OF FLOTATION

The better performance of the flotation tire over conventional size tires is accomplished by a wider tire section, more flexible tire carcass, and lower inflation pressure. These factors all contribute to a larger tire-to-ground contact area of the deflected tire. The pressure exerted by the tire on the ground is determined by:



Fig. 16 - Elevated suspension—four tires

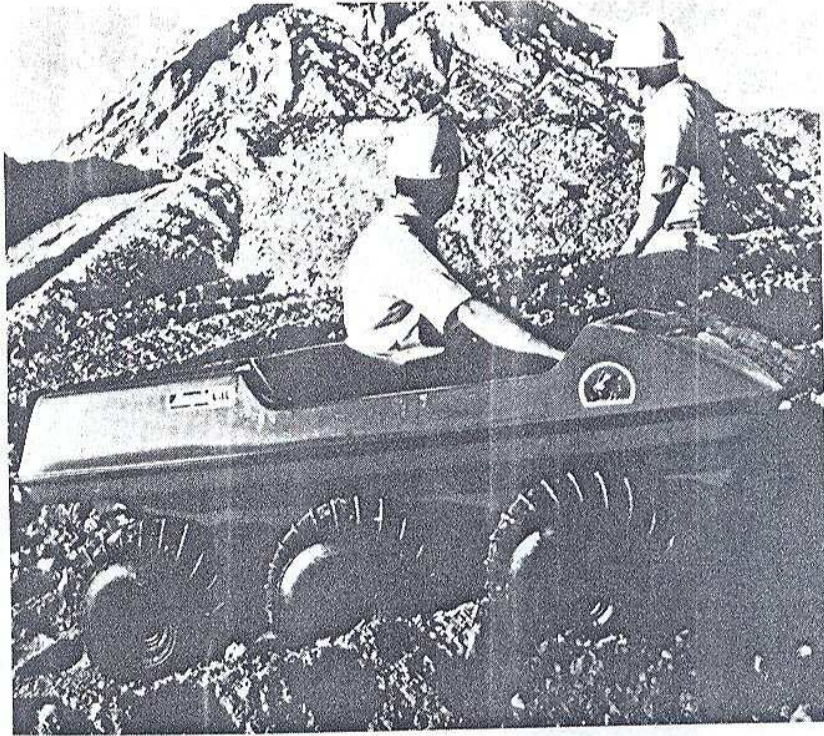


Fig. 17 - Amphi-Cat—six tires



Fig. 18 - Test rig—eight tires

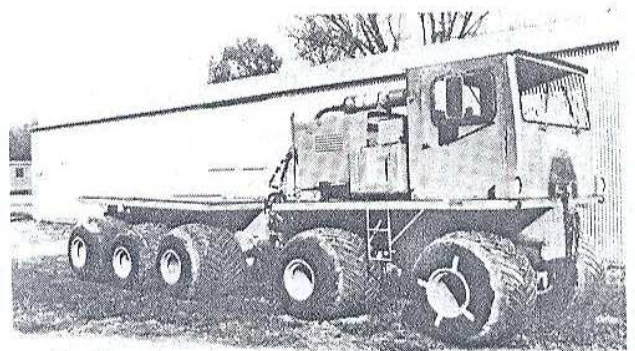


Fig. 19 - Test rig—10 tires

$$\text{Unit ground pressure} = \frac{\text{tire load}}{\text{tire contact area}}$$

which is an average and does not consider the rigidity of the tire carcass. Low unit ground pressure results in less tire penetration on soft soils, thus reducing tire rolling resistance and improving overall mobility. A rule of thumb sometimes used to determine ground pressure is the tire inflation pressure roughly equals the unit ground pressure.

The above features of flotation tires also provide improved object enveloping characteristics which improves mobility, riding comfort, and reduces power loss over rough ground.

Increasing tire width to improve flotation is not always the most effective method for improving overall mobility. Considering an increase of tire width and tire diameter equivalent in added contact area, the larger diameter tire will have the following additional advantages.

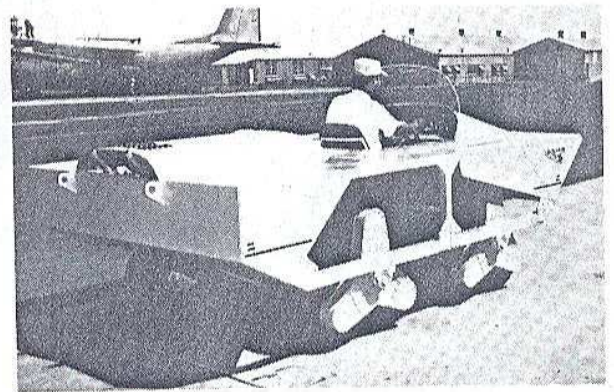


Fig. 20 - Terra-Star—12 tires

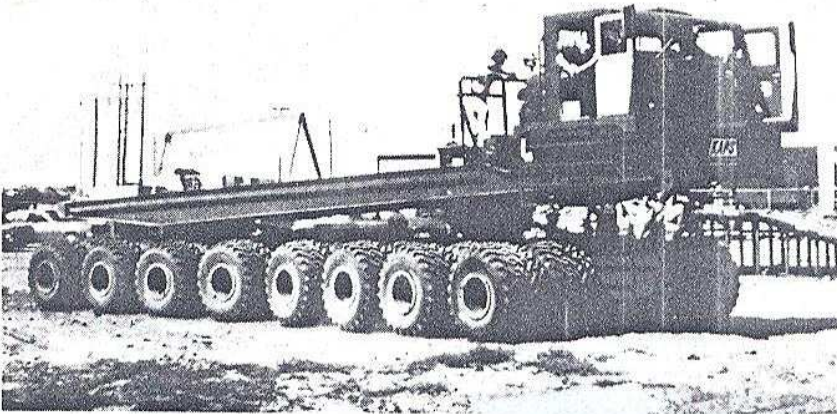


Fig. 21 - Flextrac Nodwell Model 600TT truck - 32 tires

1. Reduced rolling resistance over irregular ground and obstacles.

2. Increased vehicle ground clearance for improved vehicle mobility.

Track suspension on all-terrain vehicles has been very effective in providing low unit ground pressure and good performance over soft ground. The ability of the track to lay down its own road surface makes the track superior to tires on ground conditions of deep loose snow and cohesive mud. However, several disadvantages limit the use of tracks for many applications:

1. Complicated design of suspension and drive.
2. High initial cost.
3. Relatively low track life.
4. High replacement cost.
5. Limited road speed and distance.

For normal off-the-road service and at a maximum speed of 10 mph, deflection of flotation tires ranges from 20-30% of the tire section height, which is measured from the rim flange to the inflated overall tire diameter. A typical static load deflection chart is shown in Fig. 13 where load versus tire deflection is plotted for two tires of the same size but of different constructions. Spring rate is obtained from the area under the curve at any combination of load and inches of tire deflection.

TRACTION REQUIREMENTS

Tread patterns are often designed specifically for the vehicle and type of service to obtain the best performance. Operation on sand and golf courses require a minimum tread depth and tread grooves for best traction and minimum damage to the turf. For farm tractor service, log skidder tractors, and all purpose off-the-road vehicles a deep aggressive tread is required for good traction and self-cleaning when operating in soft mud.

Tractive effort or more specifically the coefficient of traction of a vehicle has been defined as the ratio of maximum drawbar pull exerted by a vehicle to the weight on the drive axle. There are many factors which determine or govern the value of tractive coefficient such as type surface, tire size, in-

Table 1 - Range of Tractive Coefficients on Various Surfaces

Surface	Tractive Coefficient
Concrete	0.65-0.75
Asphalt (old)	0.60-0.70
Hard gravel road	0.50-0.60
Firm soil	0.55-0.65
Loose soil	0.55-0.65
Sand	0.20-0.35
Mud	0.15-0.40
Ice and packed snow	0.08-0.20

flation pressure, tread design, and weight transfer to the drive axle.

Not considering the many variables that exist between different types of vehicles and not including the weight transfer to the drive axle, the drawbar pull (DBP) can be approximated by:

$$\text{DBP} = \text{static load on drive axle} \times \text{tractive coefficient}$$

Table 1 is a range of tractive coefficients on various surfaces obtained by actual dynamometer tests and measured at 100% tire slip.

ATV DESIGN FEATURES

In the past 15 years of ATV development almost every conceivable design of vehicle has been tried, each attempting to design for maximum mobility over all types of terrain and ground conditions. Suspension systems and number of drive axles have ranged from the two wheel lightweight motorcycle concept to the multiwheel articulated vehicle capable of carrying heavy loads over relatively soft ground at inflation pressures under 5 psi.

Examples of a few of these unique vehicle designs are shown in Figs. 14-21.

FUTURE ATV TIRE DESIGN

The radial tire construction now available in many earth-mover, truck, and passenger tire sizes has several features that are desirable for flotation tire applications for improving mobility. These are:

1. Increased tire deflection for additional ground contact area.
2. Reduced distortion of the deflected tread surface for improved traction and reduced damage to surface vegetation. Width of flotation tires will continue to increase to provide even greater flotation for reduced soil compaction, reduced rutting of ground surface, and increased overall vehicle performance.

The trend of ATV design in the category of fun vehicles in recent years has been for vehicles of lighter weight with 2-, 3-, and 4-wheel suspension. The reasons for this change are considered to be lower cost, lighter weight, simplicity of design, and ease of transport. The illustrations show several of these vehicles now on the market.

SUMMARY

The ATV flotation tire concept, started in 1951, has progressed from a simple bladder type tire to tires of numerous sizes and tread designs for many vehicle applications. Special vehicles have been designed and built for the purpose of achieving maximum mobility over the most adverse off-the-road conditions.

Presently flotation tires are produced in three different constructions. An all-rubber pneumatic tire and minimum bias ply tire which operate at a maximum of 5 psi and available only in 20 in overall diameter by 12 in wide. All other tires are bias cord construction and available in a complete range of sizes and in 2-12 ply rating. Radial construction may be added in the future for increased tire contact area and lower ground pressure.

Flotation tires are now firmly established in the industry as a special line of tires for applications where improved mobility and lower ground pressures are required. New developments are expected, especially in recreation and agriculture applications, to further the use of flotation tires.



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