TERRA TIRES

F.S. D'Avello*

1. FUNDAMENTAL PRINCIPLE

The basic principle of the Terra-Tire is high flotation, which is possible due to low inflation pressures achieved through wide flexible cross sections and small bead diameters. The section widths of several Terra-Tire sizes are equal to the outside diameter of this tire. The bead diameters are sometimes as small as 6 inches. The large cross section of the tires combined with relatively small bead diameters result in very large air volumes.

Due to these characteristics, the Terra-Tire equipped vehicle is capable of traversing terrain impassable to conventional tire equipped vehicles. The very low inflation pressure and subsequent low ground bearing pressure enable the Terra-Tire to literally float over marshy terrain as well as sand and snow. The low inflation pressure and the flexible carcass allow the Terra-Tire to envelop large objects such as boulders, tree trunks, stumps, etc, which often immobilize vehicles equipped with conventional tires.

In addition to increased mobility, the Terra-Tire has lowered the rolling resistance, increased effective drawbar pull, and improved maneuvering and tracking characteristics in some vehicle modifications. Due to these improvements, plus more dependable performance in off-the-road operations and better riding characteristics, Terra-Tires have reduced driver fatigue.

2. HISTORY

The Terra-Tire was developed to fill the need of improved off-the-road mobility, which requires increased tire flotation and traction.

The 42x40-10-Terra-Tire was designed and developed specifically for the ground support vehicles in the Matador Missile Program.

The Air Force desired a high mobility vehicle capable of transporting the Matador Missile and ground handling equipment over all types of terrain as well as paved roads at moderate speeds. Such a transporter would simplify the dispersing of tactical missiles to the desired firing position. Through the combined efforts of The Goodyear Tire and Rubber Company and Goodyear Aerospace Corporation, a model of the MM-1 Transporter was developed. The model was presented to the Air Force. The utilization of Terra-Tires was a deciding factor in the awarding of the transporter contract to Goodyear Aerospace Corporation.

Once the contract was awarded, work began on developing the Terra-Tire to carry the specified load over all types of terrain.

3. CONSTRUCTION

Terra-Tires are similar in construction to conventional tires. All Terra-Tires are of a tubeless construction with air retaining rubber inner liners. The Terra-Tires are of 3-T nylon cord construction for the greatest resistance to fatigue and heat build-up which are inherent deterents due to the low inflation pressure and subsequent high deflection necessary for optimum mobility in Terra-Tire applications.

* *Goodyear Tire & Rubber Co., Arkon, Ohio, U.S.A.*

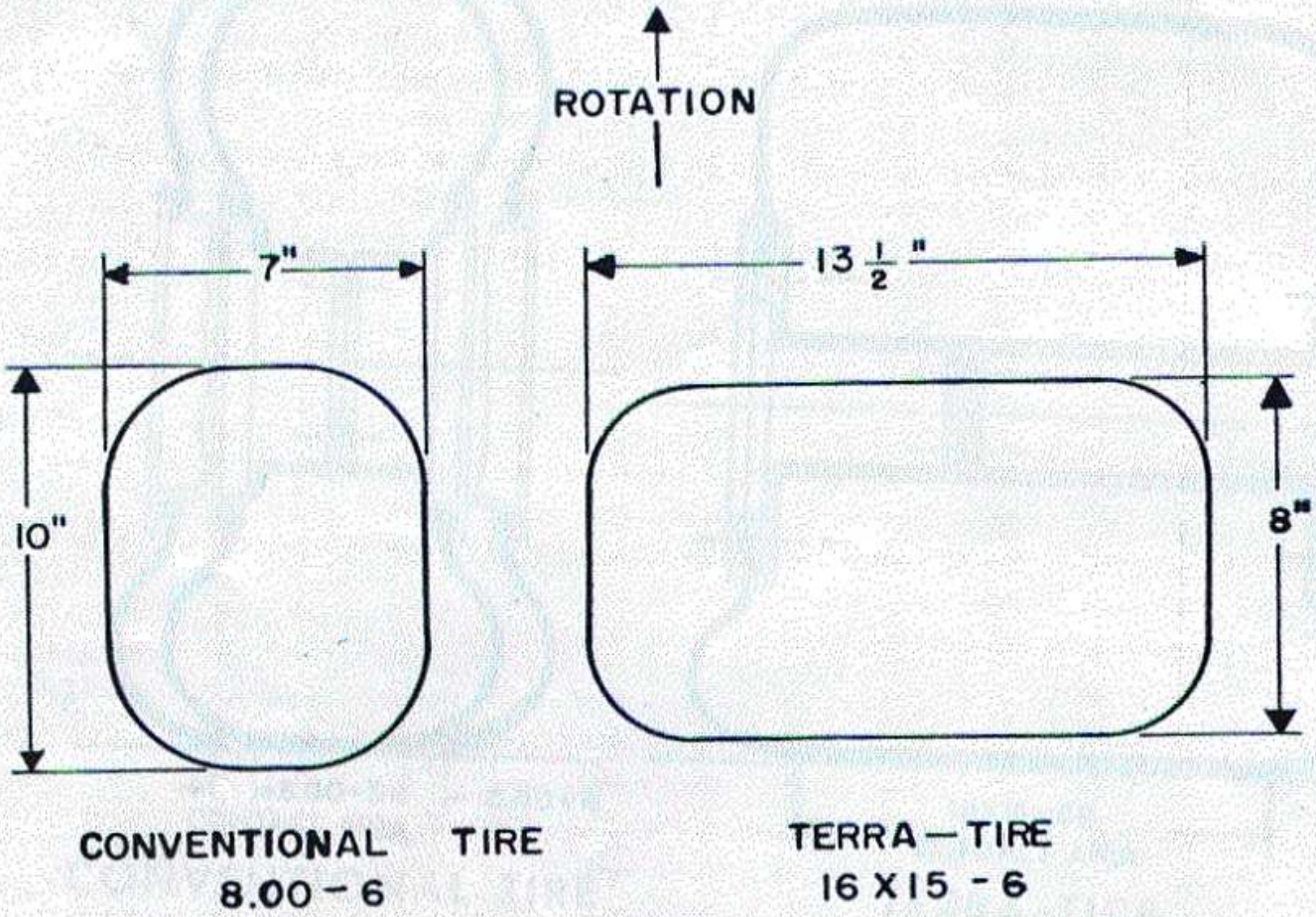

Fig. 1 Sketch of contact areas

Nylon cord fabric was selected for its ability to withstand the bruising blows, and flexures encountered when enveloping objects in off-the-road maneuvers. The high strength and resilience of nylon cord made it ideal for the Terra-Tire. The high resilience of the nylon cord provides great resistance to bruise and abrasion as well as the ability to flex and absorb the most punishing blows to the tire over any type of terrain.

Another advantage of nylon cord is the fact that it does not absorb moisture. Deterioration of the carcass due to moisture damage, if exposed to water, is eliminated. Cuts in the tire exposing nylon cord carcass can be effectively repaired. High resistance to heat, moisture, bruises, and flex - fatigue results in longer tire life.

The excessive working of the carcass due to high deflection necessitates the incorporation of the best available rubber in the tread and sidewall compounds for the Terra-Tire constructions. This high quality rubber results in improved tire flexibility, wear resistance, and extended tire life in off-the-road operations.

4. CONTACT AREA

Contact areas of conventional tires are normally of an elliptical shape with the major axis parallel to the tire track.

Terra-Tire contact areas are also of an elliptical shape, with the major axis perpendicular to the tire track.

For a comparison note the contact areas of the 16x15-6 Terra-Tire and a comparable diameter 8.00-6 standard tire shown in Figure 1.

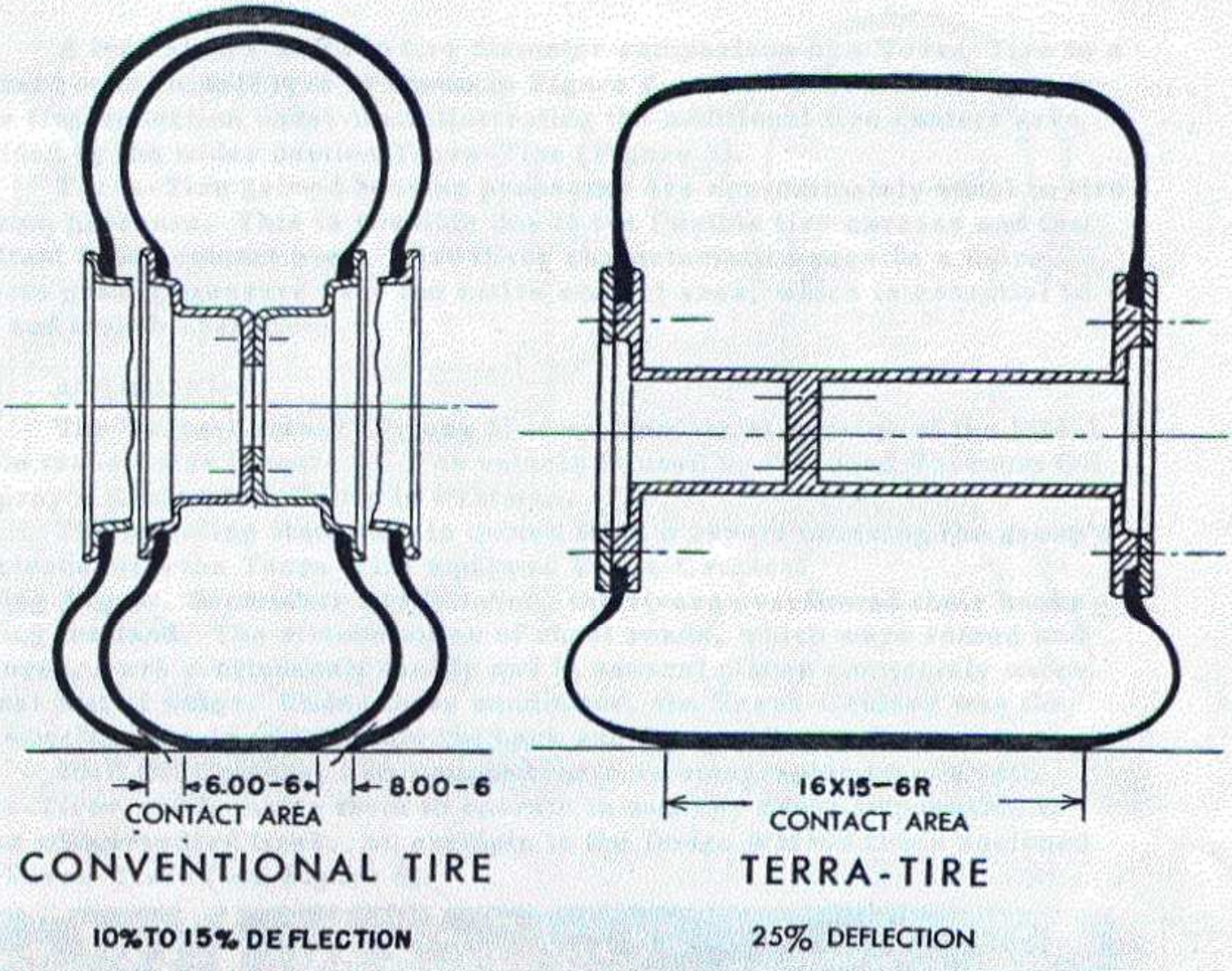

Fig. 2 Comparison of loaded cross-sections

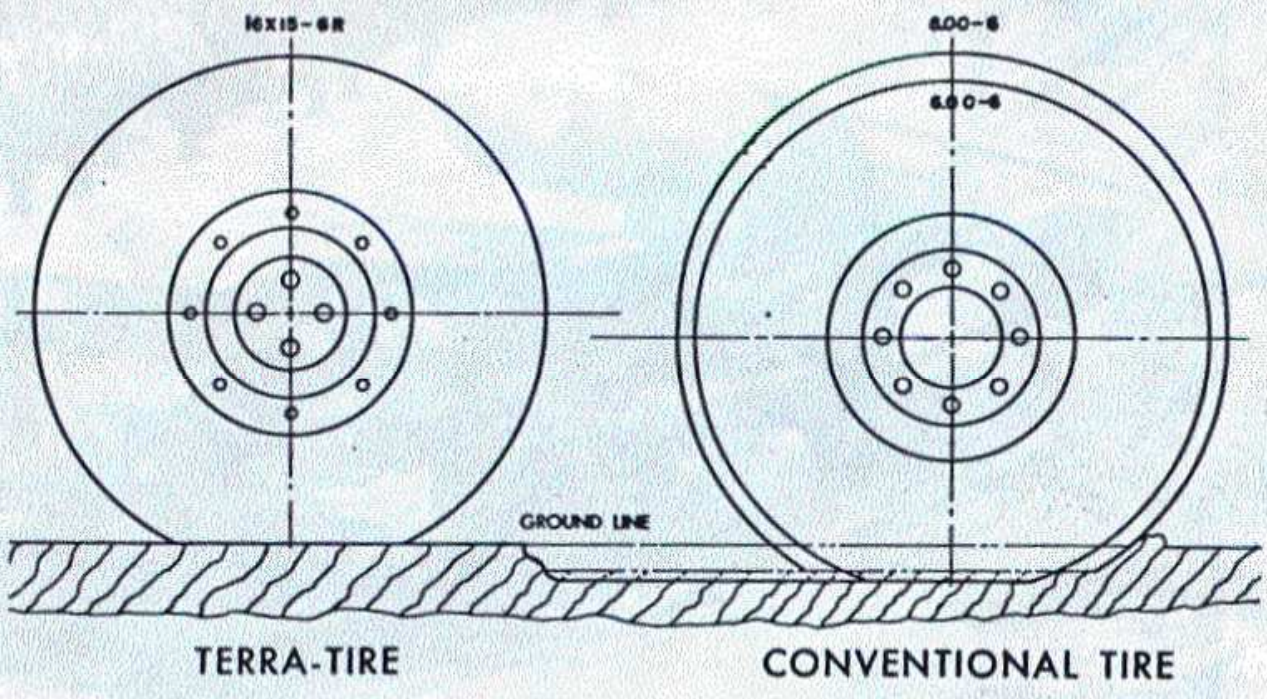

Fig. 3 Comparison of penetration differences

A typical tire width to tire diameter comparison of a Terra-Tire to a standard conventional tyre is shown in Figure 2. Also shown is the approximate tire deflection under load illustrating the additional tire contact area provided by the wider section Terra-Tire (Figure 3).

Terra-Tire ground bearing pressures are approximately equal to tire inflation pressure. This is possible due to the flexible tire carcass and the resultant broad contact area. Also these characteristics provide a more uniform ground pressure over the entire contact area, which is essential in sand and marsh operations.

5. APPLICATIONS

The Terra-Cruiser (Figure 5) is a commercial version of the MM-1 missle transporter (Figure 4). The vehicle is used by Standard Vaccuum Oil Company's Exploration Group in Pakistan.

The following statement is quoted from a report covering the group's experience with the Terra-Tire equipped Terra-Cruiser:
"During August, September and October, the rivers overflowed their banks flooding the land. The sixteen miles of rural roads, which were raised and improved, were continuously muddy and in several places completely under several feet of water. Under these conditions, the Terra-Cruiser was the only wheeled vehicle which could get back and forth to Bogra."

Shell Oil Company had equipped their seismographic trucks with Terra-Tires which enable them to operate in swampy areas impassable to trucks with standard tires. An example is the Dodge WM300 truck equipped with Terra-Tires (see Figure 6).

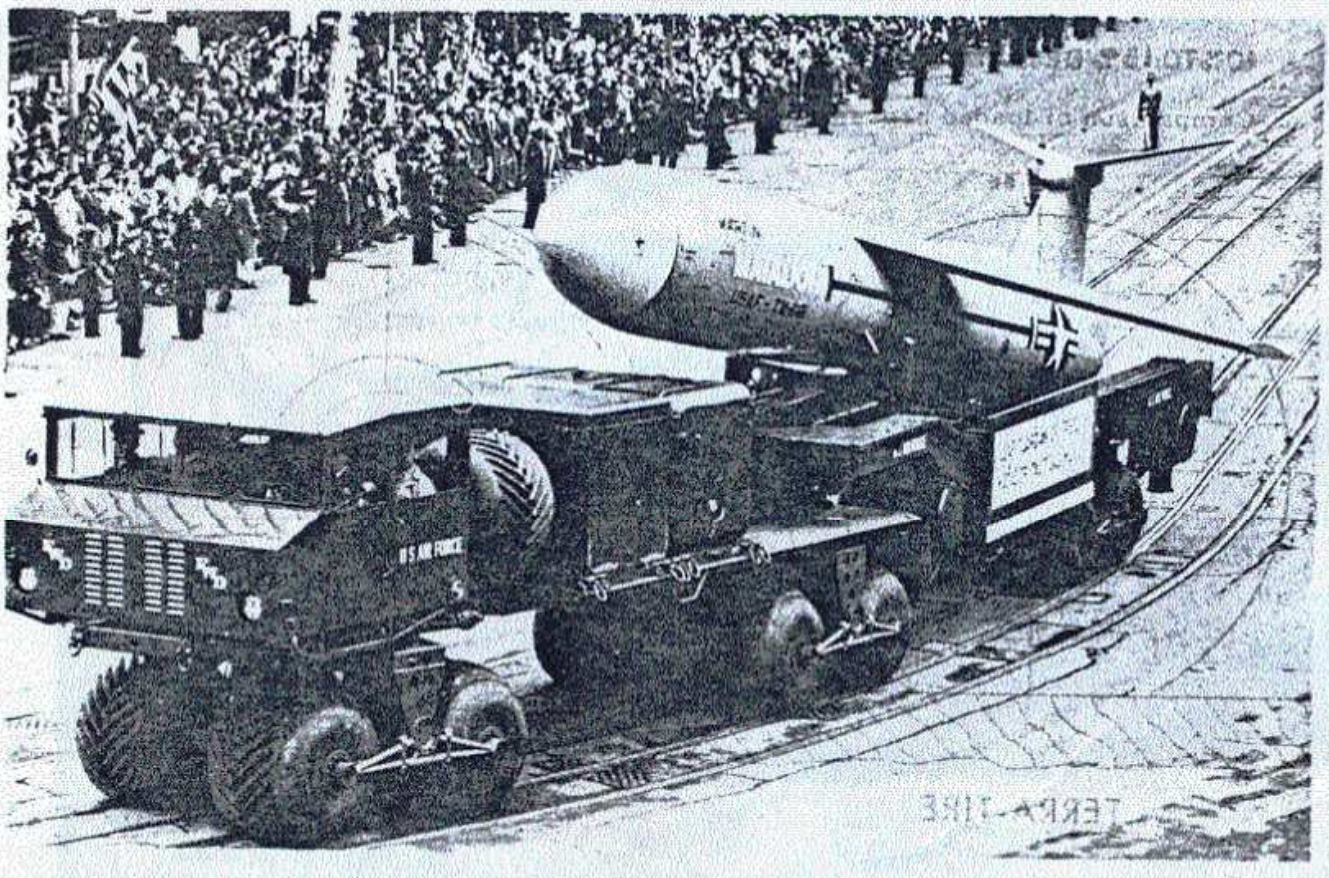

Fig. 4 MM-1 Missile Carrier with 42 x 40 -ION Terra-Tires

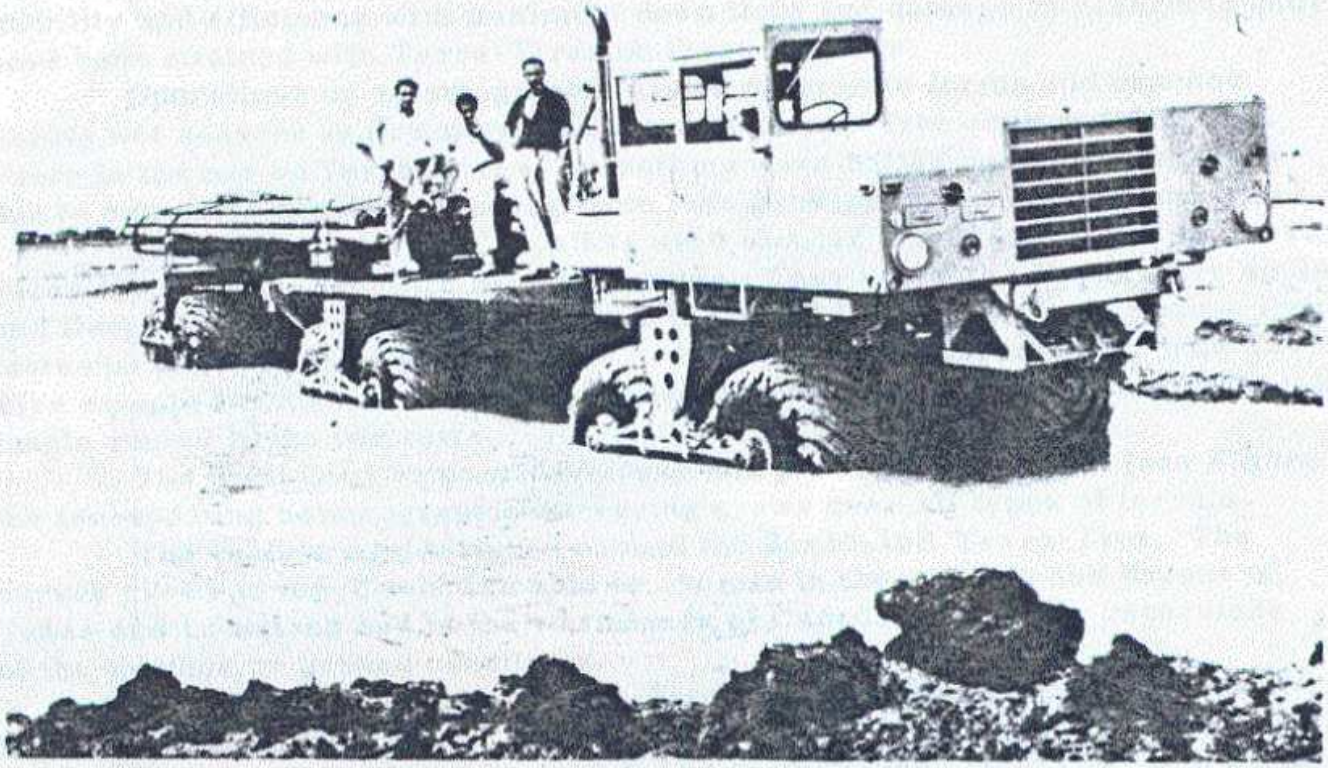

Fig. 5 Terra-Cruiser with 42 x 40 -ION Terra-Tires

Fig. 6 Dodge WM 300 fitted with 46 x 18 -16 and 46 x 24 -16 Terra-Tires

The drill trucks, explosive trucks, and trucks carrying the sensitive electronic recording instruments are all equipped with Terra-Tires. Maximum mobility and efficiency with minimum down time and damage to recording gear have been attained with Terra-Tires on these vehicles.

Operations by seismographic crews on private farms and ranches during wet seasons is now permissable with Terra-Tire equipped vehicles. Prior to the use of Terra-Tires, operations were halted during wet seasons due to extensive erosion resulting from ruts produced by standard truck tires.

The Transportation Corps has used similar trucks converted to Terra-Tires for effective mobility demonstrations. They evaluated Terra-Tire equipped Dodge WM300's in the Swamp Fox I tests and Dodge W300's in Swamp Fox II tests conducted in the Panama jungle in 1961 and 1962 respectively. The Terra-Tire equipped trucks were the only wheeled vehicle to completely negotiate the jungle routes in the two tests.

The Shell Oil Company developed and produced the 'Crab' (see Figure 7) for transporting seismographic surveying crews over all types of terrain.

The vehicle was designed around the 46x30-16R Terra-Tire. The survey crews in the 'Crab' are able to operate in the swamps and bayous of Texas and Louisiana and in the wastelands of Canada and Alaska regardless of the weather or ground conditions.

A tractor converted to Terra-Tires for maintenance of recreation beaches is shown in Figure 8. Prior to Terra-Tires it was not possible to mechanically comb this beach area. It had to be cleaned manually, which was expensive and inefficient.

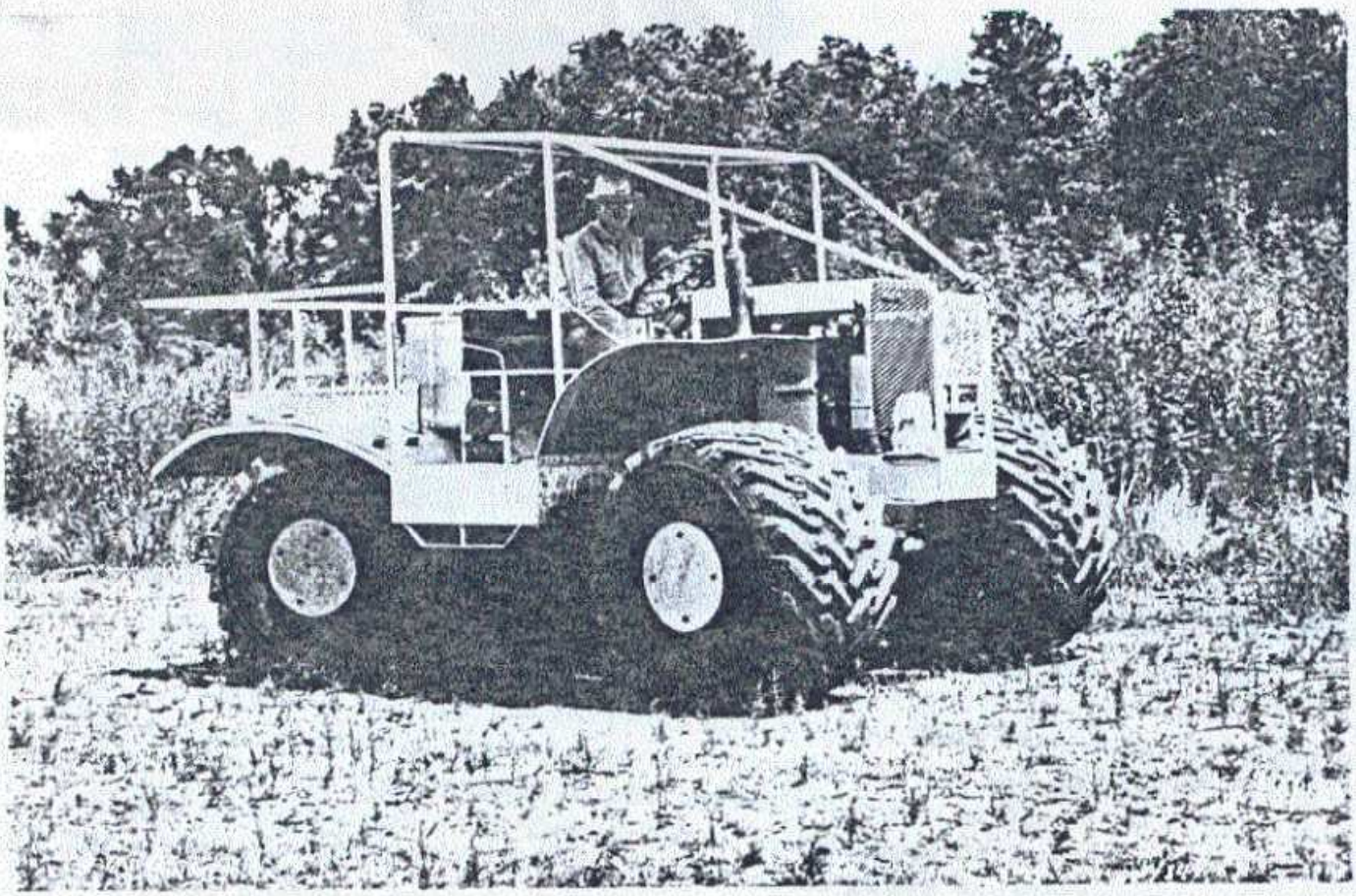

Fig. 7 Shell Oil Co. 'CRAB' on 46 x 30-16 Terra-Tires

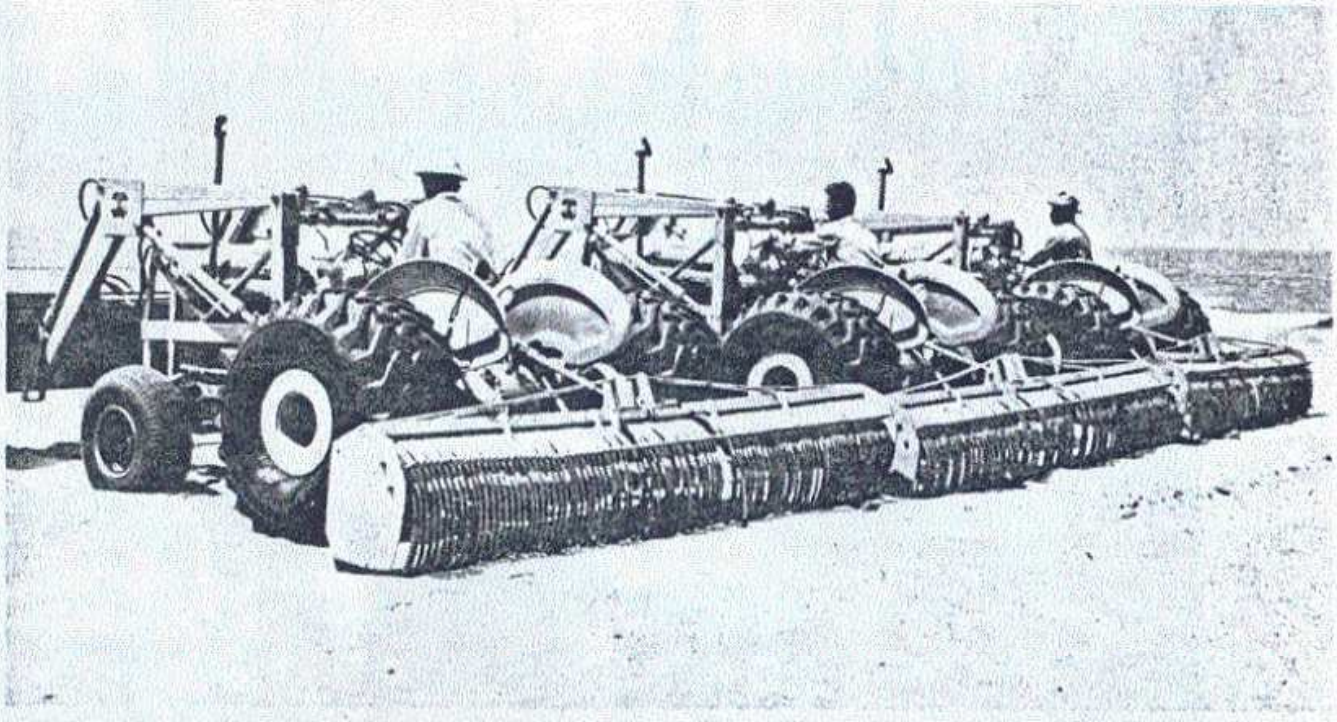

Fig. 8 Beach-cleaning tractors with 46 x 24-16 Terra Tires

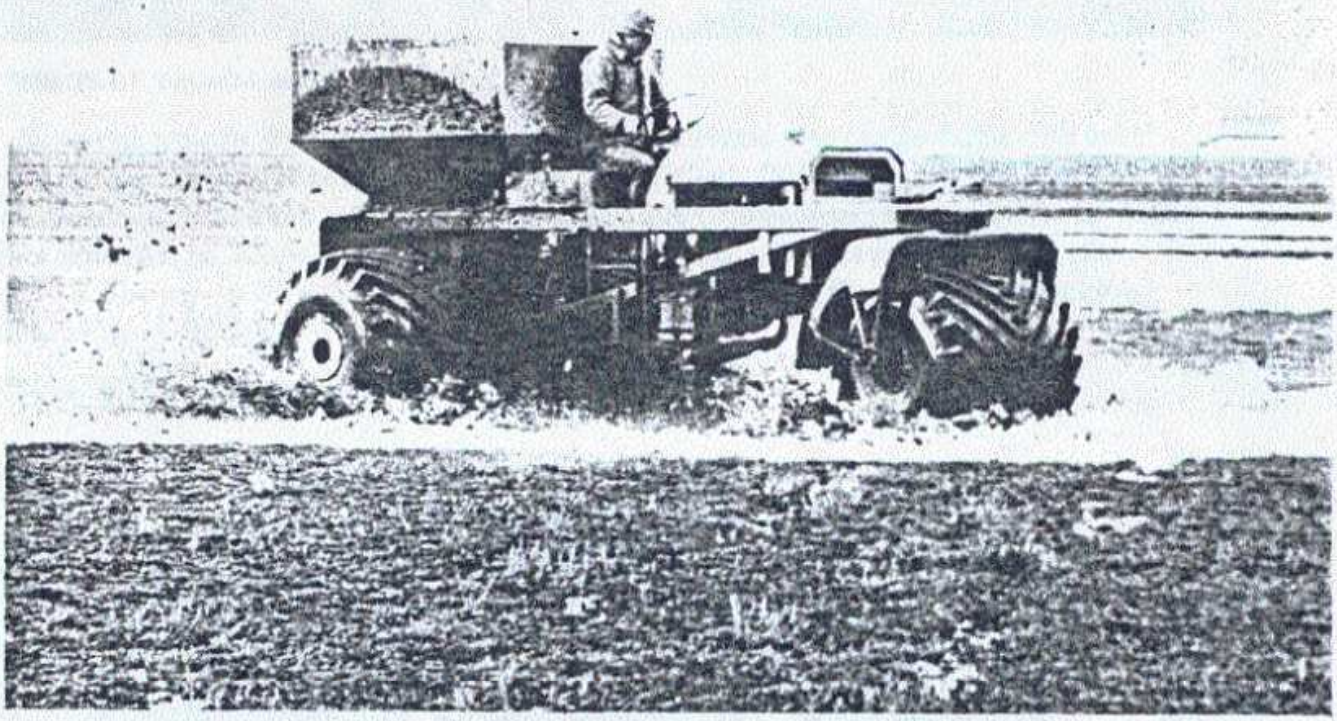

Fig. 9 A Fertilizer spreader fitted with 60 x 42-18R and 42 x 40-ION Terra-Tires

Similar tractor conversions are used at race tracks for leveling muddy tracks, consequently minimizing rut hazards for horses and jockeys.

The agricultural fertilizer spreader shown in Figure 9 is the latest vehicle designed around a Terra-Tire. In this application, there was a need for a vehicle capable of moving into fields of grass seedlings and spreading fertilizer during a period of the rainy season when fertilizing is most effective. Considerable increase in crop yield has been realized by this Terra-Tire application.

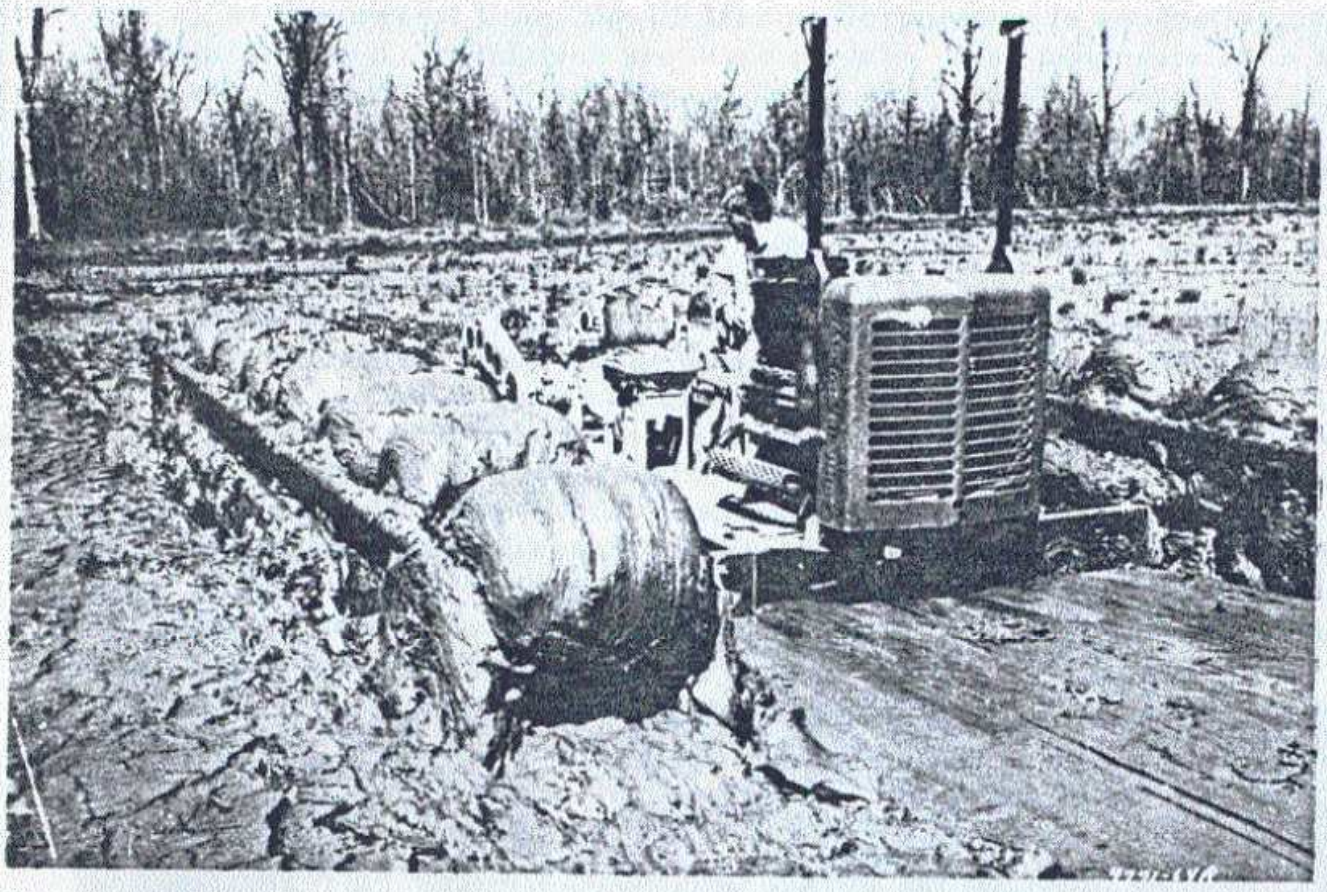

Fig. 10 'AIROLL' Vehicle on 24 x 24-6N Terra-Tires

Several years ago Borg Warner Corporation developed the 'Airoll' vehicle utilizing Terra-Tires on a track principle. (See Figure 10). After extensive evaluation tests, followed by a product development contract, the Airoll has proved to have outstanding flotation and mobility features. For example, as shown in Figure 10, the Airoll is literally floating and driving through thick gumbo type mud.

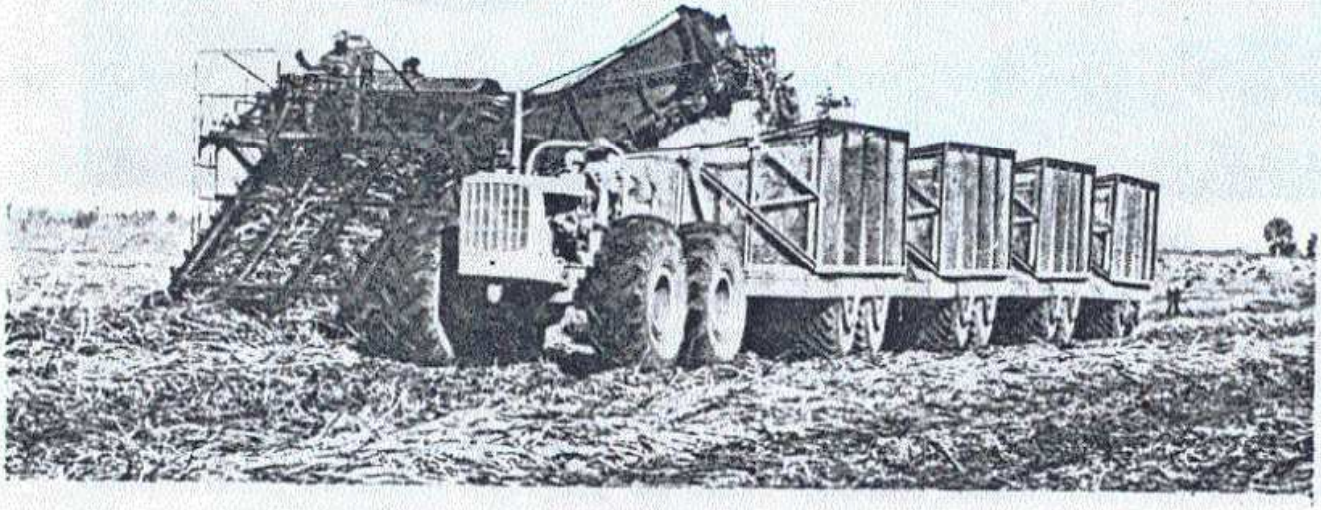

Fig. 11 Sugar cane trailers fitted with 42 x 40-ION Terra-Tires

At the present time, the US Marine Corporation is conducting evaluation and durability tests on thirteen prototype models. Also proposals for a smaller, lower silhouette vehicle with the same Terra-Tire and track-chain principle have been considered for future testing and evaluation.

In sugar cane harvest operations soil conditions in the fields require a tire with large contact area and low ground bearing pressure. The mechanized operations in cane harvesting involves cutting the cane stocks, loading them into trailers with conveyor loaders, and towing the loaded trailers across the fields to the processing plant. The use of Terra-Tires (Figure 11) has resulted in harvest operations under wet as well as dry soil conditions and without forming deep ruts as experienced with conventional tires.

United Fruit Corporation has applied Terra-Tires on trailers and tractors (Figure 12) used for transporting bananas from the fields to loading platforms and processing points. Previously, trailers equipped with conventional tires were used and considerable bruise damage to the bananas resulted from bouncing due to riding on the high pressure tires over rough unimproved roads. Spoilage from bruise damage was substantially reduced with the use of Terra-Tires on their equipment.

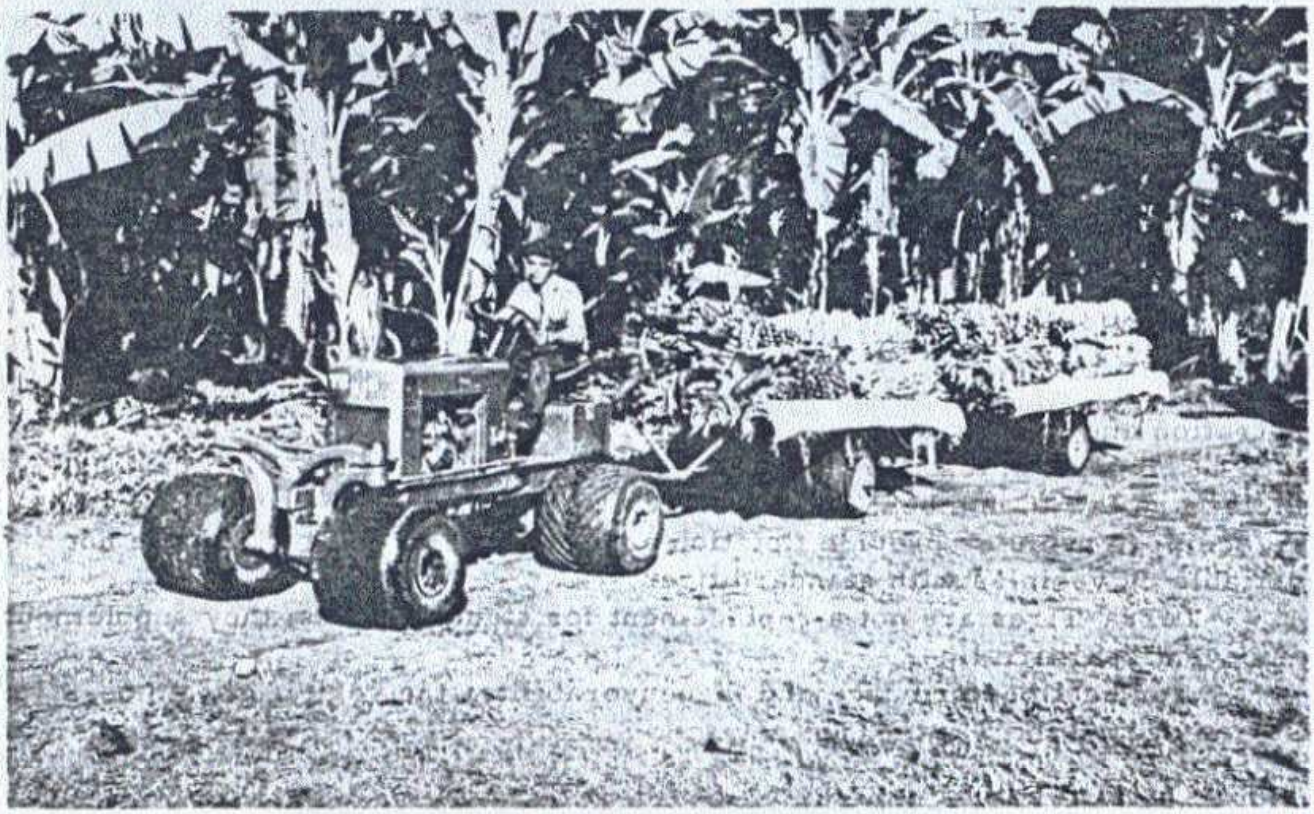

Fig. 12 24 x 24-8 Terra-Tires fitted to banana harvester tractor and trailers

Ohio Agricultural Experiment Station, Wooster, Ohio, conducted extensive tests over a 2 year period evaluating the "soil compaction relationship" to "crop response", both in plant growth and crop yield. Tomatoes and corn were used as test crops because of their sensitivity to soil compaction. The 13.6-38 farm tractor tire and the 46x24-16R Terra-Tire were used for comparison, each tire carrying the same load and mounted on the same model tractor (Figure 13).

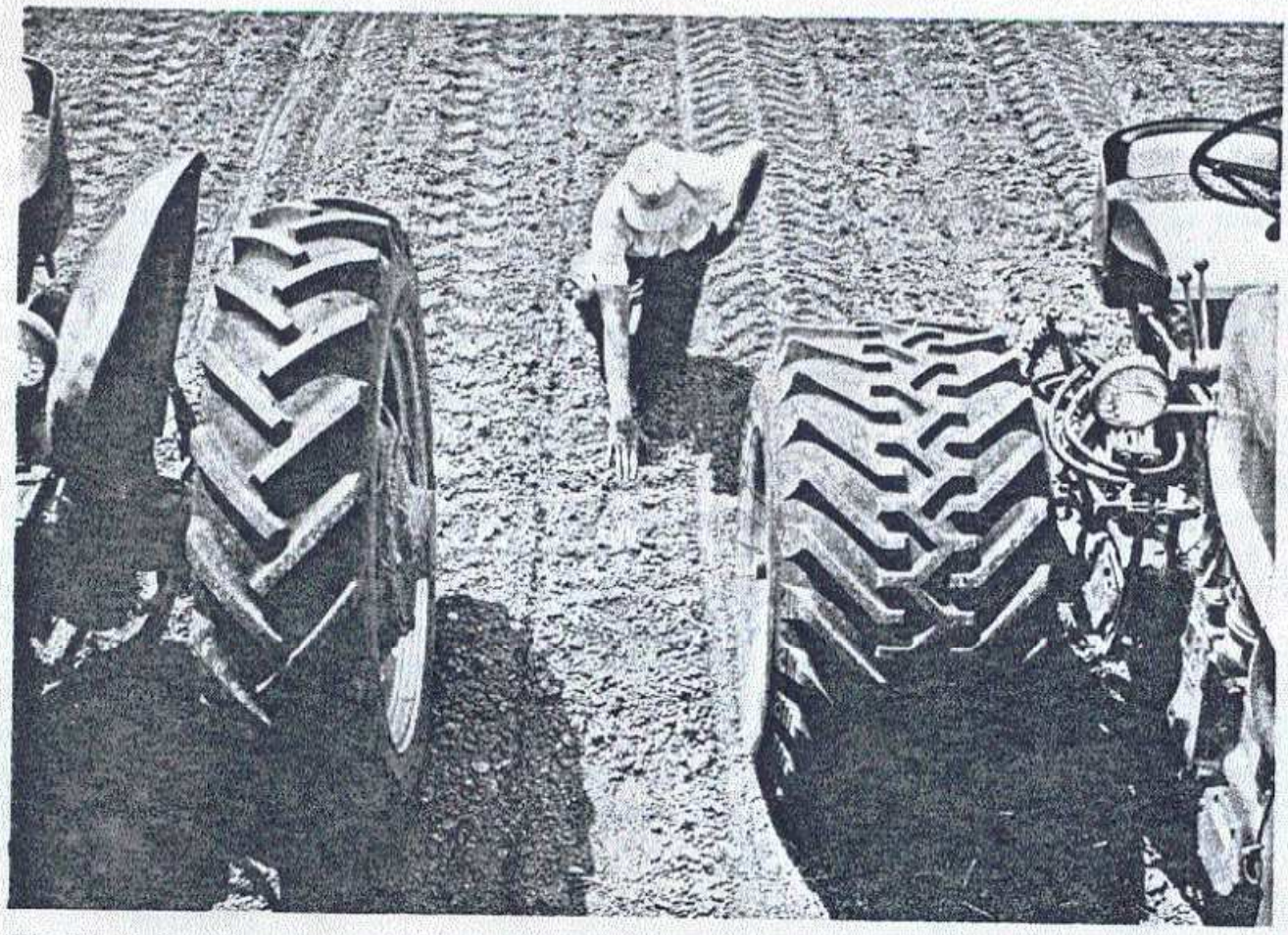

Fig. 13 Soil compaction tests with 46 x 24-16 Terra-Tires

Results of these tests were conclusive that the Terra-Tire equipped tractor provided less soil compaction thus resulting in greater crop response. Also, the Terra-Tire was comparable in tractive efficiency with less tire penetration and lower soil compaction.

Comparison tests of Terra-Tires versus standard tires on identical vehicles are few in number. The main reason being the fact that the Terra-Tire equipped vehicles provide flotation and mobility in areas which are not negotiable by vehicles with standard tires.

Terra-Tires are not a replacement for standard tires; they supplement the conventional tire line.

For best performance and maneuverability, the vehicle should be designed around the Terra-Tire.