THE ALECTO TRACKLAYER

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The last decade has seen a remarkable advance in knowledge of the behaviour of soils under the transient loads of vehicle locomotion and the techniques developed for the measurement and evaluation of soil properties, together with the data now available on the effect on these properties of climate and topography, offer great possibilities for future progress in the design of off-highway vehicles, and the prediction of their performance.

Fig. 1 The Alecto Gun Carrier

Before this knowledge became available the extent to which soil characteristics entered into the design of such vehicles was almost entirely limited to recognition of the fact that, since motion resistance in soft ground is proportional to sinkage, the lowest soil pressure and consequently the largest possible ground contact area of wheels or tracks was desirable. The practical limitations of wheel or track proportions for a given size and weight of vehicle are however quite closely defined and it seemed therefore that the most promising field for further development, at least so far as tracked vehicles were concerned, was in the reduction of mechanical losses. In a recent and most informative paper on the performance of high speed tracklayers[1] it was stated that fitting a track to a vehicle may increase the resistance to motion on a hard surface to three times its resistance when it is running on its wheels alone, so that it would appear that considerable scope still exists for improvement in this direction.

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In view of this a description of a vehicle of unconventional design where the objective was to reduce the mechanical losses usually associated with the tracklayer to a minimum, may be of interest. This vehicle, of which several hundred were built during World War II, was developed and manufactured by Vickers-Armstrongs, to the authors design and appeared in the form of a light tank and also as a gun carrier. A tank version, known as Tetrarch, with a turret mounted 40mm gun and co-axial machine gun, weighed $7\frac{1}{2}$ tons and was the first airborne tank to go into action. The gun carrier, Alecto, weighing 8 tons equipped with a 95mm howitzer and manned by a crew of four including the driver is shown in Fig. 1.

Alecto was not in full scale production until near the end of hostilities, but a considerable amount of operational data was obtained and the performance recorded under a wide range of conditions.

The original design project was commenced after an extensive analytical and experimental investigation into the origin and extent of the mechanical losses in the conventional tracked vehicle. Apart from transmission losses, which it was believed need not exceed those of a comparable wheeled vehicle if a simple layout were adopted and careful attention paid to detail design, the major sources of loss could be considered under two headings; track friction and the power absorbed in overcoming the resistance to slewing when changing direction.

Track friction arises primarily, in the case of the conventional pin-jointed track, from metallic friction between pin and link and the typical test rig results given in Fig. 2 show that, as would be expected, this increases directly with the tension. The load on the pins and consequently the friction also increases considerably with speed due to centrifugal loading. The centrifugal load imposed will depend on the pitch and weight of the track and the diameter of wheel about which it is deflected. Fig. 3 shows the effect under constant tension of speed and track link weight. The advantage of reducing track weight, particularly in the case of high speed vehicles, is evident although as military transport must be capable not only of negotiating soft ground but also hard irregular terrain the possibilities of appreciable weight reduction without risk of strength failure are limited. In the case of friction resulting from driving tension this will depend, with a given frictional coefficient, on the ratio of the track pin diameter to the diameter of the wheel around which the track passes, and of course the number of times this occurs in any particular track configuration. A comparison of the power loss with the same track but with different wheel diameters is shown in Fig. 4.

Consideration of the foregoing resulted in the adoption of a track and suspension layout employing four independently sprung, rubber tyred load carrying wheels on each side, the rear wheels differing only in the provision of inserted sprocket teeth as the driving medium. Some details of the rear wheel drive and the suspension arrangement will be seen in Fig. 5.

The effect on track friction of reducing to a minimum the extent and frequency with which the track is deformed is shown in Fig. 6 where the power absorbed on a smooth hard road surface is compared with that of a tracklayer with conventional track configuration. Also plotted on Fig. 6 are the results of tests on pneumatic tyres. The unconventional layout of Alecto enabled 10.00 - 22 tyres to be fitted for test purposes to the front and rear suspension stations, making possible a direct comparison of the mechanical losses and rolling resistance on the same basic vehicle.

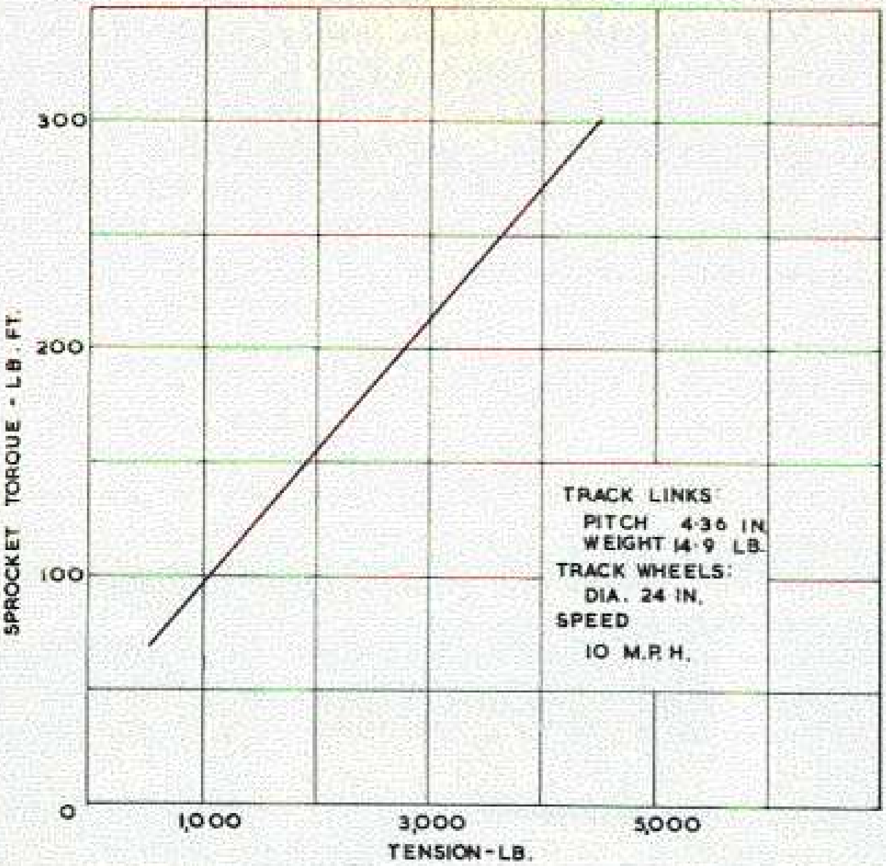

Fig. 2 Track Friction: The Effect of Tension

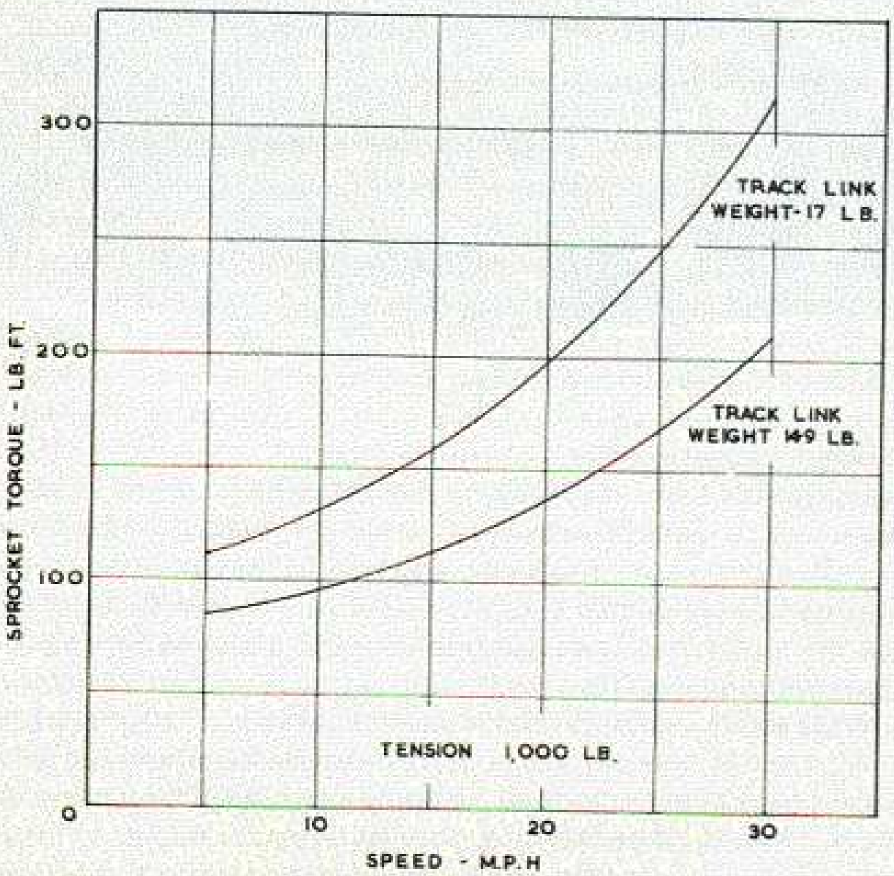

Fig. 3 Track Friction in Relation to speed and Track Weight

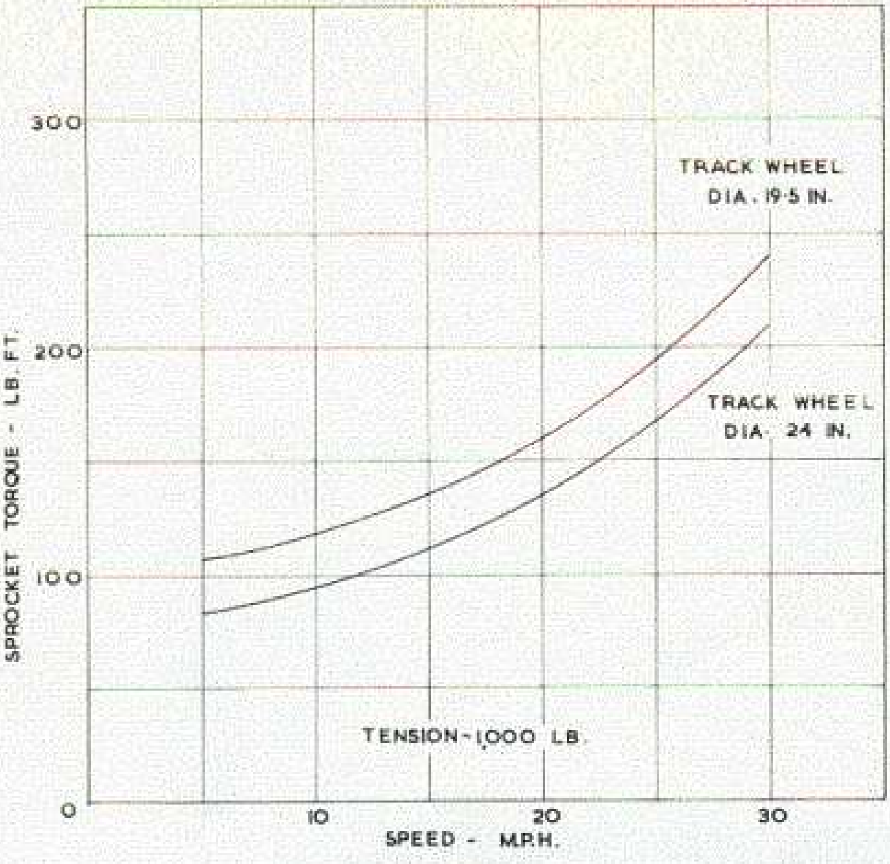

Fig. 4 Track Friction and Track Wheel Diameter

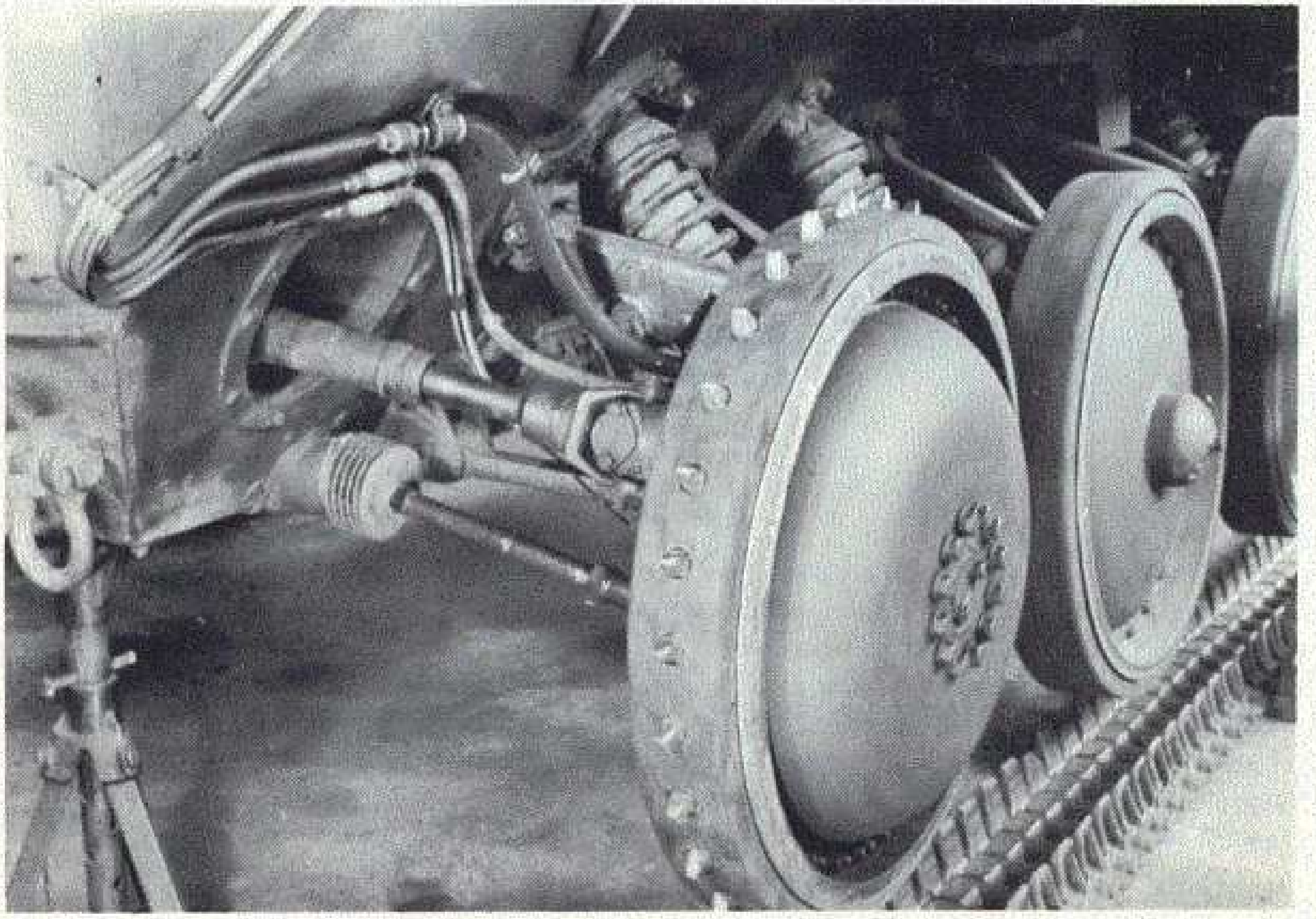

Fig. 5 Alecto Suspension and Rear Wheel Drive.

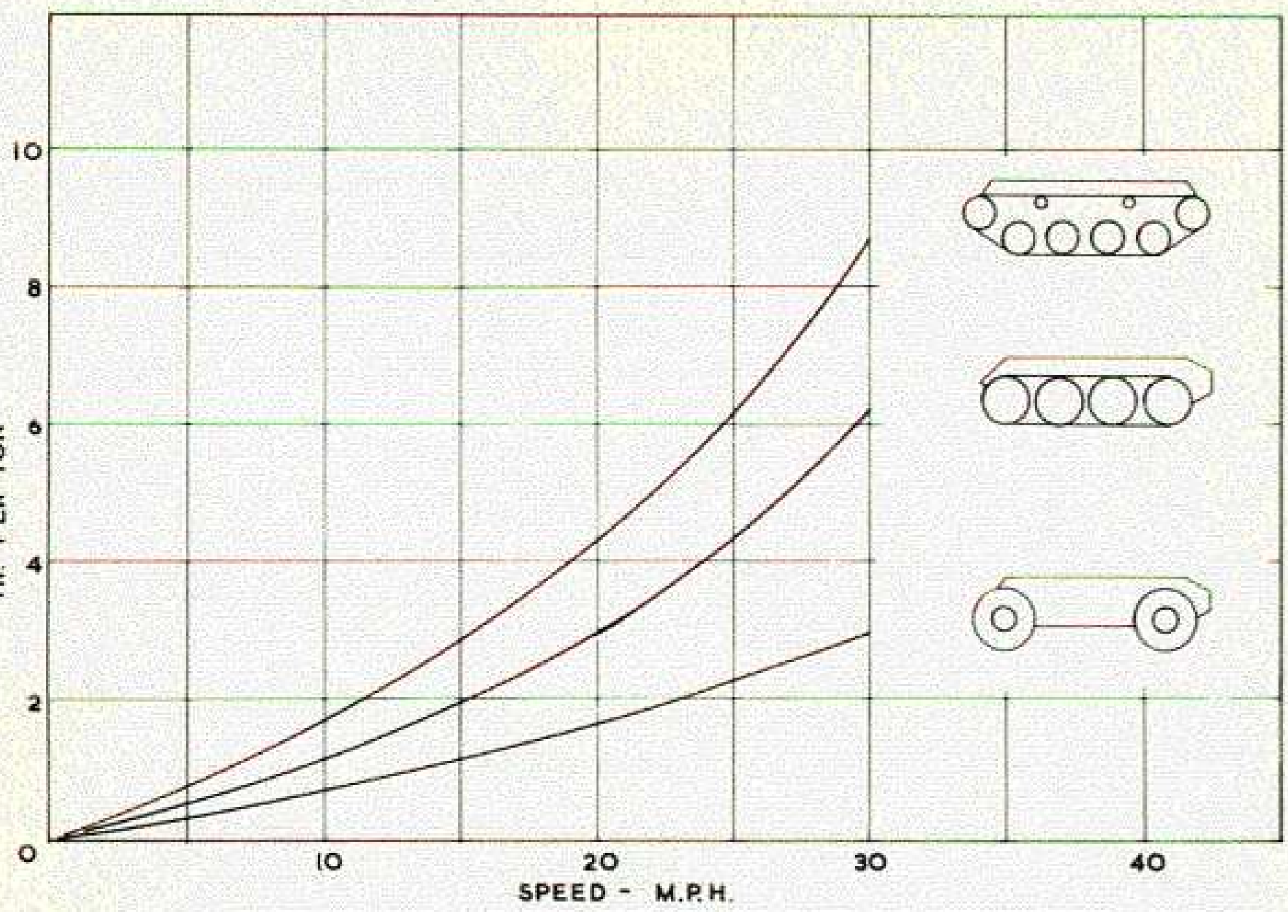

Fig. 6 Power Absorbed: The Effect of track Configuration compared with Pneumatic Tyres

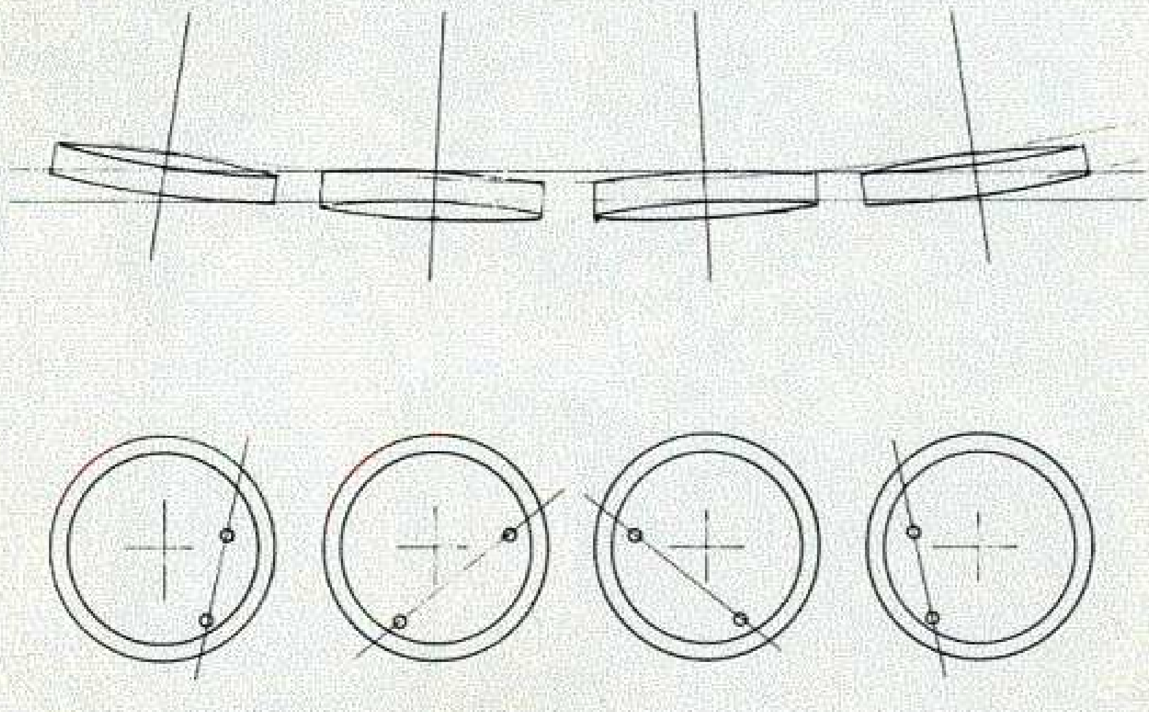

Fig. 7 Curved Track Steering: Diagram of Track Wheel Displacement

In considering the possibilities of reducing the other major power loss, that due to steering, it appeared unlikely that any really substantial improvement could be made so long as a change of direction involved lateral skidding of the track. The idea of eliminating this loss by laying the track in a curve is of course quite old and several attempts had been made in the past to devise a satisfactory mechanical arrangement to achieve this result. The principal difficulty had been that while track curvature could be maintained at the ground contact surface, where it was firmly positioned by the vehicle weight, any curvature in the unloaded portion of the track was very liable to cause it to be thrown off the sprocket or idler.

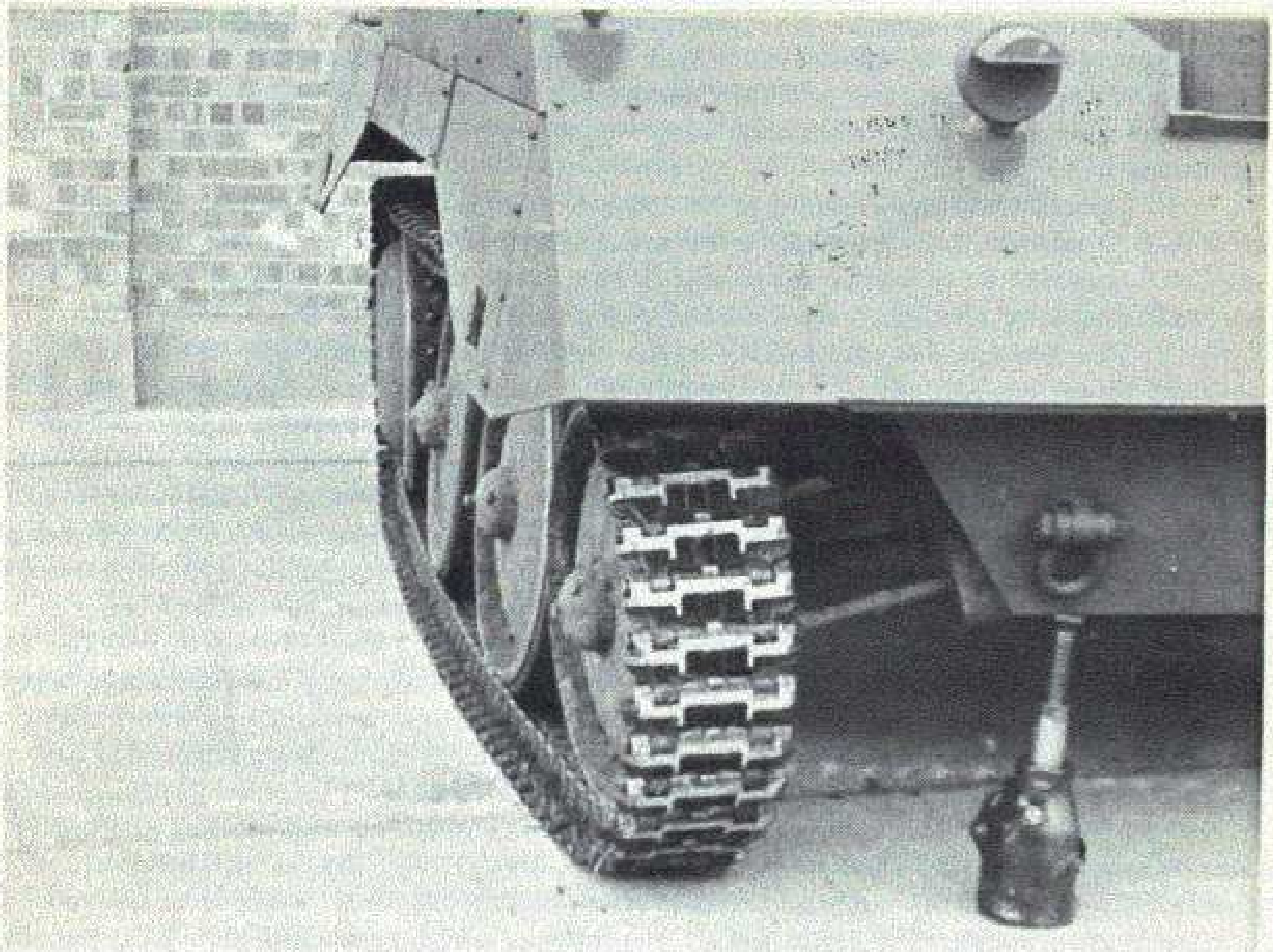

Fig. 8 Alecto Wheel Deflection and Track Curvature

A solution to the problem seemed to be an arrangement in which curvature was restricted to the length of the ground contact with the unloaded stretch of the track maintained in a straight line. The means by which this result was obtained is shown diagrammatically in Fig. 7. It will be seen that each wheel is mounted on an axis inclined at a suitable angle from the vertical in a longitudinal plane so that movement around these axes displaces the lower wheel contact to form a curve while the top of the wheels and consequently the upper stretch of the track remains in a straight line. The relative position of wheels and track when making a curve will be clear from the photograph, Fig. 8.

Steering movement was imparted to the wheels by a conventional steering wheel, hydraulic power assisted, through racks and pinions and individual push rods. The minimum turning radius obtained was 40 feet, although this could have been considerably reduced but for the requirement that the trench crossing ability should be at least 5 feet. The turning radius however proved adequate for most road and cross-country conditions and for operating in a confined space skid steering by braked differential was provided.

Reduced track friction together with the virtual elimination of steering losses, except when manoeuvering at the lowest speeds, gave this vehicle an unusually good performance across country, while on hard surfaces particularly ice and frozen snow, the positive directional control enabled high speeds to be maintained with safety. The maximum speed of Service models was limited by engine governor to 40 and 30 miles per hour in the case of the tank and gun carrier respectively, but with the governor disconnected road speeds of nearly 60 miles per hour were obtained with a power/weight ratio of less than 20 h.p. per ton.

Alecto was powered by a 12 cylinder horizontally opposed engine of 158 h.p., mounted at the rear over a conventional 5-speed gearbox and bevel and differential assembly, from which the drive was transmitted through universally jointed shafts to final reduction gears located in the rear wheels.

The design was originally criticised on the grounds that the absence of a front idler wheel reduced the ability of a tracklayer to negotiate a vertical obstacle. While in the case of the earliest tanks with a rigid suspension the height of idler from the ground had a significant effect on obstacle ability this does not apply to vehicles with a flexible suspension system. The vehicle described could surmount an obstacle some 50 per cent greater than the height of the front wheel centre from the ground, the obstacle height being limited only by the location of the vehicle centre of gravity in relation to contact length.

There was also the objection that the steering mechanism made the vehicle too complicated, an objection perhaps understandable 20 years ago when all types of military transport were much less complex than they are today. Judged by modern standards, however, the additional mechanism would not appear to be an unreasonable price to pay for a substantial gain in performance.

In view of the rapid development in recent years of wheeled off-highway transport it may well be that the future progress, and even survival, of the tracklayer in both military and civil applications will depend, in spite of its inherent superiority from a soil mechanics aspect, on the effort directed towards the solution of problems in vehicle mechanics. This is even more apparent when it is considered that the benefit from increased mechanical efficiency is not confined to the performance in terms of speed and gradient ability; of at least equal importance is the improvement which could be expected in vehicle life and reliability.

References

1. Cleare, G.V. *Factors affecting the Performance of High-Speed Tracklayers.* Proc.Auto.Div. Inst.Mechanical Engineers, London 1963-64.