The Mechanical Aspect of the Tank.

By Captain Cahen, French Army -- Translation.

The tank is essentially composed of a chassis or platform carried on a pair of endless belts. The belts are moved by means of a cogwheel or sprocket from the motor. There is a second large wheel or pulley to help return the belt. The rollers which support the weight of the chassis are hinged so as to adjust themselves automatically to the inequalities of the terrain. The tension is regulated by a second system of rollers and springs on the upper half of the chain.

Hence a tank is essentially an armored tower rolling upon tracks of its own laying.

Figure 1.

Effect of Traction.

In the movement of a tank, as in the movement of any other self-propelled vehicle, it is necessary to overcome a certain number of variable resistances. The sum of these resistances give the effort required for movement. Resistances are of two kinds; permanent and accidental. Permanent resistances consist of:

(a) Natural resistance due to the friction of the bearings on the wheels.

(b) Resistance of the rollers on the chains.

(c) Resistance of the air.

Temporary or accidental resistances consist of:

(a) Resistance due to weight.

(b) Resistance due to obstacles, such as starting, turning, climbing, etc.

We shall examine the different resistances in detail. Let P' be the total weight of the tank, chains not included, P the weight of the axles. Then P' minus P is the pressure that produces friction. If f is the coefficient of friction and D, d, respectively, the diameters of the roller and axle, the work due to friction is a unit of length, $\frac{\pi d f (P'-P)}{\pi D} = f(P'-P)\frac{d}{D}$

In the Renault f equals 1/70 and d/D equals 0.20. The resistance of the vehicle is therefore 2.85 kilograms or above 6.87 pounds per suspended ton.

Resistance due to rolling on the chains. Let f' be the coefficient of friction between the rollers and the chains. Then the resistance due to rolling on the chains is f' times P'/D, f' varying from .015 to .02. D is very small and varies from .18 meters to .20 meters. Hence the resistance varies from 80 to 100 kilograms per ton.

Resistance due to air. Let S be the surface of the tank on the vertical plane in square meters, V the speed of the machine in meters per second, and θ the constant coefficient of pressure of the atmosphere. The resistance is therefore $\theta S V^2$. This resistance is, however, negligible owing to the slowness of the tank.

Hence the effort necessary to overcome the permanent resistance is $\phi = f(P' - P)\frac{d}{D} + f\frac{P'}{D} + \theta S V^2$ which equals 90 to 100 kilograms per ton.

Accidental resistance. Resistance due to slopes. When a machine is to be moved over terrain which has a slope of the angle α above the horizontal the resistance due to the slope is P $\sin\alpha$. This effort in kilograms per ton is about as follows:

Degrees of slope	Effort in kilograms per ton.
10	100
20	200
30	290
40	370
50	450
60	515
70	573
80	625
90	670
100	707.

A Renault will not climb a slope greater than 45 degrees unless the traction of the soil is especially good.

The effort due to overcoming the moment of inertia during the instant of starting is $T = \frac{1}{2}MV^2$. For one ton $T = \frac{1}{2}V^2 = \frac{1}{2} \times \frac{1000}{9.81} V^2$ or about $50V^2$. The effort at the circumference of the driving sprocket to overcome the permanent load and the resistance due to declivity is therefore $F = \frac{\phi + P\sin\alpha}{2}$. Since the maximum slopes to be overcome are defined in the textbooks on loads F is known.

Efficiency of motors driving caterpillars. In the chain-propelled tank the transmission by caterpillar gives a mechanical efficiency of 70 per cent. The different speeds necessitated by the requirements of climbing gives throughout by means of a reducing train of gears a constant efficiency of 70 per cent. The effort of the motor would thus be about 2F or $F = \phi + 2 \sin \alpha$

The effort of traction of the caterpillar. The power of the motor being thus determined by the conditions of the tables of load we can deduce for each speed the power necessary to accomplish the work of the caterpillar.

Adhesion or useful pressure. Adhesion is the resistance to slipping of the tank on the ground which supports it. If P is the weight of the tank and N the coefficient of friction between the soil and the caterpillar the adhesion is A equals NP. That is, the effort which will make the car slide in place on the ground is $A > F$ and $NP > \frac{\phi P \sin \alpha}{2}$. N is a variable and changes directly with the effect of the weight of the car on the ground which supports it.

Tanks on variable supporting surfaces. In the tanks we have thus far considered the weight-bearing surface of the caterpillars remains constant. The unit of pressure must therefore also remain constant and the movement of the tank depends upon the compressibility of the soil.

Due to accidents of the terrain apt to be encountered in action the weight-bearing surface of the tank may become reduced, so that in tanks of the above nature the maximum traction potentialities only exist on ground of the best, that is, the most level surfaces.

In a rational machine on the contrary one should be able to vary the surface of pressure according to the nature of the ground; that is, the less advantageous the traction potentialities of the surface the more bearing surface should be applied. The solution I propose depends upon this power of increasing the bearing surface and also upon the ability of the original bearing surface to conform to variable terrain. Increased bearing surface will be obtained by adding two rollers at the other end of the tank, these rollers to be habitually concealed within the armor and only used in the descent into and ascent from ditches, the bearing surface to be made to conform absolutely to the surface of the ground by means of a tank with three articulated sectors. By constructing such a tank with segments of a calculated length it will be possible to have no segment make an angle greater than 17 degrees with any other segment no matter what the shape of the obstacle to be overcome.