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A PROPOSED PARKING DEVICE FOR MOTOR VEHICLES

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ABSTRACT

A tentative construction has been herein proposed to develop a parking device to be attached to motor vehicles. The device is simple in design, manufactured to suite various types of automotives & based on a special gear train powered by 12V D.C. motor. The device can be controlled by the driver to park safely in a minimum manoeuvring distance, also can be used for car jacking and trailing in case of emergency.

Based on a study of 3-Wheeled vehicle dynamics, a formula has been derived to estimate proper steering power and to put some bases for further optimization processes.

KEYWORDS

Parking, Device, Lifting, Mechanism, Dynamics, Design.

INTRODUCTION

Insufficiency of parking areas in big cities usually results in very serious problems. These problems, resulting mostly from traffic jams, become more severe in developing countries. In these countries the lack of displine adds another dimension to the problem. In some areas parking parallel to the pavement is allowed, but it is not in other areas. Gaps which can accomodate some vehicles are usually found in the case of parallel parking. To park within a limited space represents one of the major problems which would exhaust the driver and consumes extra fuel.

This problem can be found down town in dense cities, also in developing countries due to rapid increase in the number of cars relative to the available roads and parking places. The parking problem comes to its top level with cars which have to park within a very limited area.

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Considerable time is lost in searching for a place to park-in together with the associated loss in fuel consumed in the search process. Saving time is the prime importance in developed countries, whereas saving fuel is the most important in developing ones, especially if they are non-oil producing countries. This recommends the use of specially designed parking device to aid in optimizing the utilization of the available parking areas and to save time and money.

The parking device is a mechanism that can be attached in a simple way without any alterations in car manufacturing to ease parking. This device enables the car to move laterally and helps in increasing car manoeuvrability in limited areas. The idea of developing a parking device was in mind several years ago, however, none has been put down to application. The basic mechanism which may be considered for design will be here-in discussed aiming towards finding an ultimate optimumconstruction.

CLASSIFICATION OF PARKING DEVICES

The basic idea of a parking device is to allow the vehicle to move laterally during parking. The lateral motion although cannot be completely fulfilled i.e. it is not possible to move the whole vehicle in a transverse direction perpendicular to its orientation, a slight rotational motion about its front (or rear) wheels would do the job more easily, as shown in Fig. 1. In this case the vehicle would rotate about its front (or rear) wheels to be secured in parking position with minimum manoeuvring power. To attain such lateral rotation, three basic mechanisms can be used.

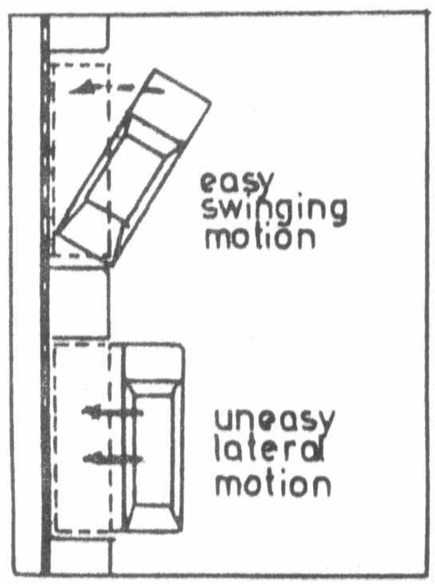

Figure 1 : Car parking methods

The use of a bevelled wheel to be forced between wheel and road, Fig. 2a; in this case the bevel must be connected to driving wheels and will be driven by the rotation of the wheel. This would be possible in case of rear driving wheel vehicles and has the disadvantage of unavoidable high slip of the other vehicle wheels.

The use of proposed mechanisms is to lift totally the vehicle by a distance just sufficient to keep it clear from the road. This lifting mechanism can be either by vertical movement of the wheels as shown in Fig. 2b, or by rotating a tilted lever to a vertical position about a centrally fixed hinge, Fig. 2c. However, let us classify these mechanisms according to the lifting and driving systems. For the suggested parking devices envisaged by authors, an extensive study of possible means to be adopted in operating them has been carried out to group the possible power transmission means as such:

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1. Mechanical drive.
2. Hydro-mechanical drive.
3. Electromechanical drive.
4. Electro-hydro-mechanical drive.

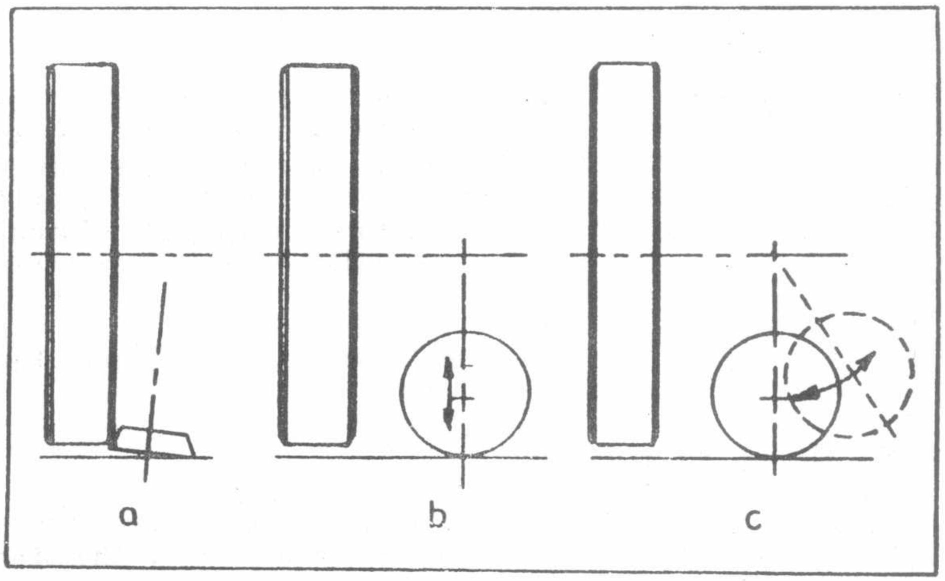

Figure 2 : Parking mechanisms

MECHANICAL DRIVE

The mechanism is driven from the car engine itself through an auxiliary gear box mounted between a main gear box and a crank shaft. The auxiliary gear box has the ability to either drive the car via its main gear box, or drive the parking mechanism (lowering mechanism).

The basic advantages of using mechanical transmission are the high power which can be used for lifting trucks and the possilility of using parking mechanism for heavy cars and trucks. However, this system suffers from the disadvantage of the need of a change in design of the main gear box which would be expensive and requires original modifications.

HYDRO-MECHANICAL DRIVE

This mechanism is driven by a continuously adjustable axial piston pump from fan belt drive of car. The power is transmitted by a closed loop continuously variable hydrostatic transmission. The lowering mechanism and driving mechanism are purely mechanical ones. The driving pump is equipped with magnetic clutch to put it in or out of motion.

This type of transmission has the advantage of no need to change the car design since the driving pump is driven by the fan belt drive of the engine. However, it is more expensive than the former system.

ELECTROMECHANICAL DRIVE

This mechanism is driven by two 12V D.C. motor from car battery. The change of polarity of D.C. motor reverses the direction of rotation. The advantages of this mechanism are its simple design and independency upon the car design. However, for heavy trucks and busses, the power of the driving motor should be increased .

ELECTROHYDROMECHANICAL DRIVE

It is divided into two types. The lowering mechanism of the first type is driven electrically through a 12V D.C. motor from car battery, while the driving mechanism is driven by a hydraulic pump as in the former drive. The lowering mechanism of the second type is a hydraulic cylinder and hydraulic pump driven by fan belt drive through magnetic clutch to put it in or out of motion. The driving mechanism is driven electrically by a 12V D.C. motor from car battery.

These types although seem to provide a well controllable design, have the disadvantage of being complicated.

PROPOSED MECHANISM

The mechanism chosen for the present work is of the electromechanical drive type.This mechanism is chosen due to its advantages over the other types such as:

- Easy manufacturing.
- Easy mounting in the vehicle.
- Safe drive.
- Independency on vehicle design.

The lowering mechanism is a power screw driven by 12V D.C. electric motor through reduction gear train of worm and worm wheel. The worm and wheel are able to self lock the device at any position. The motor can rotate in both directions by reversing its electric polarity to either lift or lower the mechanism through the power screw. The power screw has four slots spaced at 90° each for orienting the driving mechanism wheels perpendicular to or along car rear axle or front axle.

The driving mechanism is composed of an electric motor which drives two wheels through reduction gear box having a reduction ratio of approximately 45 by means of the worm and worm wheel and a single planetary gear train. Both the lifting and driving motors have been selected to be 12V D.C. motors so that they can be directly supplied with power from the vehicle electric system. Meanwhile, easy control switches can be easily fitted in front of the driver.

Full constructional drawing of the proposed device is given tentatively in Fig. 3.

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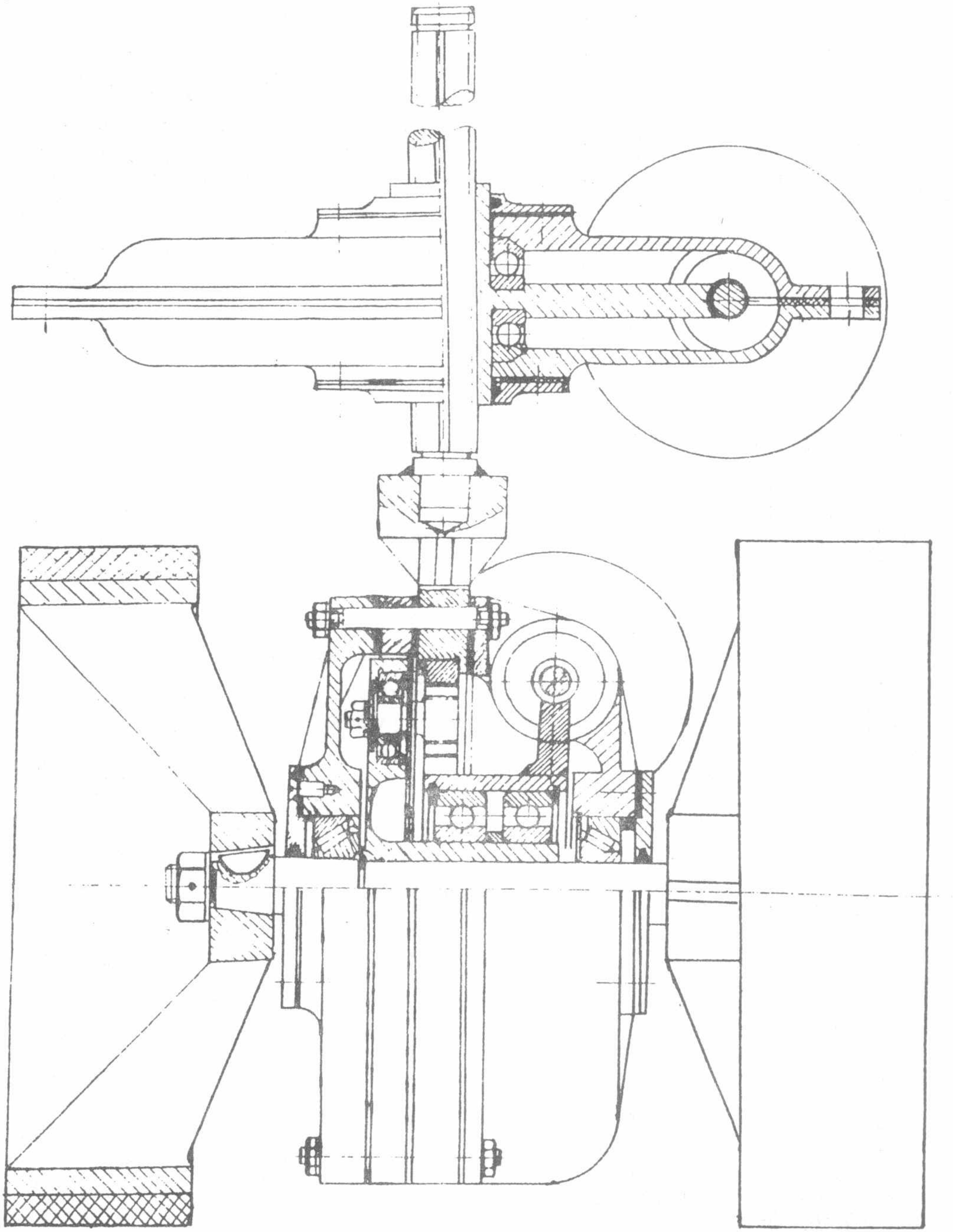

Figure 3 : Proposed Parking Device

The device being fixed to the vehicle chassis is basically composed of two systems, namely, lifting and driving systems, By means of an 12V D.C. motor, a worm and worm wheel drive could lift (or lower) the vehicle through a power screw system. The driving mechanism, however, comprises a worm wheel separately driven by an 12V D.C. motor. A planetary gear train transmits the power from the worm wheel to the parking wheels. The use of D.C. motors helps in controlling both the lifting and parking speeds through a simple electric controller situated in front of the car driver. However, the full design computations [1] have shown the reliability of the proposed mechanism for use even in heavy buses or trucks [3].

KINEMATIC STUDY OF THE PROPOSED MECHANISM

GEOMETRICAL DISCRIPTION OF THE PARKING PROCESS

It has been found from the analysis of the proposed mechanism that the optimal initial condition (position) of the vehicles should be as indicated in Fig. 4 . The vehicle at the begining should be at position inclined to the pavement by 45° providing that the centre line passes through the right rear extreme end of the front parked vehicle. It has also been found that the minimum required space for parking using the proposed mechanism is tentatively as follows:

$$A = 0.4B+L$$

Effectivness of the proposed parking mechanism is highly enhanced when the steering mechanism of the vehicle is interiorly locked during the performance then the chasis of the vehicle will rotate about the mid point between the front wheels as indicated in Fig. 4.

Of interest to mention that the mechanics of the proposed mechanism simulates 3-wheel drive vehicles, a state which also finds its applications in aeroplanes or in 3-wheel autos.

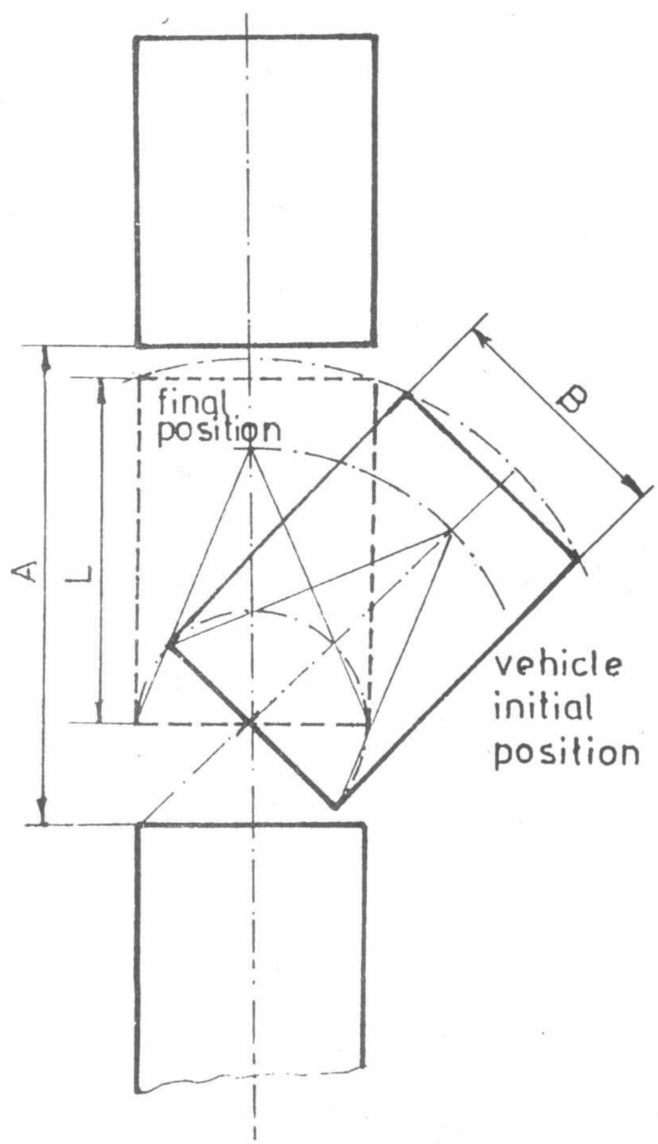

Figure 4 : Configurations of Parking Process

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DYNAMICS OF THE PROPOSED MECHANISM

Follows are the basic equations which help in estimating the value of the optimum driving forces.

With reference to figure 5, the balance equations [1,2], would read:

$$\Sigma \vec{F} = \frac{W}{g}\ddot{x} \qquad (1)$$

$$\therefore F + 2\mu W_1 \sin\lambda - \mu W_1 = \frac{W}{g}\ddot{x} \qquad (2)$$

where

$$W_1 = (W/2)\, l_o/(l_o + l_g)$$

$$W_2 = W\, l_g/(l_o + l_g)$$

$$\tan\lambda = 2\delta/B$$

$$\Sigma \vec{F} = \frac{W}{g}\ddot{y} \qquad (3)$$

$$\therefore 0 = \frac{W}{g}\ddot{y} \qquad (4)$$

$$\Sigma \vec{T}_g = I_g \ddot{\theta} \qquad (5)$$

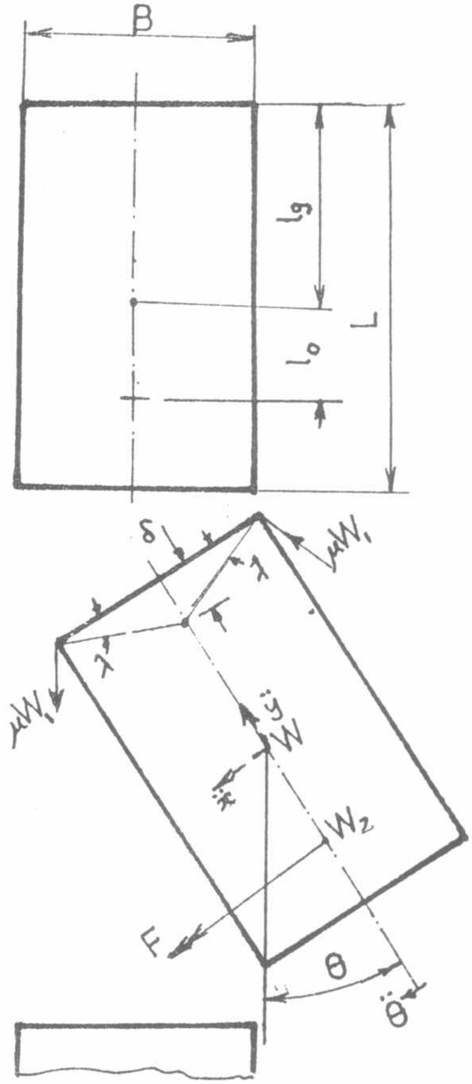

Figure 5 : Parking force analysis

$$(F - \mu W_2)\, l_o - 2\mu W_1 (l_g - \delta)\sin\lambda - 2\mu W_1 (\delta/\sin\lambda) = \frac{W}{g} K_g^2 \ddot{\theta} \qquad (6)$$

As the linear acceleration ($\ddot{x}$) is given by:

$$\ddot{x} = \ddot{\theta}\,(l_g - \delta) \qquad (7)$$

And by solving equations (2) and (6), the above equations reduce to:

$$\frac{W}{g}\ddot{\theta} = \frac{F}{(l_g-\delta)} - \frac{2\mu W_1}{(l_g-\delta)}\frac{2\delta}{\sqrt{B^2+4\delta^2}} - \frac{\mu W_2}{(l_g-\delta)} \tag{8}$$

By rearraging terms and simplifying equation (8), equation (8) would read:

$$F = \mu W_2 + \mu W_1 \frac{(l_g-\delta)(4\delta l_g + B^2) + 4\delta K_g^2}{[l_o(l_g-\delta) - K_g^2]\sqrt{B^2+4\delta^2}} \tag{9}$$

For the present proposed mechanisms the shift between the driving front (or rear wheels) axle and the instantaneous centre (δ) tends to the zero. In such case equation (9) will take the form:

$$F = \frac{\mu W l_g}{(l_o+l_g)}\left[1 + \frac{l_o B}{2(l_o l_g - K_g^2)}\right] \tag{10}$$

The design could be done, if the traction force F has a value which could be estimated from equation (10). Meanwhile for minimum traction force, an optimization technique may be useful in estimating the proper position of the mechanism relative to the driving axle.

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NOMENCLATURE

- A = Parking space
- B = Vehicle breadth
- F = Traction force
- g = Gravitational acceleration
- I = Moment of inertia
- Kg = Radius of gyriation of the vehicle
- lo = Distance from the parking mechanism wheel axle to the vehicle centre of gravity
- lg = Distance from the driving axle to the vehicle centre of gravity
- L = Total Vehicle length
- W = Vehicle weight
- x,y = Coordinates perpendicular to and along the vehicle longitudinal centre line.
- θ = Angular position
- μ = Coefficient of friction