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TYPES OF MECHANISMS DESTINATED TO STEERING BOXES ON BACK AUTO AXLE

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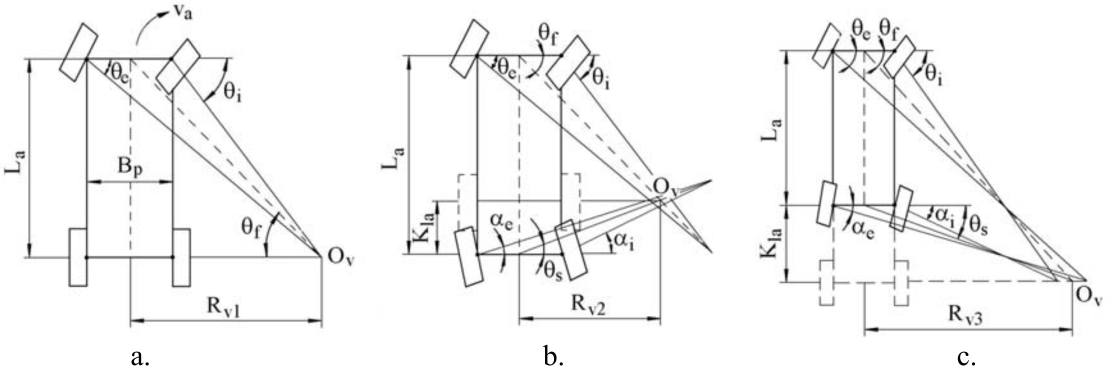
ABSTRACT
The motor vehicles which dispose of two steering auto decks, at which back and front wheels are positioned backwards for reducing the veering radius, has the advantage of reducing the stability at high speeds in auto racing.
In this paper is made an analysis of the steering boxes on back axle variant, which combine the advantage of reducing veering radius with keeping its whole stability.
Keywords: steering box, steering rear axle, integral steering

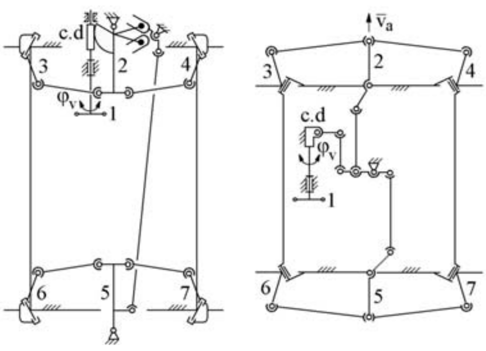
1. THE PROBLEM OF TWO STEERING AXLE
The preoccupations in maneuverability's increase and car's stability led to offering a special attention to the steering system on four wheels. In comparison to the classical car with front steering axle (fig. 1,a), in the case of rear wheels that are braking in a n opposite direction as those in the front (fig. 1,b), the desired reduction of the turning radius $r_{v2} < r_{v1}$ is accompanied by a diminution of the stability, the fictitious axle base becomes diminuted, $L_a - kL_a < L_a$, which can be dangerous when running at high speeds. In the case of steering of the rear wheels in the same direction as the front ones (fig. 1,c) we notice an improvement of the stability while turning, but also the increase of the radius $r_{v3} < r_{v1}$.
It is produced a reduction of the car's twisting moment (oversteering), an improvement in the car's behavior when the steering-wheel is abruptly handled, an increase in the stability in breaking while turning, as well as at lateral wind [2, 3]. We wrote down O_v - the turning centre, $\bar{v}_a$ - the speed (directions) of the car, $L_a \pm kL_a$ - axle base, $\theta_{f,s}$ – the rear/front wheel steering angle.
At maneuvers such as going round an obstacle or parking is necessary to reduce the turning radius – a case coupled frequently with the low speeds systems (fig. 1,b) – but at high speeds – for: increasing the stability it would be necessary braking the back wheels in the same directions as the front ones (fig. 1,c).



a. b. c.

Figure 1. The turning radius and the steering angles for 1/2 steering axle

The steering mechanism of the rear axle can be operated from the front axle (fig. 2,a) or there is simultaneously operated at both axles (fig. 2,b).



a. b.

Figure 2. Operated the rear steering axle

There have been written down in figure 2: 1 – steering wheel, 2 – front steering drop arm, 3-4 – front steering wheel drop arm, 5 – rear steering drop arm, 6-7 – back steering wheel drop arm, φ_v – steering wheel rotation angle, c.d. – steering box, $\bar{v}_a$ - the car's speed (the rolling direction).

The maneuverability improvement and increase of the car's stability are two contradictory demands imposed to a steering mechanism that operates on the rear wheels, the best solution being hard to define.

The constructors have had in their attention the "rolling speed" parameter as well as the "turning radius" parameter (steering wheel rotation angle).

With the purpose of eliminating the stability reducement at high speeds, at the car with rear steering wheels in opposite direction as the front ones, there can be provided devices through which, optionally, the action of operating the direction of an axle can be interrupted (fig. 3). Such a device [5] has 3 functional positions, the lever 3 being able to perform the linking process, through a joint connecting the drop arm 1 with 2, with carcass 4 or disconnecting (the position in the draft).

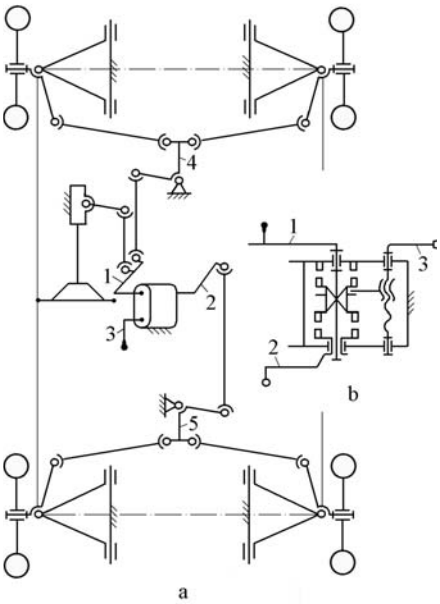


Figure 3. Device of the operated rear axle

2. INTEGRAL STEERING DEPENDING ON THE STEERING WHEEL ROTATION ANGLE

The integral steering of cars, in the present perception has as a purpose the improvement of the stability while turning at high speeds and supplementary, the car's maneuverability increase at low speeds. As it has been shown, in the first case is required braking the rear wheels, in the direction of the front ones, and in the second case is required steering the rear wheels in opposite direction as the front ones. In order to be able to achieve that both situations are functional, it is required to equip the rear axle with a special steering box, the model of such a system being presented in figure 4.

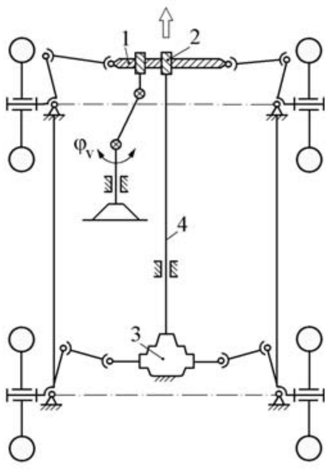


Figure 4. Steering box for the rear axle

In this way, from the pinion-rack box 1 of the front axle, a second junction 2 drives the axis 4 for the steering box 3 form the rear axle.

The rear steering box (3), according to it's structural-kinematic out-line achieves various correlations between the medium steering angels of the axle θ_f/θ_s. the ratio at the φ_v rotation given to the steering wheel, obviously the function $\theta_f(\varphi_v)$ is continuously increasing (according to a certain law, according to the kinematic out-line of the steering mechanism).

The rotation $\theta_s(\varphi_v)$ of the rear axle has to be in the same direction as that of the front axle, when beginning a turning action - at high speeds, after which to came back to the aligned situation ($\theta_s = 0$), only to go further, as the braking θ_f/φ_v increases, to rotation/braking in opposite direction as the front ones, as the turning radius diminishes (so, the rolling speed is also low) [1].

For such a situation a form of steering functions may look like figure 5 [4].

The correlation of the steering command from the steering wheel to the car's rolling speed is presupposed, meaning we suppose the car moves on a rectilinear ground at a high speed, and the turnings are large – therefore made also at high speeds, in this situation the most important aspect is the stability.

If the turning action continues towards small turning radius, then the speed is reduced too, therefore the rear wheels align themselves (θ_s=0), after which starts the braking in opposite direction, here being important the reducing of the turning radius. Obviously at returning for a rectilinear movement (φ_v=0, θ_f=0) the rear wheels cover its sinuous law in opposite direction, meaning it comes back first at θ_s=0, they are braking in the direction of the front ones, and returning in the end at θ_s=0.

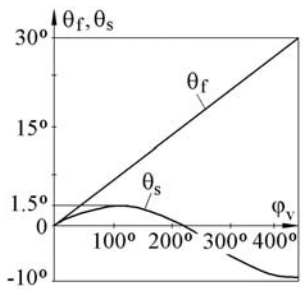


Figure 5. Braking functions for integral steering

Such a movement makes the driver feels a confuse behavior, especially at parking/maneuvers, when at the beginning the wheels seem not to follow commands.

A steering box on the rear axle, which would assure the steering angles according to the diagram from figure 5 is presented in figure 6 [Honda-Prelude, 4, 6].

From the front steering box, through the driving ax, is set into motion a planetary gear with an interior gear, formed by the satellite C and the fix coronet B. An eccentric pin tooth of the satellite sets into motion the slider D, which slides on the guide E that is joined with the bar F, which commands the rear wheels. Through the teeth number's ratio of the box's pinions 1-2 (fig. 4) can be assured, that at a steering wheel's rotation is obtained a certain rotation of the longitudinal ax A (for example 0.75 rotations), on which overlaps the movement law of the posterior steering box mechanism. The effort of braking the wheels of both axels is obviously greater than that on the case of the classical car, that is why usually they are provided with steering assisting systems.

Other steering box model [7] achieves unequal steering in one direction or another through a 1-2 wheel cylindrical gear – with eccentrics on them – on which slides on the crank 3 that moves the steering bar 4 in one direction or another (fig. 7).

In the model from figure 8 [8] a spiral disk 1 moves pin tooth arm 2 - out of which is obtained the lever's swing 3 that activates a slider.

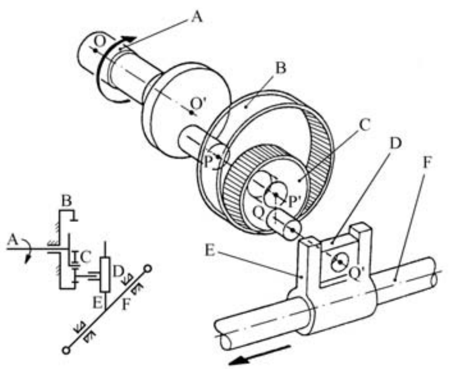


Figure 6. The planetarium steering box for the rear axle

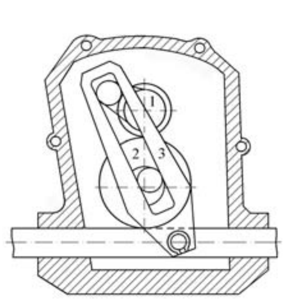


Figure 7. The steering box with eccentrics for the rear axle

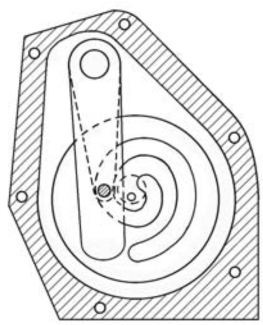


Figure 8. The steering box with spiral disk

3. INTEGRAL STEERING DEPENDING ON SPEED

The main disadvantage of an integral steering depending on the steering wheel rotation angle that is that at parking maneuvers the vehicle's behavior seems confusing, can be removed if the braking-control is done depending on the speed; this complicates the construction.

In the patent [5] is proposed a steering system, on which braking angle of the rear wheels θ_s is superiorly limited and controlled depending on the car's speed $\bar{v}_a$ and on the steering angle θ_f of the preceding wheels, according to a characteristic in keeping with those from figure 9,a.

The model of such a steering system is given in figure 9,b, the adjustment element being set up by the sliding nut 1, that is moved by the screw 2 from the engine M. According to the commands given by the analyzer A, on the basis the signal received from the revolution primary element – assembled on the wheel's ax (reads the speed $\bar{v}_a$), and depending on the reaction signal given by the potentiometer P is positioned the basis 3, that commands the movement of the steering bar 4 of the rear steering mechanism, meaning the angle θ_s achieved at the rear axle [9].

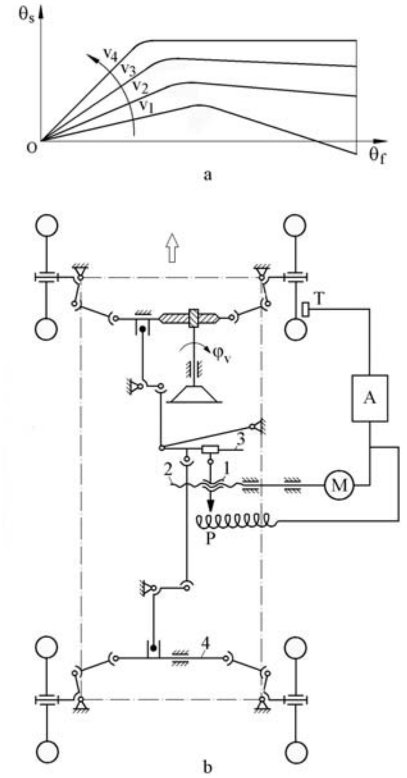


Figure 9. The Steering system for the rear axle controlling of speed and angle

The command of the front/rear steering through the steering wheel rotation angle φ_v is materialized through the articulated bar system presented in the model, the two steering mechanisms, rear/front, are of the type with transition steering box.

An integral steering model depending only on speed, fulfill the following duties:

- up to 35 km/h the rear wheel turn in the opposite direction as the front ones (to reduce the turning radius),
- at speeds around 35 km/h rear wheels are aligned θ_s=0;
- as the speed increases the rear wheels are braking in the same direction as the front ones (to increase stability).

The steering angle modeling of the posterior wheels according to speed is achieved with the help of the device from figure 10. From the steering wheels are operated the front steering as well as the ax 1 and the conical gear 2-3.

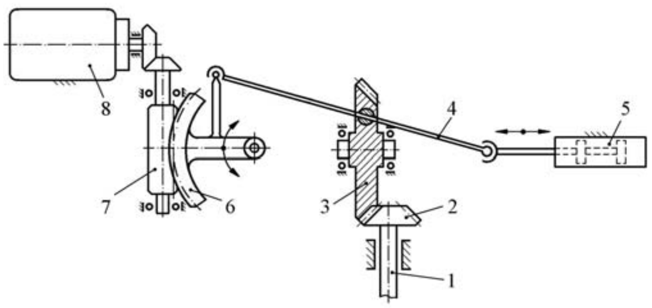


Figure 10. Controlling device of the speed direction function

The wheel 3 is provided with a spherical eccentrically articulation through which the bar 4 is glided, connected to the hydraulic distributor 5, through which is ordered the braking of the rear wheels.

The step by step engine 8, electrically commanded through an analyzer that receives the signal from a revolution detecting element assembled on one of the wheels, operates, through worm gear 6-7, the other end of the bar 4. The system assures turning performances of the car, but it is constructive complicated.

4. CONCLUSIONS

The problem of the integral steering is not clear, the surplus of maneuverability and stability being decreased by the constructive complication, meaning by the cost price. There are necessary researches for harmonize the contradictory demands of this problem.

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[8] United States Patent, nr. 4.941.672