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# Modernization of the Audi 90 suspension in preparation for the rally

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**Abstract.** The paper considers the vehicle sports – technical sports. The authors put special emphasis on racing, rally and some other kinds of technical sports where ground-based vehicles, i.e. cars, are employed. The work is devoted to the history and evolution of the racing sport and technical development of sport cars. In addition, the authors also mention the founders and geography of spreading the sport since its origin. The classification and design of racing cars are analysed and discussed in this paper. Technical requirements and standards have been taken into account while considering the peculiarities of the sport cars, without which no sport car is allowed to participate in any sport motor racing event.

## 1. Introduction

Racing is a technical sport, which uses a ground-based vehicle – car. Initially, the word “car” denoted a steam wagon made by French mechanical engineer Qunion in 1769. The model of the world's first mechanical crew is kept in the national Museum of arts and crafts in Paris. 1885 was considered to be the year of car creation. Its inventors were German engineers G. Daimler and K. Benz.

Motorsport in pre-revolutionary Russia was characterized by the first car races between the cities, especially between St. Petersburg and Moscow, one-mile races, motor races and other competitions. The first “motor race” in Russia took place on October 23, 1898. It happened near St. Petersburg between the railway stations Alexander and Strelna Warsaw railway at a distance of about 40 miles (42.6 km). The term “rally” as a type of motorsport was first used in January 1907 during the first rally in Monte Carlo [1].

The rally took place for the first time in 1894. It was a race between Paris and Rouen with the support of the newspaper “Le Petit Journal”, which caused considerable interest of the public and leading manufacturers. The prizes were awarded by the jury based on the reports of observers sitting in each of the cars: Panhard and Peugeot won the race.

This event marked the beginning of a period of road racing between cities in France and other European countries. In that period, the organizers established many of the rules that exist today. These are separate start, checkpoints on the road, road notes and legends, a long drive on ordinary, mainly gravel roads in any weather and season. The cars used in motorsport have been classified according to various criteria and characteristics, which have been regulated by the International sports code (for Russia - classification and technical requirements) [2].

But American entrepreneur William G. France created one of the most popular car competitions in the world. Back in the thirties of the 19th century, France organized the car race and understood that the audience like such competitions maybe more than the competition of special racing cars [10].



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Rally of the third categories is the most affordable type of official motorsport; anyone can take part in it! It is possible to participate in any car category B without any special training.

Rally of the third category is amateur competition. According to the principle of organization this is rally of the first category with the difference that instead of special sections its route may include additional competitions that can be held on the roads open to public use. And the speed of their passage is not necessarily a determining factor for achieving the results of these additional competitions [12].

Rally of the third category, in contrast to the usual rides, is classified events. Participating in them, one can get the real sports titles including candidate master of sports in motor racing [6].

In different regions of the country races of the day are called differently: sprint, mini-rally. But the essence of such competitions is the same: the participants compete on a compact route consisting of several passes on one or two short special stages.

Initially, such races attracted mostly amateur pilots; professionals considered it unwise to participate in competitions consisting of some 20 - 40 kilometers, were disinterested in sports terms. However, today the picture has changed, the relevance of the weekend races is obvious, they are already held in a dozen Russian regions, and the "quality" of the tracks on them has grown considerably. And the result is that rally in a compact format attracted not only fans but also professionals [7].

For example, the "Luzhsky rubezh" rally, a sprint in Leningrad and Novgorod regions in the 2015 season, gathered up to six dozen crews at the start.

The regional sports federation of automobile sports of the Chelyabinsk region, and the federation of automobile sports of Ozersk district (Chelyabinsk region) announced 2018 as the year of the multi-stage "Open championship of Chelyabinsk region" in the 2018 rally including rally of the third category.

This year the fifth stage of the cup of Russia and the first stage of the open championship of Chelyabinsk region on rally 2019 have already been held in the city district of Kyshtym and Ozyorsk city district.

On the first day of the competition, the racers overcame 19-mile snow that covered track, which runs in the forest between the villages of "Kosoi most" and "Kuwatal". Special sections of the second day of the is 87.3 kilometers, total distance – 191.54 kilometers.

Athletes from Sverdlovsk, Chelyabinsk, Kurgan, Tyumen regions, Perm region, Udmurtia, Bashkortostan apply for participation in the rally. In total, the list of declared crews includes 44 participants among Russian athletes and European rally stars.

## 2. Rally

Rally is a kind of car racing, taking place on open or closed tracks, using modified or specially built cars. This type of race is characterized by the fact that the races are mainly laid on public roads in the format "from point A to point B" with the passage of control points. Pilots go at a maximum speed only along specially blocked high-speed sections. And athletes move from one special stage to another, observing all traffic rules and for a strictly defined time standard [3].

There are two main types of rally: special tracks for rally of the 1 category and public roads for rally of the 3 category. Beginning with the 1960s, race on special tracks became professional in the sport. They are held on high-speed roads, isolated from general traffic. These roads can be asphalted mountain passes, complex forest trails, snow and ice tracks, as well as hot deserts.

Rally is unique in terms of choice of place and time of races. Races are held on any surface and under any conditions: asphalt, gravel, snow and ice, and sometimes all together in one race [4].

The standard race consists of special stages (up to 50 kilometers), when in fact there is a struggle and "distillation stages", when cars have to get to the next stage. This is the difference between rally cars and other racing cars; they retain the right to drive on public roads [5]. A lot of journalists cover this competition. Foreign and Russian scientists, as a rule, only analyze the passage of car racing stages and their training. So Gerasimov N.P. wrote the article "analysis of the development of motor sport in Russia in the historical aspects of the participation of the team "KAMAZ-MASTER" in the international rally raids" for the collection "Sport and physical culture: theoretical and applied aspects of scientific

knowledge”. V.G. Doronkin, A.S. Lyamkin in their article “Development of automotive sports in Toliatti” covered the development of the rally in the regions.

On March 17, 2019 on the territory of the ski complex "Sunny valley" in Miass, Chelyabinsk region, amateur competitions "Ground autosprint" were held, in which anyone could take. The track was in the field, the trajectory was fenced tires.

The first attempt to organize an ice race in Miass was in the winter of 2016, but then the organizers failed to obtain the necessary permits. In the summer of 2017 there was the competition “automobile multiathlon” with speed maneuvering between the cones. In the winter of 2018, the participants of the winter races on the ice met at three stages of the competition: in January, February and March.

The race was organized by two brothers, Yuri and Roman Naiman. The men were actively assisted by father Vladimir Naiman, master of sports in auto racing, a participant in the European track trial championship. Family friends also helped whenever it was necessary. Yuri and Roman were addicted to car racing for 5 years, participated in various amateur competitions.

Cars can be divided into 10 classes from sports to standard, including one class called “lady”. Competitions were popular and the organizers had to introduce a limit in the preliminary applications - 90 cars.

### **3. Selected components to refine the suspension**

Let us consider some of the technological features of sport cars referring them to the class of motor racing cars. The first feature is a mechanism called an absorber.

#### **Absorber**



**Figure 1.** Absorber OHLINS TTX (Rally Group N).

Figure 1 shows an inverted shock absorber, so there are no bending loads on the rod, there is no external mechanical impact on the rod; stones, dust, moisture do not fly.

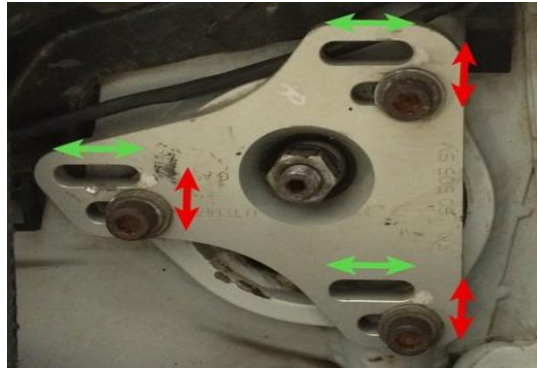
The presence of a remote tank allows you to increase the stroke of the shock absorber, because the gas and the separation piston is not on the axis of motion of the shock absorber rod. A larger volume of oil inside means greater resistance to long-term loads with different amplitudes and as a result less heating. Great resistance, in this case implies no effect of foaming oil and loss of performance.

It has adjustments such as fast compression, slow compression, release, preload spring by moving the lower spring support.

During the race, the standard shock absorber does not allow the car to go at a high speed on bumps, pits, jumps, as it can not withstand high loads acting on it while overcoming the track.

The next mechanism is the top support.

#### **The top support of the shock absorber**



**Figure 2.** The top support of the shock absorber.

Figure 2 shows the support of the shock absorber strut, which allows you to adjust the angles of a camber and castor (the rear axle of the car does not require castor adjustment), made entirely of metal without elastic elements. We applied a bearing type “Swivel” because the shock absorber strut, due to the kinematics of the suspension, rotates in three planes, and the rolling bearing would work on the fracture. On a standard car this mechanism is made of rubber material with a metal clip. In the center there is a rolling bearing so that the shock absorber rod can rotate when turning the car wheel.

During the race, the standard support quickly fails, the rubber element and the rolling bearing are subjected to high loads. The rubber is used in crumpled broken suspension kinematics and stray wheel mounting angles. [9]



**Figure 3.** Reinforced tubular lever of the car suspension - Audi 90 1985.

Figure 3 shows sports wishbones, tubular, performance, durability for Audi 90 quattro. The mounting platform of the ball bearing is made with the ability to adjust the angle of the wheel camber, which allows you to adjust the camber angle to improve the handling of the car on different types of coating tracks.

The ball bearing is made according to the type of “Swivel Joint”. There are cases when during the competition the car moves off the track in a side slide hitting the wheels against the parapet. Standard stamped levers do not withstand such loads and crumple, and with reinforced sports levers they have a high chance to continue the race without loss.



**Figure 4.** Swivel bearing of the company Fluro installed in the lever.

Figure 4 shows the Fluro swivel bearing mounted in the suspension lever. The use of this element instead of rubber-metal hinge type "silent block" makes it easier and more accurate to adjust the angles of the wheels. Static adjustment is not greatly disturbed when driving. The suspension on the basis of its kinematics is more accurate. The car goes through the transitional phases of control faster. During standard race, the rubber "silent blocks" is easily damaged, because the rubber element crumples and gets wheel alignment.

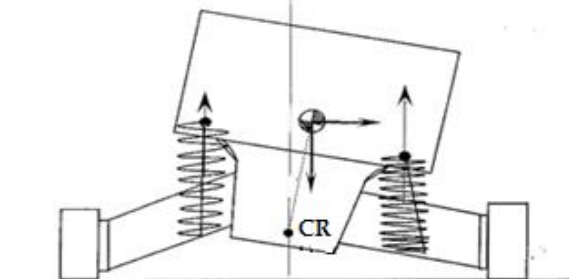
#### Steel bushings for attaching the subframe to the body



**Figure 5.** Steel sleeve welded to the subframe of Audi 90 1985.

In a standard car in the subframe, mounted rubber is a metal "silent blocks" through which it is attached to the body. At the race, rubber-metal "silent blocks" quickly fail due to high loads, resulting in stray wheel angles, suspension does not work correctly (figure 6), as they are elastic elements, which adversely affects the driving. When the driver performs a lateral maneuver due to the impact of disturbing forces on the car, a lateral (centrifugal) force directed from the center of rotation begins to act, which causes the appearance of a lateral roll and lateral reaction forces in the spots of contact of its tires with the road surface [8].

To describe the nature of the lateral roll, the concept of the center of the transverse roll is used. The center of the cross roll (CR) is an imaginary point in a vertical plane which passes through the centers of the wheels, and when you roll the car at any given point, in time it remains stationary.



**Figure 6.** Diagram of the roll of the vehicle.

To prevent this, instead of rubber-metal "silent blocks" we installed steel bushings, which are shown in figure 7.

#### Stabilizer bar



**Figure 7.** The stabilizer bar of Audi 90 1985.



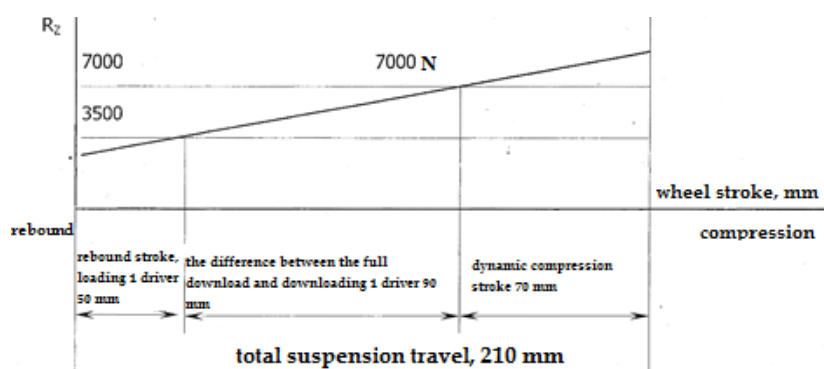
For the correct suspension settings, sports cars need different hardness stabilizers. For Audi 90 quattro there are 3 types of stabilizers of different stiffness; the thickness of which is 19, 22 and 26 mm. For tracks with slippery surfaces such as snow and ice, soft stabilizers are used. For ground, gravel coatings we use stabilizers of medium stiffness. For asphalt pavement we use rigid stabilizers.

#### 4. Conclusion

After replacing these parts, the elastic characteristic of the car suspension is increased almost 2 times.

The quality of the suspension is determined by its elastic characteristic, which is the dependence of the vertical load on the wheel ( $G$ ) from the deflection of the suspension, measured directly above the wheel axis. Due to the influence of friction and other factors, this dependence is different in the course of compression and rebound, for the elastic characteristic of the suspension conditionally it takes the middle line between these curves [8].

Also, the elastic properties of the suspension are characterized by static deflection, dynamic motion, suspension stiffness, energy intensity and a number of other parameters.



**Figure 8.** The elastic characteristic of the suspension.

These components of the suspension are suitable only for participation in competitions. Driving in urban conditions with the use of such improvements will be uncomfortable, because removed multiple rubber elements that make the suspension softer at low speed shock absorbers are too hard; they are designed for high loads and high speed to overcome obstacles.

Such components as a shock absorber, a shock absorber upper support, levers have settings and adjustments to improve the handling of the car for a specific type of track and weather conditions [11].

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