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Development of a Universal Transport Services for Traveling Facilities, Signaling and Communication in Railway Transport

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Abstract This article presents information on the development of a promising vehicle structure having the ability to travel, both on the track, and on different roads and off-road. For this purpose a number of devices enabling transfers running gear, both in the state of their movement along the rails, and to normal operation provides the latest in their normal conditions. Calculate the main kinematic and geometric parameters of a number of such structures. Development of recommended research and industrial structures in the automotive industry for its further consideration and possible implementation in practice.

Keywords Wheel and an Additional Drive, Rail Head, Disc Springs, Stiffness of the Tire

1. Introduction

Efficiency of rail transport is mainly based on the improvement of the operational organization of the railways, the technical condition and modernization. At present, the system of "Russian Railways" are widely used modern means of automation, remote control and communication that greatly improve the throughput plots, traffic safety and productivity of the railway, which provide operational control of complex processes traffic. At the same time, the growth of implanted hardware is naturally not the solution, as the regularity and safety in highly dependent on the reliability of the devices, which provides maintenance and depends on the level of organization and management of the whole economic signaling, communications and computers railways.[1-3]

A crucial stage in the organization of repair and maintenance of automation systems and communications service SHCH line is the delivery of repair crews in the workplace, which is produced mainly by the use of technical means of rail and road transport. Often these transport operations are not always effective, and therefore being sought ways to create versatile vehicle capable of moving both on roads and off-road and on the tracks. At the same time it is known that such universal craft widely used, for example, Canada and the USA. Such vehicles are equipped with sophisticated device on the base with the optional wheels (rollers), controlled by the translation of the provision, which was used for the movement of it along the track in a position where it has to navigate through the different roads and off-road. However, despite its structural perfection, they all have significant disadvantages in that they have a significant own weight, requiring a complex hydraulic system of transfer from one position to another, as well as their design speed when driving along the track is much lower than at the railway rolling stock.

However, despite its constructive perfection they have a significant disadvantage in that they do not have the ability to move on rails railroad. We know that in Russia there are sections of railway track length of over hundreds of kilometers, for example, in Karelia, Siberia, the Far East, etc., which are completely isolated not only from the road, but also completely impassable, and therefore access to them by road excluded.

In Yelets state university of I.A. Bunin for a long time jointly with MIIT conducted study on request by the Office of UVJD branch of JSC "Russian Railways", focused to improve the quality exploitation line work of business UVJD and one of the sections this scientific work to create a universal means of transport and is dedicated to this article.

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2. The Purpose of the Study

Given the foregoing, the purpose of this study is:

1. Development of a number of promising designs versatile vehicle that can travel on public roads, roads and rail tracks that have simple design, efficient use and referred to the domestic road vehicles.

2. Development of the method of calculation of one of its nodes, they enable the geometric parameters of propulsion and can transport vehicles both on roads and off-road, and on the railway tracks.

3. The development of a computer program allows you to automate calculations of the above procedure for vehicles of different capacity and types.

3. Methods

Analysis of multiple bibliographic sources, as well as domestic and foreign patents[7, 9 - 14], allowed us to develop a number of technical solutions recognized inventions(RU2255004, RU2268156, RU2277049, RU2264944, RU2284923), who can successfully solve the problem associated with the operation of company cars able to move both on public roads, off-road, and if necessary on rail tracks. The first solution is the wheel of the car-bound, for example, the UAZ-451M, which (Fig. 1) between the disc and the brake drum is an additional drive.

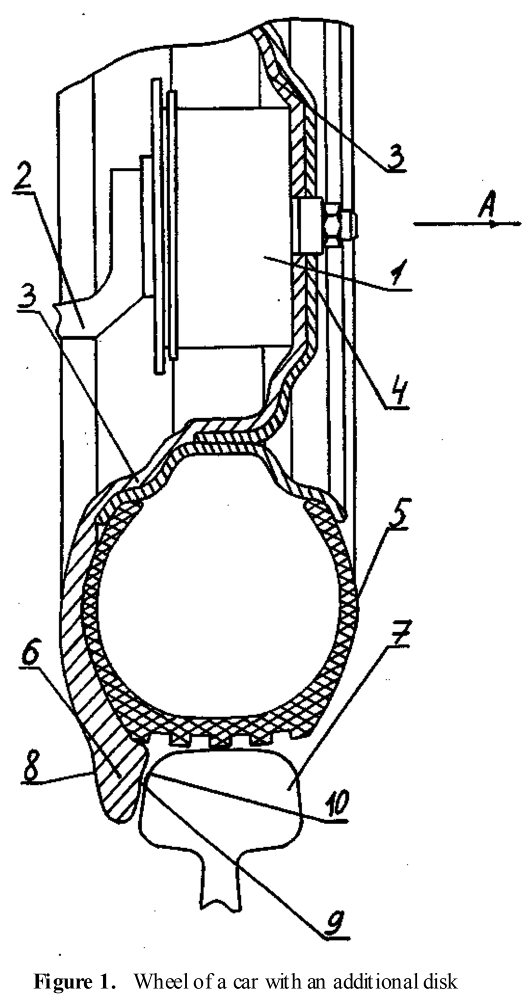

Figure 1. Wheel of a car with an additional disk

Profile is identical to the profile of an additional disk drive wheels to the boundary interface to the bus and then changing its curvature adequate sidewall of the latter, and in the area of the curved wall thickness made additional disk larger than in the previous section of the profile, and its outer circular manner established in the form of the crest, which on the one hand has a curved surface to mate with her side face head railroad tracks, and on the other surface, it provides easy access to the elements of the railway track switch.

The work of the vehicle wheels is as follows. On-road and off-road vehicle has wheels, consisting of wheels and tires, and so he moved on the roads, as all trackless wheeled vehicles. In case you need to transport repair crews to emergency sites spans railways, equip it with additional disk 3 as follows.

Car fitted to the track, and all of their last four wheels run over the surface of the rail head 7, for example, holding the position of your tires 5 as shown in Figure 1. After that, well known in the art, or lift it various cranes at a small height and unscrewing the nut, remove the four wheels with tires 5, moving them along the arrow A. Then, pre-prepared disks 3 installed on studs brake drums 1, moving three additional drives in the direction of the arrow A. install additional disks 3, joining them to the end of the brake drum 1, in the direction of the arrow A, attached to the last four wheels and attach them as is the case for holding the wheels on cars. Having finished this vehicle mount is lowered onto the head rail 7 and its tires rest on the surface as shown in Figure 1.

In the future driver of the car is also widely known in the art, locks the steering and the car begin to move. In this case, due to the presence of ridges 6 bus 5 cannot get off the rail head 7 as ridges 6 are from the rail head 7 the curved profile which, for example, is used for bandages locomotives. Once, when there is no need to use a car to run on the rails, the additional disks 3 dismantled in reverse order, as described above, and it can again be operated on different roads and off-road.

The second solution is a family car "Gazelle", in which the steering wheel and rear are designed as double (fig 2) and in the space between the discs of each pair of wheels with the ability to share with them the rotation posted resilient spring-loaded metal disc dished shape with varying thickness in certain areas in its generator and resilient air balloon in contact with said metal disc, made with a profile, adequate profile of the outer surface of the head rail train and play the role of the wheel flange to allow operation of the vehicle on the railroad tracks in finding the specified elastic air cylinder pressurized air, or - with the possibility of traffic on various roads and homeless rye - no pressure.

Work universal vehicle is as follows. When driving it on the roads with different surface and off-road air pressure in the air cylinders 11 no elastic and they are under the influence of the elastic properties of Belleville disc form 9 and compression springs 10 are in the leftmost position, deforming the resilient air cylinders 11 of the arrow A. n this case, the external image profiles 15 drives do not touch the road 9 and 13 are from her with some clearance 5. When you need to make a vehicle on rails, customize it to last (it is convenient to do, such as crossing or on specially prepared for this site) and place it so that the tie 3 and 4 rear dual wheels housed as it is shown in figure 2. After that, well known in the art supplies compressed air to the elastic air cylinders 11 and extend the impact of the past on the dished shape discs 9 and elastically deform them in the direction of the arrow A, while compressing the compression spring 10. The elastic deformation of discs 10 leads to the fact that they get a linear movement of the arrow B. As a result, nine discs fit head 16 rail 14 and took a position as shown in Figure 2. The vehicle is ready for movement on rails 14. In this case, the tire coming off the rails 12 14 is excluded, as the elastic dished shape discs 9, acting as a paddle wheel, as is the case for rail vehicles (locomotives and wagons), securely holding them on the track. It should also be noted that before driving the vehicle on rails, in order to avoid double wobble steering wheels 3 and go off the rails 14, block them well-known in the art. If necessary, the vehicle on the road outside the railway track, the air pressure in elastic air cylinder 11 is removed, which ultimately allows the plate disc form 9 go to the state shown in figure 2, and the steering is unlocked. Next, the process of translating universal vehicle from one location to another can be performed repeatedly. Another technical solution is shown in Figure 3, is a construction trailer, which folding ladders installed on both ends of the frame and connected, in its longitudinal plane, rods, pistons are slid ably located in the case of floating cylinders, mentioned ladders fitted elastic stops interacting in the transport position the trailer with front faces trackless self-propelled vehicle and provided with a lock of their situation, and on the floor of the frame for rotation has at least two pairs of horizontal, in its transverse plane rolls with grooved bearings, made in the form of the hyperboloid equipped with brake and gears interconnected with counter rigidly fixed on the axis of wheel sets, wheels are fitted with crests and have the appropriate profile rolling their interfaces with the rail head of track, and, trackless self-propelled vehicle is equipped with a rotating cantilever crane, adequate own weight unlade trailer

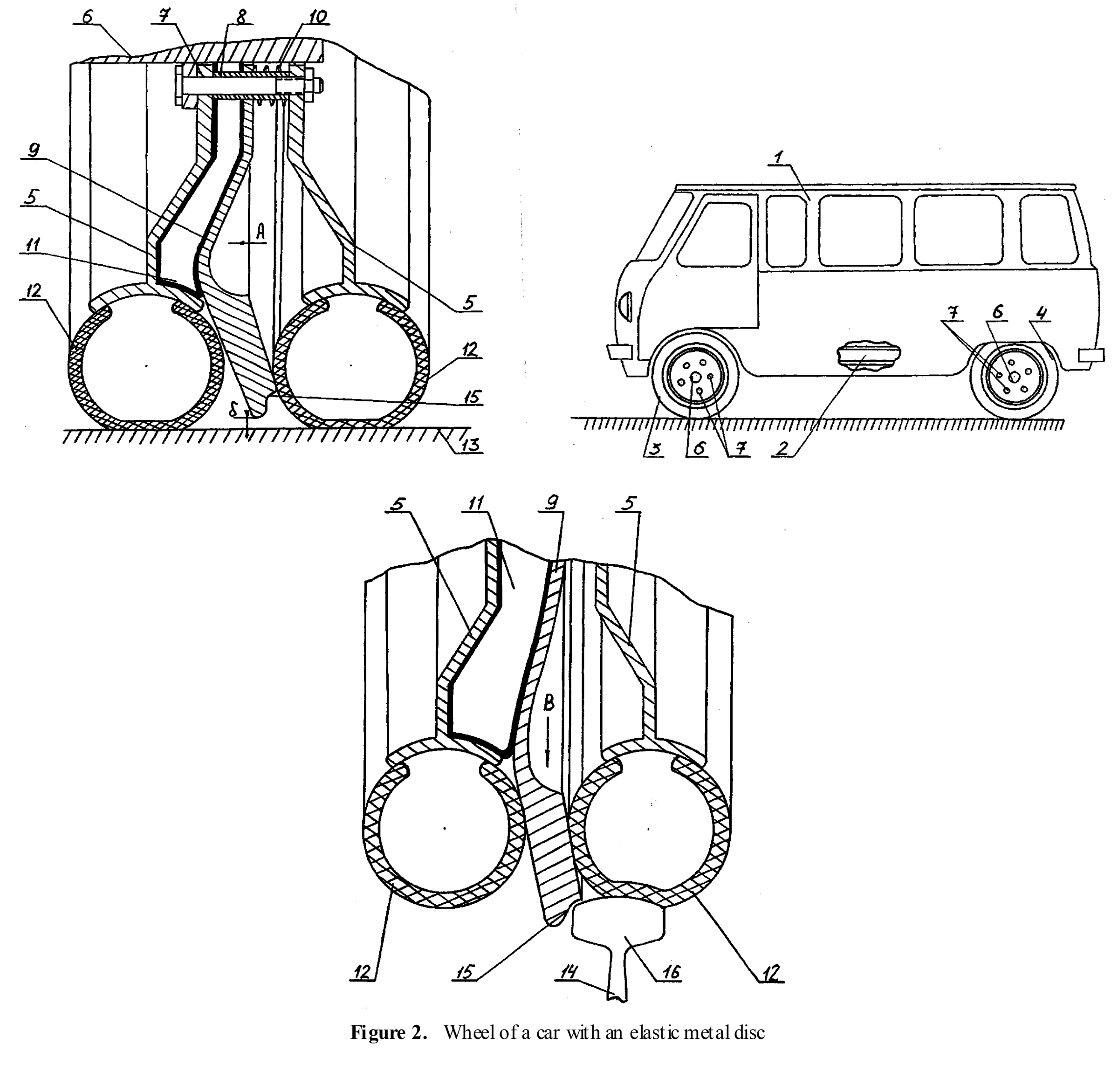

Figure 2. Wheel of a car with an elastic metal disc

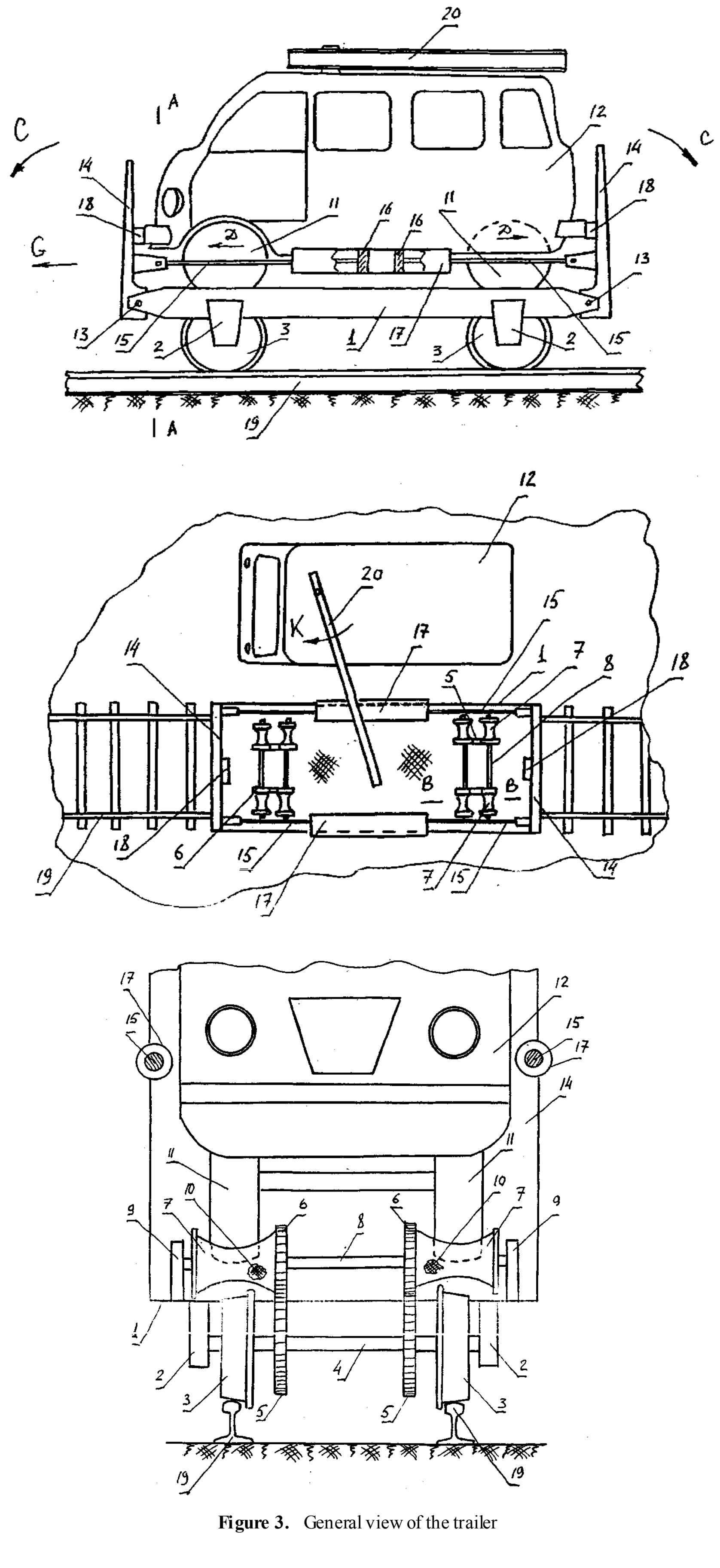

Figure 3. General view of the trailer

Works trailer (fig. 3) as follows. For service on the railway run, where it is possible to drive wheeled vehicles railway track in close proximity, delivery maintenance teams carry cars and in this case, for example, van model UAZ-451M. In those cases where a team to deliver to the work site by road is not possible (cross-country, swamps, bogs, impenetrable forests, mountains, etc.), then use the trailer, upon which the vehicle 12. The process of this installation is the following. At first trailer remove or dismiss the clips that secure folding ladders 14 in transport upright and last, swiveling 13 to arrow C, stacked with their ends to the rails 19. Since the rods 15 are connected with folding ramps 14, and they share with their pistons 16 are nominated by the arrows A, moving in the cylinder 17. The vehicle 12 starts to move to one of folding ladders 14 forward and reverse, and then moves on frame 1, and subsequently their tires 11 is located between the rollers 7. Such movement of the vehicle 12 is locked wheels 3 trailer, and he cannot move along the rails 19, 11 when the tires go on folding ramp 14 and rolled on rollers 7. As soon as his car 12 tires 11 located between pairs of rollers 7 of its driver with a source of compressed air, placed on the car 12, connect it to the cylinders 17 and its stocks under pressure air begins to move in the direction of the arrow A, which ensures the angular rotation folding ladders 14 in the direction of the arrow C. Air pressure in the cylinder 17 serves as long as 14 folding ladders its supple stops 18 come into contact with the end of the car, which ensures a secure hold on the last frame of one trailer. After that, the driver of 12 records upright folding ladders 14. He then cuts off the compressed air in the cylinder 17, to lock the steering wheel brakes dissolve 3 and with aid gears the car 12 delivers torque T on wheels. Under the action of the torque T rollers 7 will rotate the arrows E and then their gear 6 provides the rotation of gears 5 by arrows F. And as the five gears are rigidly fixed to the axis 4, the wheel will also have three rotation, and a trailer with a car begins to move the arrow G. Velocity of the trailer, as well as inhibition of its motion along the rails 19, the driver of change and produces the same technical facilities, which are available on the latter, that is, using the throttle carburetor engine gearbox and hydraulic brake control wheels. It should be noted that the bus 11 by the presence of a roller 7 corrugation 10 have reliable frictional contact and thus ensure stable motion trailer. Reaching the work site, the driver stops moving the trailer and the wheels braked 3 release latches folding ladders 14, which are then stacked on the arrow C the rails 19 through the motorized 15 riflemen D under the pressure of the compressed air in the cylinder 17. Once this happens, the driver unlocks the steering and forward and reverse drives off the trailer frame 1 by folding ramps 14 on the railway line and then on his shoulder. After that, the car is braked, the driver turns jib crane 20 on the arrow K, and produces the trailer for his slinging frame 1. In the future, lifting it above the rails 19 by turning the boom jib crane 20 of the arrow K, until the trailer is off-track dimensions. After that, the driver puts it on the ground. As a result, the way is clear, and it may be followed by a train. After finishing repairs and through the existing relationship with the manager and received permission, which can be set back on track trailer, the driver, just as it was described above, places the car on a trailer and move it along with a team of workers to the place where this technique is attributed to the land based repair team. Further, the process for the delivery teams of repairmen to the place of work is repeated. As can be seen, each of the above structures will be in the field, as well as benefits and drawbacks. For example, in the first case of the installation and dismantling of conventional wheels, their replacement wheels fitted with wheels is quite laborious and carry with it additional discs with crests are not always convenient. Described the latest trailer, carrying a car-van, also may not always be used, especially in cases where there are no sites along the way on the mound and so no car, no trailer to place on such sites is not possible. Given this, and the fact that the second solution, shown in figure 2, is more convenient and versatile in operating conditions, we take it as recommended by the automotive industry model and calculated its basic geometrical parameters. To study the force loading wheel and main parts calculate its basic parameters developed analytical model shown in Figure 4, which provides a resilient metal disk as one disk spring-loaded force created by the elastic air balloon with two internal overpressure.

To determine the elastic stiffness of the air cylinder conventionally cut out part of its radius (fig. 4), and then the balance of this element can be written as $P = p \cdot S_{эфф}$ where $S_{эфф} = \pi \cdot r_0^2$.

Relationship between load and pressure can be obtained using the principle of virtual displacements[18], which has the form:

$$Qdf + pdV = 0$$

where: df - the deflection wall air balloon.

dV - change the volume of the container in the presence of depression df.

Design scheme wheel drive with an elastic

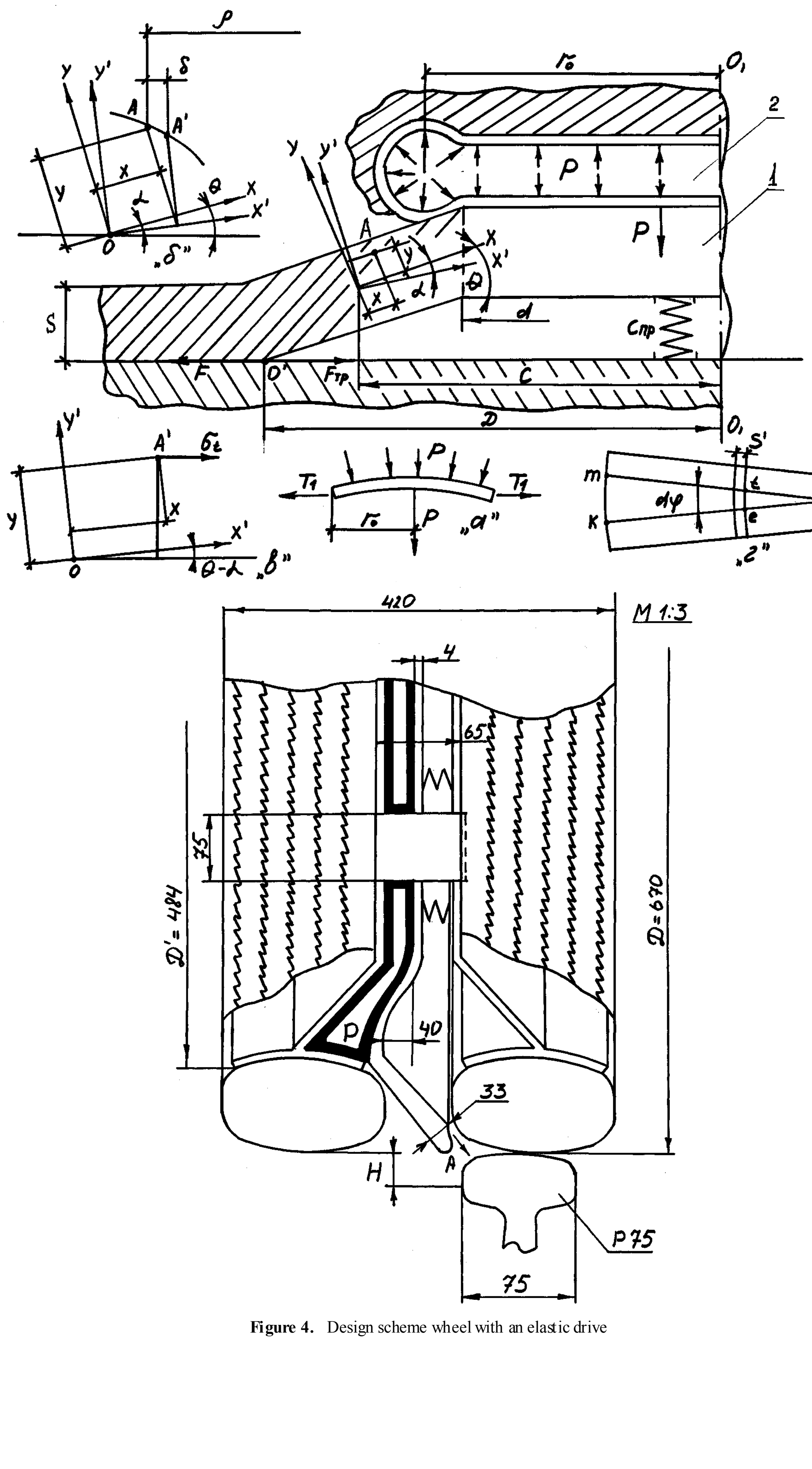

Figure 4. Design scheme wheel with an elastic drive

This equation implies that the derivative of the volume element on the deflection $\frac{df}{dV} = -S_{эфф}$ equal to the absolute value of the effective area of the air cylinder. Since in the present value *p* и *V* of these dependencies and how aware they are related by the equation of gas state:

$$(p+1)\cdot(V+V_p)^n = (R_0+1)\cdot(V_0+V_h)^n \qquad (2)$$

Where: *n* - the polytropic an isothermal process is equal to 1, and when the heat is present its value is 1.4;

V - The volume of the receiver.

Integrating two get:

$$V = V_0 - \int_0^f S_{эфф}\cdot df\,. \qquad (3)$$

Solving this equation is widely known methods can obtain an expression for the stiffness of the air cylinder:

$$C бP = (\ +1)\frac{nS^2_{эфф}}{V+Vp} + p\frac{dS_{эфф}}{df} \qquad (4)$$

One of the terms of this equation depends on the design parameters and the method of loading an air cylinder, and the other only defines the process of forming it.

Under the action of the force *P* generated by the air cylinders, disc springs 1 will also deform elastically, while squeezing the return spring stiffness C_{np}.

Assume that the load P meridian section plate spring turned at an angle α (Fig. 4) with respect to an arbitrarily chosen point O at a distance from the axis of symmetry, and then, for example, randomly selected point A with X and Y, which are unchanged, close to the axis of the disk spring by an amount δ. Because of the smallness of the angles α and θ can write the equation:

$$\delta = X\alpha(\theta - \frac{\alpha}{2}) + y\alpha \qquad (5)$$

The relative linear deformation in the circumferential direction at point A at a distance ρ is defined by the equation:

$$\varepsilon_\tau = \frac{\Delta\rho}{\rho} = \frac{x(\theta-\frac{\alpha}{2})+y}{(c-x)}\alpha \qquad (6)$$

Consequently, considering the body as a circular disk spring board, the normal stress in the meridional section in accordance with Hooke's law can be written:

$$\delta_t = E\varepsilon_t = -\frac{x(\theta-\frac{\alpha}{2})+y}{(c-x)}\times E\alpha \qquad (7)$$

If we consider the equilibrium condition of the floor plate spring plate (Fig. 4), the sum of all the forces acting on the selected item ekmt axis is given by:

$$\frac{P(D-d)}{2}\times\frac{d\phi}{2\pi} = -2\int_F \delta_t\frac{d\phi}{2}\left[x\sin(\theta-\alpha)+y\cos(\theta-\alpha)\right]\cdot dF \qquad (8)$$

Integrating this equation, one can obtain an expression that indicates the force P required for the elastic deformation of the disk spring, which should be created by an air balloon:

$$P = \frac{2}{3}\frac{\pi\cdot E\cdot S\cdot\lambda_1}{(D-d)^2}\ln\frac{D}{d}\left[(f-\lambda_1)\left(f-\frac{\lambda_1}{2}\right)+S^2\right] \qquad (9)$$

where:

f - the height of the inner cone of spring;

λ_1 - elastic sediment can be chosen equal to 0.8;

D - outer diameter plates;

d - inner diameter plates;

S - the thickness of the sheet tray.

Using the above representation of dependence, and the geometric dimensions of twin wheels vans family "Gazelle" and ignoring the return spring stiffness due to their small we make the calculation efforts, needed for the elastic deformation of a metal disc dished form, and set the course of his rational in the radial direction for the following values of initial data: f=40мм, , λ_1= 0,8 f = 32 *мм*, D=670 *мм*, d = 280 *мм*, S = 4 *мм*, E=2,1·10^5^ *МПа*. Substituting these values into the formula 9, we obtain the numerical value of the force required to drive the elastic deformation dished shape.

$$P = \frac{2}{3}\cdot\frac{3{,}14\cdot 2{,}1\cdot 10^5\cdot 4\cdot 32}{(670-280)^2}\cdot\ln\frac{670}{280}\left[(40-32)\left(40-\frac{32}{2}\right)+4^2\right]$$
$$= \frac{160768000}{456300}\cdot 181{,}3 = 63877{,}4H = 6387{,}7кг$$

We now define the surface area of the disc dished form, which is a ring with dimensions D' = 484 *мм* и d = 75 *мм*.

$$S_K = \pi\left[\left(\frac{D^1}{2}\right)^2 - \left(\frac{d}{2}\right)^2\right] = 3{,}14\left(24{,}2^2 - 0{,}38^2\right) = 1838 см^2$$

Taking pressure $\eth$ =3,8 $кг/см^2$ (0,38 *МПа*), generated by a compressor mounted on the car, we define the force that will push the air in the expansion air-balloon.

$$P^1 = p\cdot S_K = 3{,}8\cdot 1838 = 6984кг = 69840H$$

Hence and then dished disc shape to move the value of the arrow A is the order of 20 mm and comes in contact with the rail head, where the value is the disk radial extension dished shape.

Consider another solution recognized invention RU2284923, which aims to modernize the propulsion company cars, able to move as well as the previous one, as on public roads, off-road, and if necessary, by rail. This versatile vehicle, in contrast to the known, consists of a body, equipped with front-steering-wheel and rear-wheel drive. The wheels are mounted on movable axes and their bizarre plots, also placed movable arms with castors. Support rollers are provided with ridges. In levers through openings for the location in which clamps set also mentioned axes. Rollers in contact with the rails. When the vehicle is on the road and off the levers of support rollers are fixed in the transport position, in case of need the movement of his arms on rails convert the vertical operating position so that the wheels of the car are movable on the support rollers. To study the force loading of main parts of the proposed mover in driving around a track and calculate its basic kinematic and geometric parameters developed analytical model (fig. 5), representing the tire and wheel in a weightless ring having a free wheel radius resiliently connected to the hub.

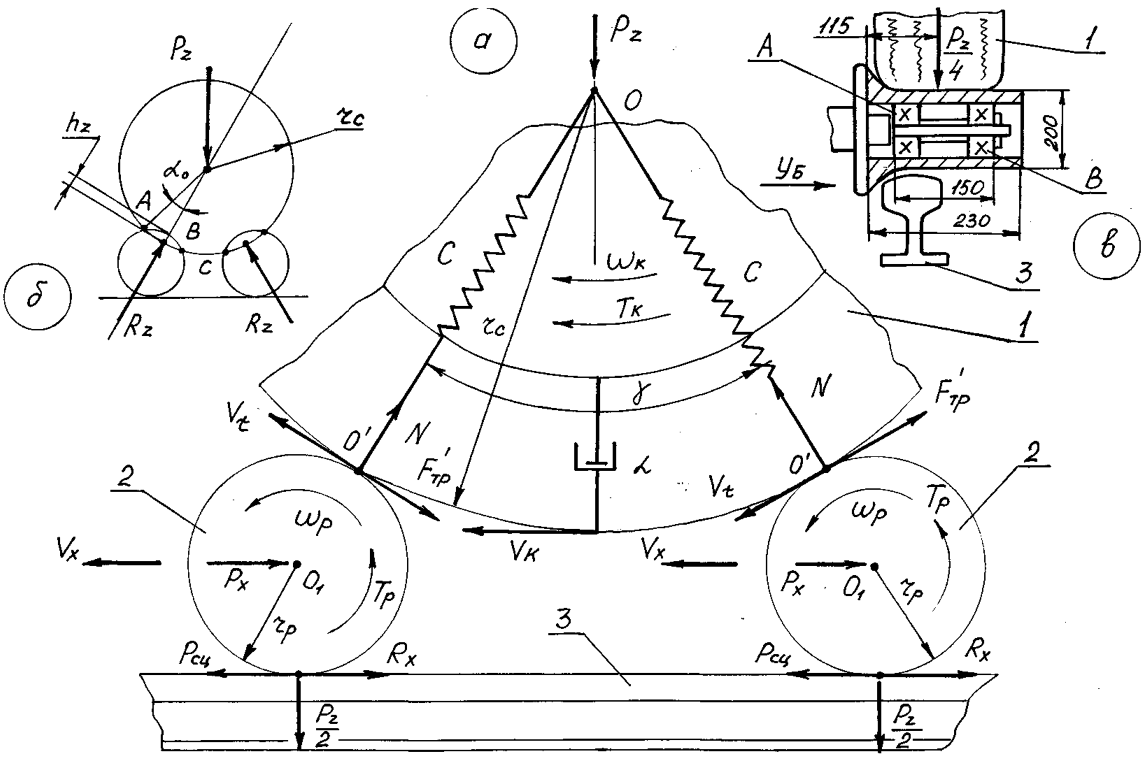

Figure 5. Estimated scheme of propulsion with supporting rollers

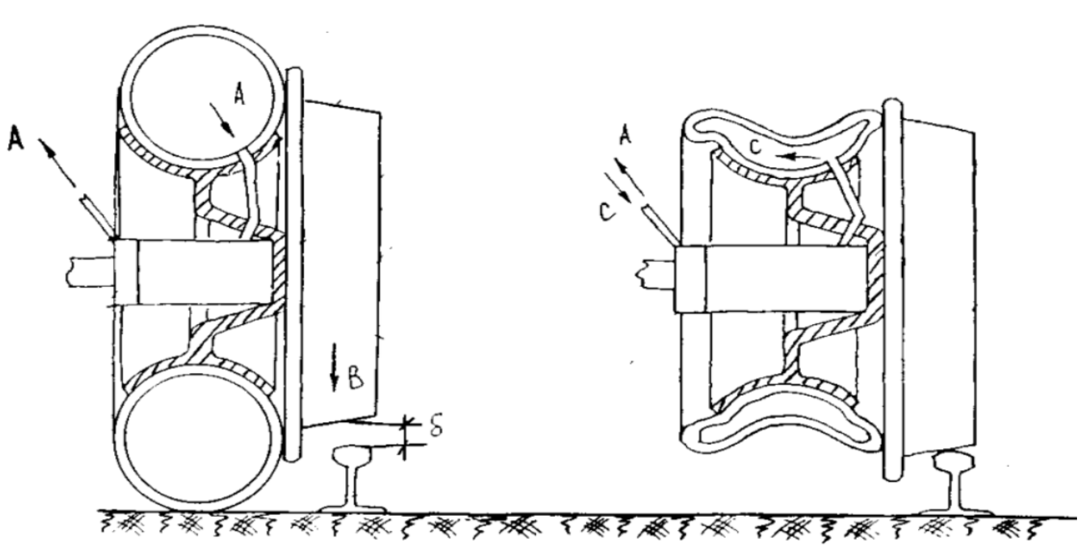

Figure 6. Elastic wheel with integrally metal disc

Its radial stiffness is characterized by elastic properties of the tire with its damping coefficient. Attached to the wheel vertical load of its own weight the car is transferred to the support rollers with effort $\frac{P_Z}{2}$. Attached to the wheel torque *T*, passing power flow to the support rollers, which rotate with the angular velocity ω_D, thus creating a torque on them *T*. At the points of contact with the wheels or castors attached friction F_{TP} and they have a peripheral speed $V_\tau = \omega_P \cdot r_P$. The rotation of the support rollers contributes to the emergence of forces thrust vector is the same as the angular velocity vector ω_D, and they move the vehicle with a forward speed V_X on rails. Since the rolling surface of the wheel bearing rollers will be different deformation of the tire, the rolling wheels will be associated with a corresponding loss. These losses determine rolling resistance tires of one of the main types of resistance to motion of the whole wheel machine and they are related to the internal friction in the tire, a tire slip on the support surface, sucking it to the contact surface and aerodynamic resistance. To simplify the solution of this problem related to the definition of loss of rolling resistance tires will provisionally assume that the tire undergoes a deformation under the effect of the normal load *N* in the radial direction of her. We also assume that the work done by friction (slip) in contact with the wheels or castors, refer to the work of friction forces radially deformable elements tires. During loading of the tire by N each element in the contact area with the support rollers will move from the value of the radius r_C of the circle in the radial direction and the magnitude ξ of this deformation is determined by the dependence $\xi = r_C - \frac{r_C - h_Z}{\cos\beta}$ /3/,

where:

β - the current value of the angle changing in the contact area with the ground wheel roller;

h_Z - maximum value of radial deformation of the wheel.

Then the work of all the elements of the wheel with a single cycle of loading-unloading describe the integral form[18,19]:

$$A = \int_{-\alpha_0}^{+\alpha_0} A_1\, d\alpha$$

$$= 2k \int_{-\alpha_0}^{+\alpha_0} \xi\, d\alpha = 2k r_0 \int_{-\alpha_0}^{+\alpha_0} \left\{ \frac{1 - \left(\frac{h_Z}{r_C}\right)}{\cos\alpha} \right\} d\alpha$$

$$= 2k r_C \left\{ 2\alpha_0 - \left[1 - \left(\frac{h_Z}{r_C}\right)\right] \ln\frac{1+\sin\alpha_0}{1-\sin\alpha_0} \right\}$$

It is clear that the work $\grave{A}_{2\pi}$ done on the deformation of the wheel one revolution will be more work with a single loading cycle as many times as the number of times an area $S_{2\pi}$ greater than the area $S_{сегм}$ of the ring strain segment generated tire wheel at the contact point with the support roll that is:

$$A_{2\pi}A = A\frac{S_{2\pi}}{S_{сегм}} = \frac{\pi \cdot h_Z(2r_C - h_Z)}{r_C^2\alpha_0 - r_0(r_C - h_Z)\sin\alpha_0}$$

At the same time, the work done on the movement of the wheel one revolution will

$A_{2\pi}^1 = P_{f_0} 2\pi \cdot r_k$, where P_{f_0} the resistance of the wheel rolling.

This work is in uniform motion, and without loss of air resistance can be compared to the work $A_{2\pi}$ and then the power of the driven wheels rolling resistance determined

$$P_{f_0} = \frac{A_{2\pi}}{2\pi \cdot r_k}.$$

Given the above dependence can determine the coefficient of rolling resistance of the driven wheel on the relation[18]:

$$f_0 = \frac{P_{f_0}}{P_Z} = \frac{k}{P_Z r_k}$$

$$\left[2\alpha_0 - (1 - \frac{h_Z}{r_C}) \cdot \ln\frac{1+\sin\alpha_0}{1-\sin\alpha_0}\right] \cdot \frac{h_Z(2r_C - h_Z)}{r_C\alpha_0 - (r_C - h_Z)\cdot\sin\alpha_0}$$

According to this formula, you can not directly calculate the coefficient of rolling resistance, because it is not known, the specific strength k of internal friction. However, its analysis leads to an important conclusion, which is as follows. So with decreasing stiffness $\tilde{N}$ of the tire and, therefore, increase its deformation h_Z rolling resistance increases. By increasing the radius r_C of the wheel is free, and the rolling radius r_K of the rolling resistance is reduced. Experimental studies conducted by loading tires of cars in stand and operating conditions show that the rolling resistance increases almost to the speed of rolling around 50 km / h, with particular intensity of 100 km / h[18]. To define additional component of the coefficient of rolling resistance f_M occurs when rolling a driving wheel is accompanied by additional deformation of the tire, we use the function[18]: $f_M = \frac{\lambda_M \cdot M_K^2}{P_Z \cdot r_0 \cdot r_K}$. The coefficient of rolling resistance of the drive wheel can be written as - $f = f_0 + f_M$. Research conducted in this area show that the additional component f_M is very small and it is essential for large amount of torque needed to move vehicles on bad roads and off-road. Another important parameter is also the ratio of the longitudinal force wheels $K_P = \frac{P_X}{P_Z}$ depends on the wheels of a skid S_{σ}. The greatest value of the coefficient K_P associated with the concept of maximum adhesion φ_{MAX}, which is characterized by the ratio $\varphi = \frac{P_{\varphi}}{P_Z}$, where P_{φ} the force of traction.

Given the above we perform the calculation of the basic kinematic and geometric parameters of the proposed technical solutions using the example as a flying detachment vans UAZ-452 with the following features: freight 800 kg; curb weight 1720 kg; complete front axle load 1260 kg and for the rear1410 kg; a maximum speed of 95 km / h, the base of 2300 mm; the air pressure in the tires on the front wheels0.2 MPa and the rear 0.22 MPa, outer diameter wheel tires 791mm, tire width 218 mm[4].

Assume that the diameter of the bearing rollers is 2 = 200 mm, and then the gear ratio kinematic pair wheel-bearing roller is equal $U = \frac{2r_C}{2r_P} = \frac{791}{200} = 3{,}95$. We also believe that the drive wheel vehicle as it moves at a speed $V_A = 25 км/ч = 416,6 м/мин = 6,9 м/с$ of paved road, has an angular velocity $\omega_{\hat{E}} = \frac{2 \cdot V_A}{2 \cdot r_C} = \frac{6{,}9}{0{,}395} = 17{,}5c^{-1}$. Then the angular velocity ω_D of the support roller will $\omega_D = \omega_E \cdot U = 17{,}5 \cdot 3{,}95 = 69c^{-1}$. Rotation frequency of the reference roller at this rate will be $n_{мин} \frac{30 \cdot \omega_P}{\pi} = \frac{30 \cdot 69}{3{,}14} = 659{,}2 \quad ^{-1}$. Consequently, the path traversed by the support roll, in this case defined as $S = r_P \cdot (2\pi \cdot n_P) = 0{,}1 \cdot 6{,}28 \cdot 659{,}2 = 414м$ the forward speed of the vehicle as it moves along the rails will be $V_X = 60 \cdot 414 = 24{,}8 км/ч$. For sustained driving on rails define the adhesion tires wheels or castors on the dependence of - $P_{СЦ} = \varphi \cdot N = \varphi \cdot P_Z$ respectively for the front wheels and the rear tire grip coefficient taking $\varphi = 0{,}75$:

$$P_{СЦП} = \varphi \cdot N = \varphi \cdot P_Z = 0{,}75 \cdot 1260 = 945кг$$

$$P_{СЦЗ} = \varphi \cdot N = \varphi \cdot P_Z = 0{,}75 \cdot 1410 = 1057{,}5кг$$

We define the basis of the obtained values $P_{СЦ}$ traction on the front and rear wheels:

$$P_{TП} \le (\varphi + f) \cdot N = (0{,}75 + 0{,}015) \cdot 945 = 722{,}9кг$$

$$P_{TЗ} \le (\varphi + f) \cdot N = (0{,}75 + 0{,}015) \cdot 1410 = 1078{,}7кг$$

We also assume that the support rollers are made of steel 50L and as they rolled on steel rails that carry out the calculation of traction force and in this case considering that $\varphi = 0{,}224$ at a speed of $25 км/ч$

$$P^{1}_{TП} \le (\varphi + f) \cdot N = (0{,}224 + 0{,}015) \cdot 945 = 225{,}9кг$$

$$P^{11}_{TП} \le (\varphi + f) \cdot N = (0{,}224 + 0{,}015) \cdot 1410 = 336{,}9кг$$

Then, full traction to prevent slipping crew support rollers should be no more $225{,}9 + 336{,}9 = 562{,}9кг$.

Carry out the calculation of rolling bearings for supporting rollers, specifying their desired dynamic load C_{TP}. Since most loaded of the rear axis of the car $\frac{P_Z}{4} = \frac{1410}{4} = 352{,}5кг$, the lateral and circumferential force, respectively, will $Y_{\acute{A}}$ = $0{,}6\frac{P_Z}{4} = 0{,}6 \cdot 352{,}5 = 211{,}5кг$, $P_{СЦ3} = 1057{,}5кг$. The distance between the axles bearings constructively take equal $150мм$, and the line of action $Y_{\acute{A}}$ is relative to the longitudinal axis of symmetry axis by the amount of the support roller $c = 45мм$. Considering as a beam axle rollers positioned on two supports (supports are roller bearings) and, using the known equation of statics $\sum M_{A,B} = 0$ define support reactions R^{11}_A, R^{11}_B, lying in a horizontal plane rail and R^{1}_B, R^{1}_A, lying in a vertical plane on relationships:

$$R^{11}_B = R^{11}_A = \frac{P_{СЦ} \cdot 75}{150} = \frac{1057{,}5 \cdot 75}{150} = 528{,}75кг.$$

$$R^{1}_B = R^{1}_A = \frac{P_{ZБ} \cdot 75 + Y \cdot 50}{150}$$

$$= \frac{352{,}5 \cdot 75 + 211{,}5 \cdot 50}{150} = 246{,}75кг$$

The overall reaction R_A and R_B calculate the formulas:

$$R_B = R_A = \sqrt{R^{1}_B + R^{11}_B}$$

$$= \sqrt{246{,}5^2 + 528{,}5^2} = 583{,}3кг$$

Install the bearing life $L_h = 25 \cdot 10^3 часов$ [21] and then we define a desired load bearing on the dependence:

$$C_{TP} = R_A \cdot \left(\frac{60 \cdot n_P L_h}{10^6} \right)^{0{,}3}$$

$$= 583{,}3 \cdot \left(\frac{60 \cdot 659{,}2 \cdot 25 \cdot 10^3}{10^6} \right)^{0{,}3}$$

$$= 4617{,}7кг = 4{,}6кН$$

According to GOST 333-79 on tapered roller bearings tapered roller bearings choose row light series number 7206 with a dynamic load capacity $C = 31{,}0кН$. We see that this value is 6.7 times higher than the estimated required value. But it is done on the basis of the design considerations of the layout of the site and the selected axis of the roller diameter equal. It should be noted that all the above-described construction of the universal means of transport, in spite of its efficiency, have a significant drawback lies in the fact that they have a rather complicated structure, time-consuming to maintain and repair, and, consequently, the conditions cannot meet the specified reliability. With this in mind, we have developed another more simple design of the universal vehicle is also recognized as an invention (RU 2255004). This vehicle (Fig. 6) for vans model UAZ-451M includes a chassis with steering and driving wheels, consisting of wheels and tires and a back with a control cabin, control gear steering wheels, air compressor and vacuum device that uses negative pressure in the intake manifold engine. On the outside rim rigidly fixed additional wheels fitted with all-metal profile rolling circle and crests, made under the head of the train rail and internal cavity of the wheel tires attached through a separately controlled valves to the air compressor and the vacuum device that uses negative pressure in the intake manifold motor, the outer diameter of the wheel tires rolling around at a pressure of compressed air in them the diameter of the rolling circle-metal wheels, and the steering device is provided with a mechanism to lock. Powered universal wheeled vehicle follows. In motion on different roads and off-road and in those cases where it is necessary to increase its permeability is widely known in the art is able to increase or decrease the air pressure in the tires. During the same maintenance work path or interlocking systems, signaling and communications on the track, the vehicle wheels to give birth to their railway so that last housed between two strings of rail track. Under the effect of discharging the last elastically deform and take the form shown in figure 6 on the right, which allows us to accommodate all-metal wheels on the rail head. After that, the movement of the vehicle on rails in a given direction by adjusting its speed, braking and carrying etc. that is, as it is usually used when driving. At the same time, elastically deformed tyre to provide a free pass over crosses switches, flooring crossings over other obstacles that can be placed in between the railway. During the movement of the vehicle on the tracks below the work, given the value of the vacuum in the tire is supported automatically. Delivering team of workers to the work area and select a location on the side of the path, where you can temporarily set the vehicle so that it does not obstruct the trains and did not disturb the schedule of movement, the tires pumped compressed air from the compressor and under the pressure last take such a position, as shown in figure 6 on the left. Then unlocks the steering and the vehicle under its own power drives off to the side of the path. After completion of the work in consultation with the supervisor, the vehicle again move between tracks and in this way, as described above, it lowered its all-metal wheels on the rails, which again allows him to carry out the movement in this direction. In the future, these processes can be repeated many times.

It is known[6,7] that one of the main design parameters of tires of cars is their radial λ_E and lateral $\lambda_Б$ rigidity, respectively, each of which depends on the deflection f_E, the vertical component of the load F_E, tire pressure p, lateral load $F_Б$ and lateral displacement $f_Б$. Numerous experiments show that if the rolling of the wheels is missing, the deformation of the tire in a circle and in the transverse direction is distributed symmetrically with respect to the vertical and transverse plane passing through the axis of the wheel, therefore, mean values of stiffness characterized dependencies: $\lambda_E = \frac{F_E}{f_E}$ and $\lambda_Б = \frac{F_Б}{f_Б}$. As can be seen, these relations are valid for air pressure in the tire. In the case of a vacuum in it, the latter is deformed in the opposite direction, and internal efforts to facilitate such a strain, will be equal $P = S \cdot K_S(p_a K_a - p_E) \cdot K$, and speed vacuum is determined by the formula $t = 2,3\lg\frac{p_a}{p_E} \cdot Q_П$ . .[7] If you highlight an area element on the tire df, the relationship between load P and created discharged p_E, it can be written, using the principle of virtual displacements, the following equation: $Pdf_E + pdV = 0$. Since $P = p_E S$, where S the inner surface area of the tire, then the equation of possible motion becomes $\frac{dV}{df} = -S = -\pi^2 R_0$, where R_0 the average inner radius of the tire. From the selection equation that they present value p_E characterizing thin air in the volume of the tire and the internal volume, which are connected by a gas known equation of state:

$$(p_E + 1)\cdot(V + V_P)^n = (p_0 + 1)\cdot(V_0 + V_P)^n$$

where V_P the volume of the receiver, and n the polytropic.

Transforming these equations, we obtain an integral equation of the form:

$$V = V_0 - \int_0^f Sdf$$

resulting solutions, which can calculate the required value of the radial stiffness of the tire on the dependence

$$\lambda_E = (p_E + 1)\cdot(\frac{n \cdot S^2}{V}) + (p_E \frac{dS}{df}).$$

This equation is the sum of two terms, one of which depends on the design parameters and the type of loading tire and the other defines it forming. Using the above procedure and asking a wide range of numerical values of the parameters in the last equation, and also based on the fact that the maximum pressure within the tire, which can cause the unit to discharge the air, located in the intake manifold of engine, which is generally from $9,0 \cdot 10^3$ to $1,5 \cdot 10^4$ $Па$, were calculated in relation to the vehicle UAZ-451M, the main characteristics of the special type of tubeless tires 8,40-15, 152L (6L) such as: its outer diameter 800mm; maximum vertical load 765kg; maximum pressure 0.26 MPa; radial stiffness λ_B = *25,6 kgf/ mm;* lateral rigidity λb = 9.5 kg

/ mm and torsional stiffness λk = 52.0 kg / mm. The parameters obtained special tires needed for its development and further use on vans UAZ-451M, will effectively implement the process in its elastic deformation in the translation of the car from the usual pattern in rail traffic, and vice versa, as well as to ensure its proper operation reliability.

For the economic evaluation of the proposed technical solutions used methods of financial and investment analysis and audit in the implementation of new technology. The base model adopted vans model UAZ-452 Ulyanovsk Automobile Plant. Analysis of the financial activities of the service department PCH Yelets's UVJD OAO "Russian Railways» for 2009 shows that the costs related to transport crews to perform maintenance road is about 8% of the total cost going to perform for repair works department, and it is about 750.3 thousand rubles in the year. Based on the above, and using the data table are the annual economic effect from the introduction of the upgraded model of the vehicle UAZ-452 (RU 2255004) improves the efficiency of delivering crews to the work site. We use the following indicators for this.

№	indexes	symbols	unit	modern vehicles	with aid the universal vehicle
1	Total time for delivery team to the work site	A	hour	1,5	0,25
2	Mileage briefing detachment to medium repairs	D	thousands of miles	32, 4	56,8
3	Cost price of repair	C	thousands of roubles	76,6	67,2
4	Capital investments for a briefing	Y	roubles	110540	125600
5	Normative coefficient effectiveness	E	-	0,15	0,15

1. The coefficient of comparative economic effectiveness, determined by dependence:

$$E = \frac{C_1 - C_2}{У_2 - У_1} = \frac{76600 - 67200}{125600 - 110540} = 0,62$$

2. The coefficient of reduction of costs to the same volume of production of the upgraded car repair model UAZ-452 and serial:

$$K_1 = \frac{Д_2}{Д_1} = \frac{56,8}{32,4} = 1,75$$

3. The costs shown on the compared model cars UAZ-452

a) by serial -

$$C_1 + E_н \cdot У_1 = 76600 + 0,15 \cdot 110540 = 93,2 тыс.руб.$$

b) a modernized -

$$C_2 + E_н \cdot У_2 = 67200 + 0,15 \cdot 125600 = 86,04 тыс.руб.$$

4. The costs shown with the reduction coefficient to the same amount of run series and the upgraded model of UAZ-452:

$$K_2 = (C_1 + E_н \cdot У_1) \cdot K_1 = 93,2 \cdot 1,75 = 163,1 тыс.руб.$$

Based on the above, we perform the calculation of the annual benefits derived from the introduction of service PCH universal vehicle designed on the basis of the UAZ-452 depending on the $П = K_2 - (C_2 + E_н \cdot У_2) = 163,1 - 86,04 = 77,06 тысруб$

4. Results of the Study

Based on the above, we can make the following conclusions and proposals:

1. Analyzing the activities and organization of work, held electro mechanics service signaling and communication network of roads shows that most imperfect link in the processing chain of works on the line and spans, is to deliver people to the place of repair and maintenance work. This imperfect and even complex transport organization of labor in the off-road conditions significantly affect the quality and performance of repair work.

2. Given these shortcomings, and the practice of universal use of foreign vehicles, capable of moving along the rails and roads, we have developed a number of technical solutions at the level of inventions (RU2255004, RU2268156, RU2277049, RU2264944, RU2284923), characterized by a device from known designs are widely used, for example, in Canada and the United States.

3. Comparing the development described above to each other, select one of them, which in our view is simpler and more promising (patent RU2255004) and can be created as a mock-based van vehicle UAZ-451M. You must use a special type of a tubeless tire 8,40-15, 152L (6L) with the following parameters: outer diameter of 800 mm, maximum vertical load 765kg, maximum pressure 0.26 MPa, radial stiffness λv = 25.6 kg / mm, lateral rigidity λb = 9.5 kg / mm and torsional stiffness λk = 52.0 kg / mm. In the end, this will effectively process for its elastic deformation in the translation of the car from the usual traffic pattern in rail, and vice versa, as well as to ensure its proper operation reliability.

4. The proposed development in the form of a research report submitted to the Office UVJD branch of JSC "Russian Railways" for consideration and possible production model sample to test its performance in operational conditions, and recommends NII the auto industry and other design organizations and industrial structures, designs and manufactures automobiles, both in our country and abroad.

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