MANAGEMENT BY MOTION OF CARS ON ROADNET

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Summary: *Practical application of the optimization of motion of heavy cars worked out earlier a mathematical model is shown on the street-travelling network of city on the basis of criteria of minimum total time of passage of lorry convoys and minimum possible ecological damage from the negative affecting of cars environment. A chart over of placing of travelling informative boards is brought on the street-travelling network of city of Lipetsk.*

Key words: *a transport system, transport stream, city.*

Inefficient management the decline of среднетехнической speed of cars, regular origin of congestions, considerable overrun of fuel, speed-up wear of knots and aggregates of transport vehicles and high level of accident rate on a motor transport, causes motion of transport streams.

On present estimations annually in Russia losses from transport congestions make 7-9 % gross of internal product. The decline of rates of movement conduces to the increase of prime price of transportations on 20-30% of a transport constituent in the eventual cost of products and services, that in the last bid of the Russian products arrives at to the 15-20% (in USA and Europe this index does not exceed 7-10%).

A transport situation accordion presently in the regions of Russia often is the result of absence of reasonable strategy in the decision of the examined problems. As foreign and home experience shows, the problem of overload of street-travelling network in cities can not be successfully decided only due to application of separate particular solutions. Researches of many countries confirm that the quality improvement of the folded situation is possible only on condition of planning and realization of measures on perfection of terms of motion as single and indivisible.

Transport situation accordion presently in regions the Major place in the decision of these tasks belongs to organization of travelling motion, including to rational distribution of transport streams on an existent street-travelling network. Along with insignificant expenses, as compared to the reconstruction of roadnet, distribution of transport streams allows to promote efficiency of

the use of existent network by the effective loading her motion, to prevent congestions of transport, decrease time of delivery of load and mass of extrass of harmful substances from cars in an environment.

Deciding tasks is possible the achievement of balance between all by increasing demand on transport services from one side and real vehicular ability of a transport complex - with other. Consequently, in all technical and organizational structure of a transport complex it is necessary to mortgage not only a management by transport streams, but management by passenger and freight transportations on concrete one.

In modern terms the task of admission of maybe greater number of transport vehicles due to the coordinated management changes traffic-lights on the task of maintenance of a transport balance between the carrying capacity of existent street-travelling network and her real loading due to the redistribution of transport streams.

In [1] the problem of multicriterion optimization of admission of transport streams of heavy cars is set and decided on the street-travelling network of city. Basic descriptions of transport streams, qualificatory the terms of motion on roads, it is been: intensity of motion, composition of a transport stream, rate of movement of streams on a bus network. Total time of employment of street-travelling network is determined heavy cars on a formula

$$F = \sum_{j=1}^{1} N_j \tau_j \left(N_j \right) \tag{1}$$

Where N_j - is intensity of motion on the arc, of conditional cars/h; $\tau_j(N_j)$ - time of passage on an arc as a function from intensity of motion, h.

The supervisions conducted in a clock "peak" and in the clock of slump of a transport stream showed that time of passage on j- ouch arcwise depends an arc on intensity of motion on this arc N_j . Consequently, time of passage on j- ouch an arc can present as a linear functi

$$\tau_j = \left(N_j \right) = \alpha_j N_j + \beta_j \tag{2}$$

Where β_j - time of passage on j- ouch to the arc at a zero intensity of motion(single car), h.

Time of passage is determined on a formula

$$\beta_j = L_j / V_j \tag{3}$$

Where L_j - length j- ouch arcs, km; V_j - regulation speed of motion on j- ouch to the arc, km/h.

An objective function is made. As a criterion of efficiency total time of passage of heavy cars is used on the street-travelling network of region

$$F = \sum_{j=1}^{l} N_j \tau_j \tag{4}$$

As be set by supervisions, time of passage arcwise depends on intensity of motion and a stream on the arc of j consists of streams following on her pithily setting of k, then, putting values τ_j and in N_j a formula(4), expression of objective function is got

$$F = \sum_{j=1}^{l} \left(\sum_{k=1}^{M} N_j^k \left(\alpha_j \sum_{k=1}^{M} N_j^k + \beta_j \right) \right) \to \min_{N_j^k} \tag{5}$$

In [1] the task of optimal distribution of streams of heavy cars is set forth and decided on a road net.

A minimum of objective function (5) at limitations

$$A \cdot N^k = Q^k, k = \overline{1, M} \tag{6}$$

$$N_j = \sum_{k=1}^{M} N_j^k, j = \overline{1, l} \tag{7}$$

$$P_j \geq N_j \geq 0, j = \overline{1, l} \tag{8}$$

$$N_j - \text{unit}, j = \overline{1, l} \tag{9}$$

Where P_j - reserve of carrying capacity of arc of j remaining for admission of heavy cars, of conditional cars/h.

Task of optimization of transport streams of heavy cars on a street-travelling network, coming from the criterion of ecological safety.

Mass of extrass of every harmful substance from the stream of heavy cars for a separate arc looks like

$$W_j = a_j + b_j N_j \tag{10}$$

Where a_j - size of base-line contamination(from stationary sources) on j- ouch to the arc, a conditional g/arc; b_j - the brought mass over of harmful extrass from one heavy car during work on j- ouch to the arc, conditional g/arc.

Then, the brought mass over of harmful extrass will make on a street-travelling network

$$W = \sum_{j=1}^{l} \left(a_j + b_j N_j \right). \tag{11}$$

Possibility to set forth the task of optimization of transport streams of heavy cars on a street-travelling network appeared, coming from the criterion of ecological safety.

To find

$$W = \sum_{j=1}^{l} \left(a_j + b_j N_j \right) \to \min_{N_j^k} \tag{12}$$

At limitations

$$A \cdot N^k = Q^k, k = \overline{1,M} \tag{13}$$

$$N_j = \sum_{k=1}^{M} N_j^k, j = \overline{1,l} \tag{14}$$

$$P_j \geq N_j \geq 0, j = \overline{1,l};\ N_j - \text{unit}, j = \overline{1,l} \tag{15}$$

$$\left(a_j + b_j N_j \right) \leq V_j, j = \overline{1,l} \tag{16}$$

Where V_j - reserve of prorunning extrass for j- ouch arcs, conditional gs/arc.

We will present the street-travelling network of Lipetsk as the oriented count the knots of that are industrial districts, and by arcs are main streets their connecting (fig 1).

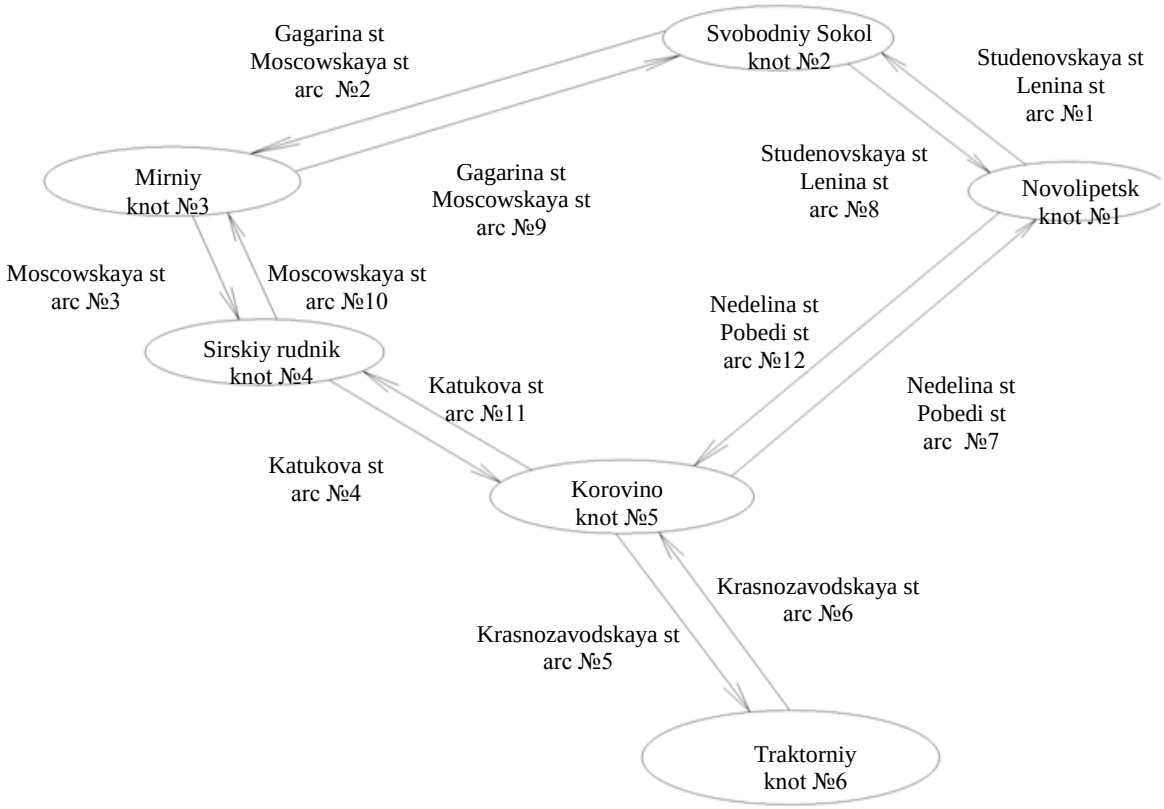

Fig 1. *Count of street-travelling network of Lipetsk*

It was set as a result of inspection of industrial districts(knots of count), that knots with numbers 1,2,3,4,6 are the generators of a transport stream of heavy cars, and knots with numbers 2,3,4 simultaneously are the absorbers of part of these streams. On a fig. 2 knots-generators and knots-absorbers of transport streams are represented. For knots-absorbers numeration of exits of transport streams is entered - 1,2,3.

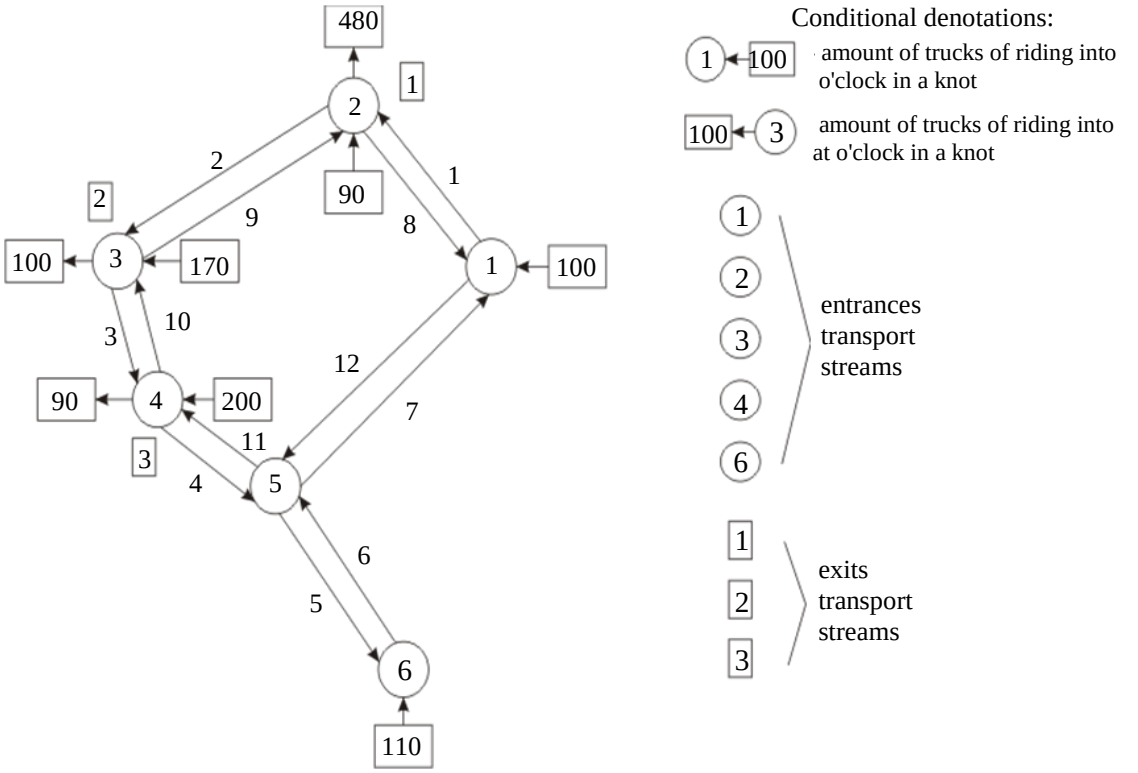

Fig 2. *Entrances and exits of transport streams of heavy cars*

As a result of supervisions were set routes of the following of transport streams of heavy cars in Lipetsk (table 1). On a fig 3 epures over of intensities of motion of analyzable transport streams of heavy cars are brought.

Table 1. *Description of routes of motion of heavy cars*

Route	Length of route, kilometre	Intensity motions, conditional cars/h
Knots: 1-2 (arc 1)	7,95	50
Knots: 1-2-3 (arc 1 - arc 2)	18,81	10
Knots: 1-5-4-3 (arc 12 - arc 11- arc 10)	18,02	40
Knots: 2-3-4 (arc 2 - arc 3)	13,96	90
Knots: 3-2(arc 9)	10,86	170
Knots: 4-5-6-5-1-2(arc 4 - arc 5 - arc 6 - arc 7 - arc 1)	34,15	190
Knots: 4-3-2 (arc 10 - arc 9)	13,96	10
Узлы: 6-5-1-2 (arc 6 - arc 7- arc 1)	24,41	60
Узлы: 6-5-4-3 (arc 6 - arc 11 - arc 10)	12,84	50

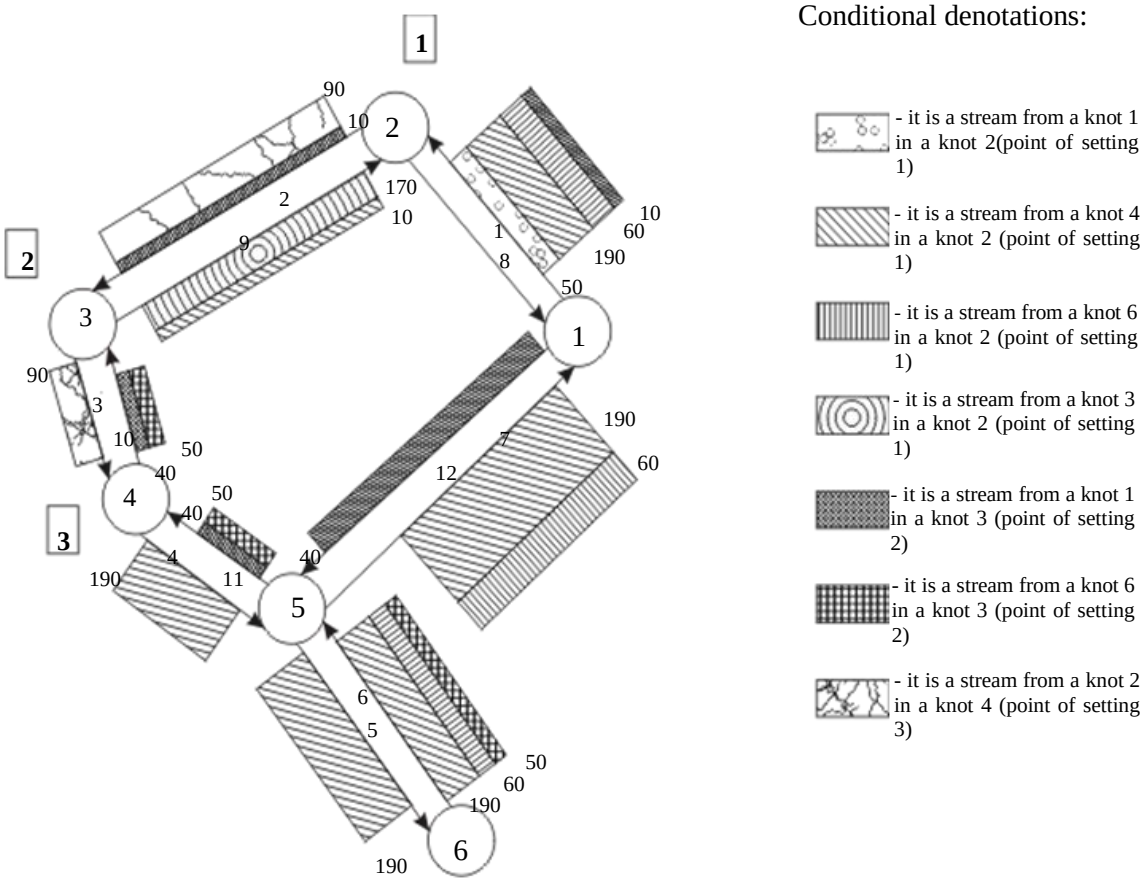

Fig 3. *Epures of intensities of motion of transport streams heavy cars*

On fig 4 total intensities of motion of anymore-heavy cars are presented in conditional units/h on the arcs of count of street-travelling network.

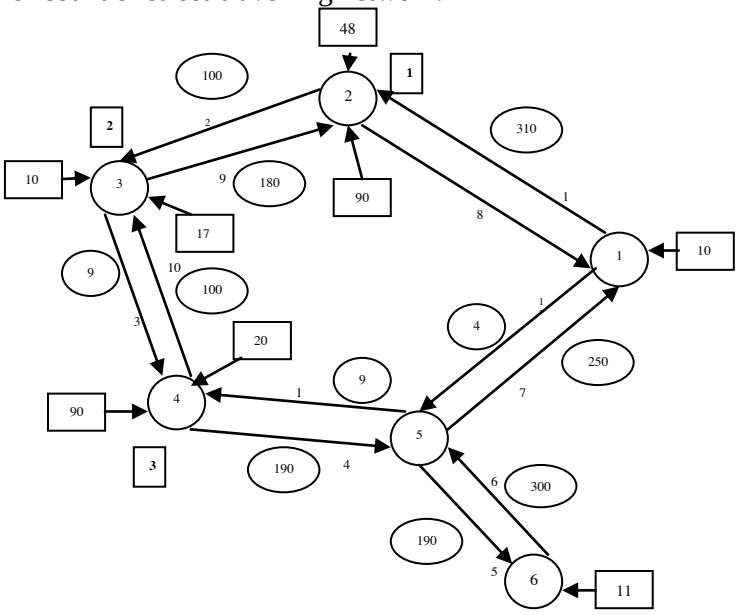

Fig 4. *Distribution of intensities of motion of cars on arcs*

In the article the task of optimization of distribution of transport streams is decided on two criteria. The first is time of motion, second - the brought mass over of extrass of harmful substances.

On a fig 5 optimal distribution over of streams of heavy cars is brought on arcs on the basis of complex decision of task of distribution of heavy cars on a street-travelling network Lipetsk, and on a fig. 6 the epures of intensities of motion of optimal streams are given.

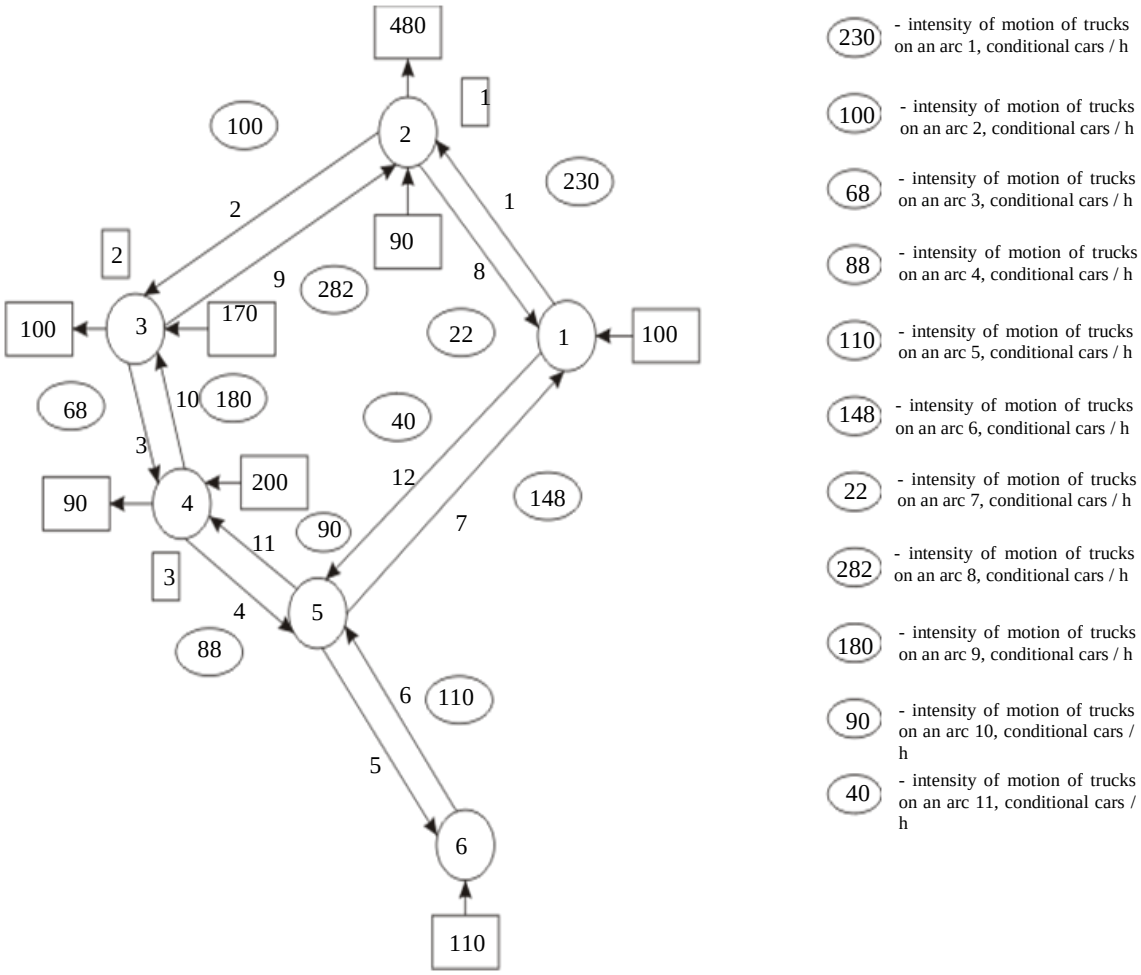

Fig 5. *Optimal distribution of trucks on a roadnet*

During realization of the measures offered in the article on organization travelling motion, the special role belongs to introduction of technical equipments on a management by transport streams: sign-boards and informative boards, facilities of the traffic-light adjusting, directing devices, navigators and systems of radio contact.

Travelling informative boards are used for warning of drivers, managements by transport

streams, and also for their redirecting. By the grant of corresponding information real-time board affect drivers, inducing them to the choice of route of movement, to the change of rate of movement, and also to the change.

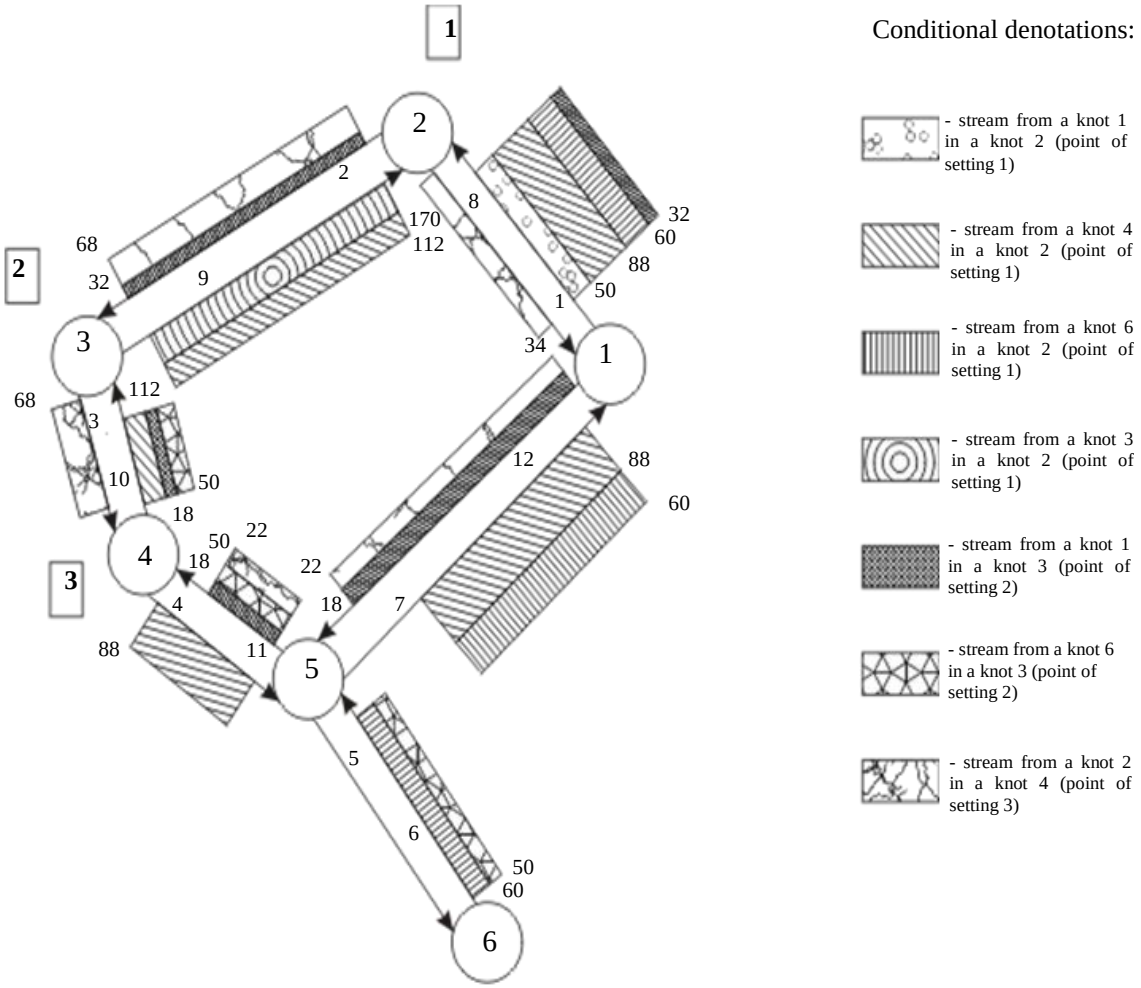

Fig 6. *Epures of intensities of motion optimal distribution of trucks*

Informative boards rationally to use on those areas, where the entrances of freight transport streams are situated and there are variants of routes of motion. The chart of arrowing of motion is shown on a fig 7.

The worked out scientifically reasonable measures on adjustment of transport streams allowed to get: cost saving due to reduction of general run of heavy cars is a 125 millions roubles /year; socio-economic effect from reduction of contamination of atmosphere cars - 115 millions roubles/year.

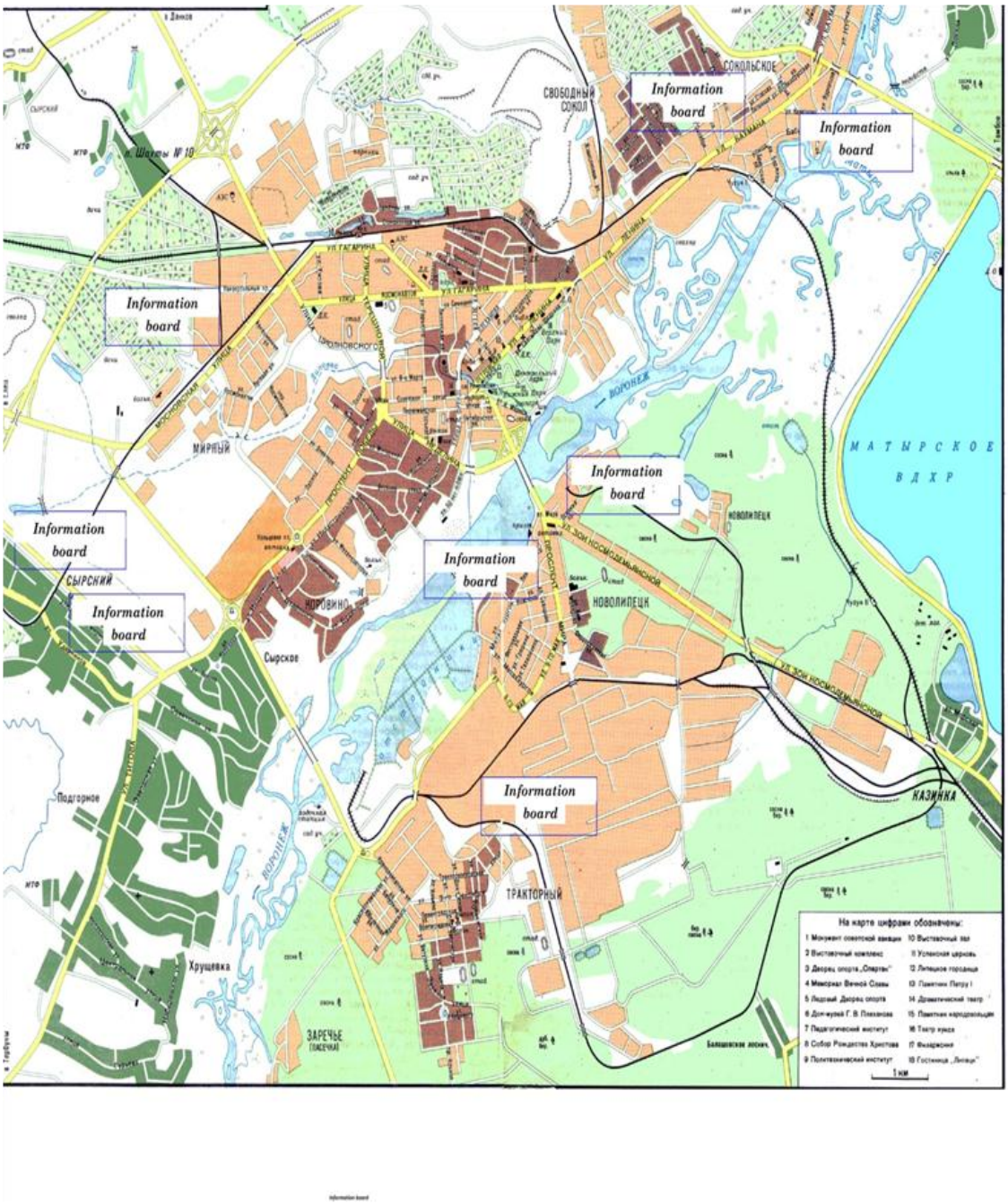

Fig 7. *Chart of placing of board on the street-travelling network of city of Lipetsk*

References

[1]. Korchagin V.A., Suvorov V.A., Rizaeva Yu.N. Optimization of motion of heavy cars on the street-travelling network of city // Vestnik MADI. –2013.-№2.

[2]. Korchagin V.A. Innovative ecological econom.-Lipetsk / LGTU, 2010. – 200p♦