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Dr. Boris Farber

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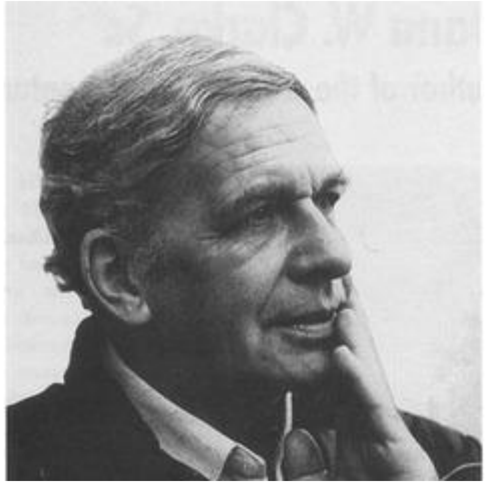
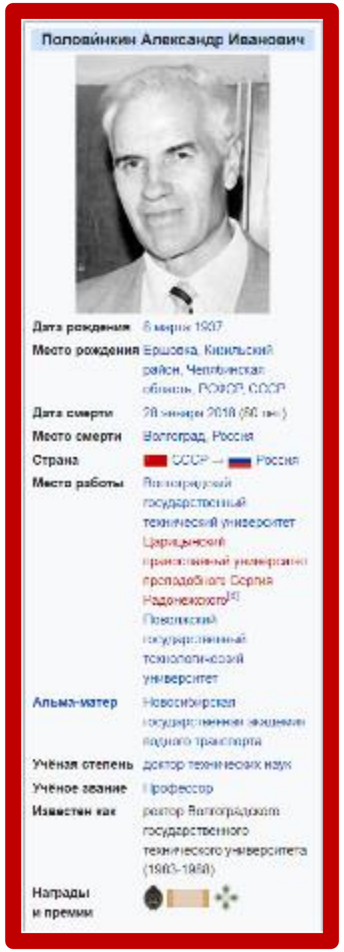


- “Apparently, the possibilities for controlling the thinking process are endless. They cannot be exhausted, because Reason, the greatest instrument of knowledge and transformation of the world, is capable of transforming itself. Who can say that there is a limit to the process of humanizing a person?.. As long as a person exists, the management of this force will be improved. We are only at the very beginning of a long journey.” G.S. Altshuller, 1979, “Creativity as an exact science”

Dr. Polovinkin Alexander: Fundamentals of Engineering Creativity, Automation of Search Design



Имеется m n_j-мерных параллелепипедов

$$a_i^j \leqslant x_i^j \leqslant b_i^j, \quad i = 1, \ldots, n_j, \quad j = 1, \ldots, m, \qquad (30)$$

как с непрерывным, так и с дискретным характером изменения переменных $\overline{X}_i^j$. Для каждого из параллелепипедов задана по единому критерию качества целевая функция

$$f = f^j(\overline{X}_j), \quad j = 1 \ldots, m, \qquad (31)$$

и система ограничений

$$g_r^j(\overline{X}_j) \geqslant 0, \quad r = 1, \ldots, p_j, \quad j = 1, \ldots, m. \qquad (32)$$

Требуется найти точку $\overline{X}_j^*$, принадлежащую j^*-му параллелепипеду, для которой

$$\left.\begin{aligned} g_r^{j^*}(\overline{X}_{j^*}^*) \geqslant 0, \quad r = 1, \ldots, p_j^*; \\ f^{j^*}(\overline{X}_{j^*}^*) = \min f^j(\overline{X}_j^*); \end{aligned}\right\} \qquad (33)$$

$$1 \leqslant j \leqslant m.$$

Таким образом, задача структурной оптимизации состоит в нахождении глобально-оптимальной структуры и глобально-оптимальных значений переменных внутри этой структуры, т. е. эту задачу можно назвать также задачей *структурно-параметрической оптимизации*.

К задачам структурной оптимизации относится задача выбора оптимальной компоновки ТО. При постановке и решении таких задач следует использовать закономерность минимизации компоновочных затрат (см. п. 3 гл. 5).

Отметим некоторые особенности задач структурной оптимизации. Во-первых, почти всегда в этих задачах одновременно присутствуют и дискретные, и непрерывные переменные, т. е. задачи структурной оптимизации в общем случае относятся к смешанным задачам математического программирования. Во-вторых, при структурных преобразованиях изменяются число и характер переменных и соответственно функции ограничений и целевые функции. Что касается характера многосвязной области поиска, то отдельные подобласти или имеют различную размерность или (при совпадении размерности) образованы различными наборами переменных.

Алгоритм поиска глобального экстремума. Алгоритм поиска глобально-оптимального решения можно использовать для решения задач как параметрической, так и структурной оптимизации. Укрупненная блок-схема ал-

2. Каждая основная точка делает шаг локального поиска, в результате чего точки (34) переходят в новую последовательность

$$\overline{X}_1^{l+1}, \overline{X}_2^{l+1}, \ldots, \overline{X}_\eta^{l+1}. \qquad (36)$$

3. Синтезируется λ_{l+1} дополнительных допустимых точек, каждой из которых разрешается сделать $l+1$ шагов локального поиска при условии, что после каждого шага с номером τ $(0 \leqslant \tau \leqslant l)$ ее критерий не хуже, чем соответствующий член последовательности (35). При нарушении этого условия точка исключается и не участвует в дальнейшем поиске глобального экстремума. Таким образом, имеется q $(q \leqslant \lambda_{l+1})$ дополнительных точек, сделавших $l+1$ шаг локального поиска:

$$\overline{X}_1^{l+1}, \overline{X}_2^{l+1}, \ldots, \overline{X}_q^{l+1}. \qquad (37)$$

4. Среди точек (36) и (37) отбирается η точек с лучшими критериями:

$$\overline{X}_1^{l+1}, \overline{X}_2^{l+1}, \ldots, \overline{X}_\eta^{l+1}, \qquad (38)$$

которые являются основными на $(l+1)$-м групповом шаге поиска. Значение худшего критерия точек из последовательности (38) дополняет последовательность (35) числом φ_{l+1}.

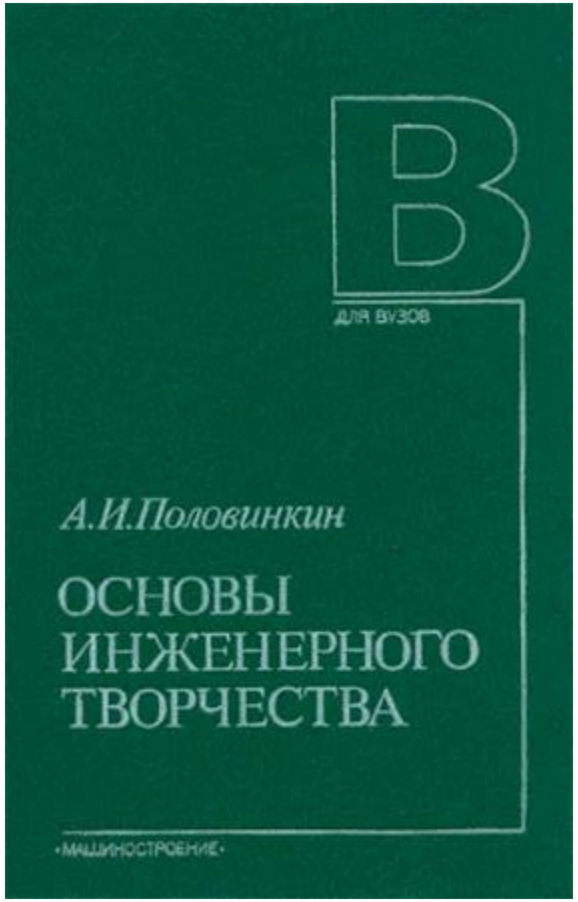
5. Цикл по пп. 2—4 повторяется до нахождения глобального экстремума по заданным условиям прекращения поиска. В качестве условий прекращения поиска могут быть использованы, например, выполнение заданного числа T групповых шагов.

Считая параметры λ_l независимыми от l, будем иметь только два настраиваемых параметра алгоритма: η — число основных точек и λ — число дополнительных точек.

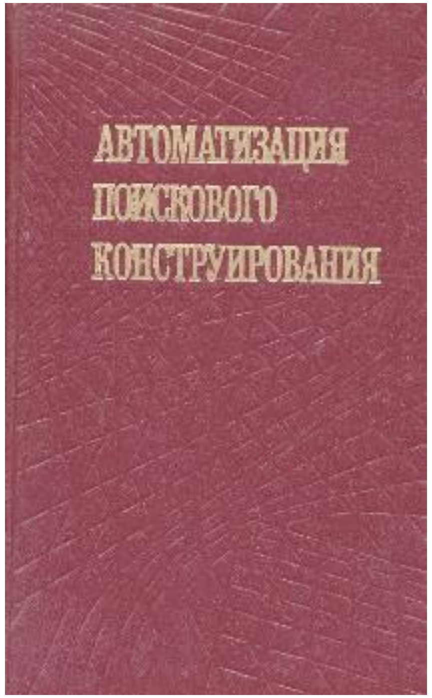
Проведенные исследования [1, 17] позволяют рекомендовать следующие оптимальные значения этих параметров: $\eta = 2 \div 3$, $\lambda = 12 \div 18$. Для простоты реализации алгоритма можно брать постоянные значения η и λ.

В качестве процедуры ШЛП рекомендуется использовать следующие алгоритмы поиска локального экстремума [1]:

алгоритм случайного поиска в подпространствах (см. п. 2 гл. 13);



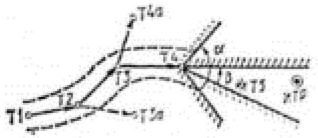
Dr. Polovinkin Alexander’s Automation of Search Design



Descriptions of computer Mathematical Modeling methods of exploratory design and construction used to search for improved physical operating principles and technical solutions are provided.

Рис. 38. Главная магистраль развития ТО:

T1, T2, T3 — предшествующие массово выпускаемые ТО, T4 — рассматриваемый прототип; α — угол поиска без знания ИТР; β — сужение угла поиска с ориентацией на ИТР



Определение ИТР. Будем считать техническое решение идеальным, если оно имеет одно или несколько из следующих свойств:

1. В ИТР размеры ТО приближаются или совпадают с размерами обрабатываемого или транспортируемого объекта, а чистая масса ТО намного меньше массы обрабатываемого объекта.

2. В ИТР масса и размеры ТО или его главных функциональных элементов приближаются к нулю, а в предельном случае равны нулю (когда устройства вообще нет, но необходимая функция выполняется).

3. В ИТР время обработки объекта приближается к нулю или равно нулю.

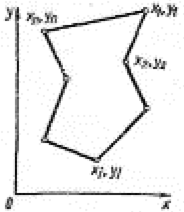


Рис. 66. Прямоугольная система координат

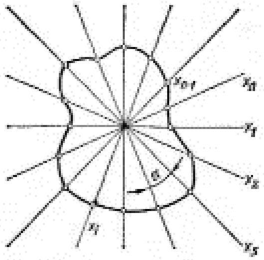


Рис. 67. Полярная система координат

зуют либо прямоугольную либо полярную систему координат. Произвольная форма тела описывается в прямоугольной системе (рис. 66) вектором

$$\overline{X} = [(x_1, y_1), (x_2, y_2), \ldots, x_n, y_n)], \quad (41)$$

а в полярной системе (рис. 67) вектором

$$\overline{X} = (x_1, x_2, \ldots, x_n, \alpha), \quad \alpha = 2\pi/n. \quad (42)$$

В ряде задач при описании плоскосимметричных и осесимметричных тел более подходит специальная система координат в виде параллельных осей X_i (рис. 68). При этом высота оптимизируемой формы вдоль оси y делится на отрезки равной (Δy_i = const) или неравной ($\Delta y_i \neq$ const) длины. Наборы оптимизируемых параметров в этом случае можно описать соответственно векторами

$$\overline{X} = (x_1, x_2, \ldots, x_n, \Delta y); \quad (43)$$

$$\overline{X} = (x_1, x_2, \ldots, x_n, \Delta y_1, \Delta y_2, \ldots, \Delta y_n). \quad (44)$$

При фиксированной длине отрезков Δy в формуле (43) или Δy_i в формуле (44) набор оптимизируемых переменных описывается вектором (25).

Если требуется иметь однозначное плавное очертание формы,

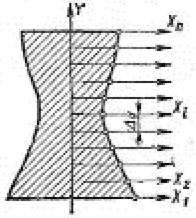


Рис. 68. Способ описания плоскосимметричных и осесимметричных тел

последовательный локальный спуск каждого решения (вначале грубый, затем более точный) происходит независимо от спуска других решений.

Конкуренция позволяет за счет отсева решений, спускающихся в локальные экстремумы, достаточно быстро находить глобальный экстремум в задачах, для которых значение функционала, осредненное по области притяжения глобального экстремума, меньше значения функционала, осредненного по всей области поиска, а область притяжения глобального экстремума не слишком мала.

Алгоритм конкурирующих точек — один из наиболее простых и эффективных по сравнению с другими распространенными алгоритмами поиска глобального экстремума. Так, например, трудоемкость поиска (затраты машинного времени) по этому алгоритму на порядок меньше по сравнению с алгоритмом случайного перебора локальных экстремумов и на два порядка меньше по сравнению с методом Монте-Карло [1, 17].

Для удобства изложения алгоритма решение будем называть также точкой (в многомерном пространстве поиска) и независимо от того, решается ли задача параметрической оптимизации (25)—(28) или задача структурной оптимизации (29)—(33), будем обозначать его X.

Алгоритм конкурирующих точек в общем виде включает следующие операции [1].

1. По процедуре СДС синтезируется l ($l = \eta + \lambda_0$) точек $\overline{X}_j$ ($j = 1, \ldots, l$), в которых определяется значение минимизируемой функции (критерия сравнения). Из этих l точек отбирается η точек, имеющих наилучшие значения критерия, которые в дальнейшем называются основными. Запоминается наихудшее значение критерия основных точек φ_0. При этом считается, что совершен нулевой глобальный (групповой) шаг поиска ($t = 0$).

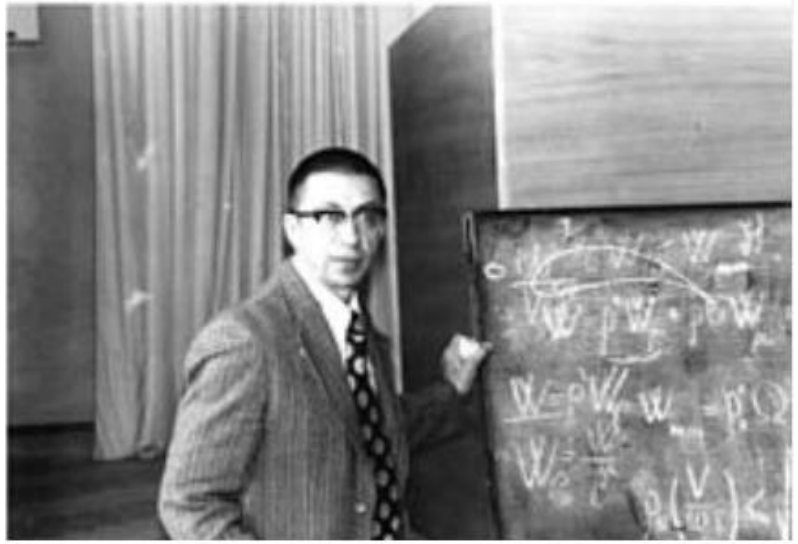
Таким образом, на t-м групповом шаге поиска имеем основные точки

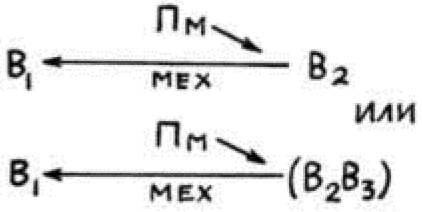
$$\overline{X}_1^t, \overline{X}_2^t, \ldots, \overline{X}_\eta^t, \quad (34)$$

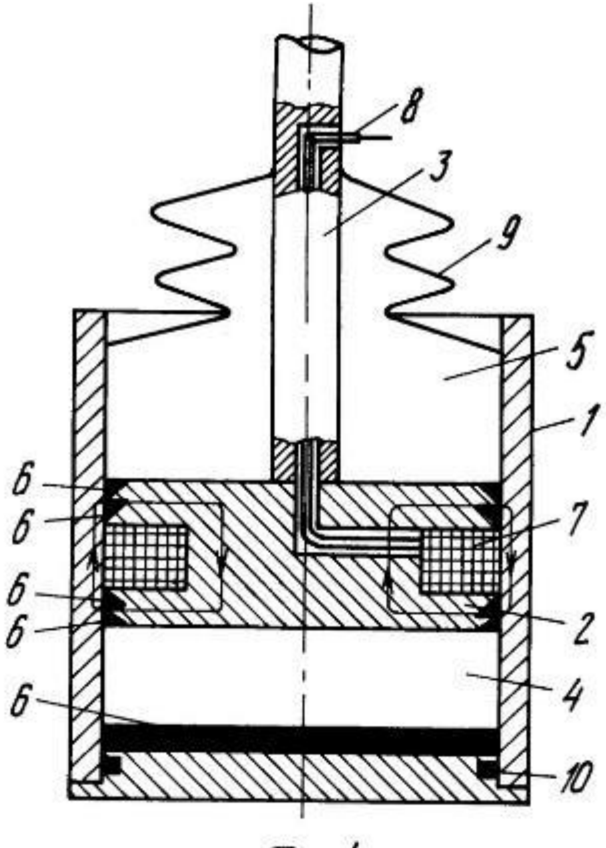
и соответственно невозрастающую последовательность чисел

$$\varphi_0, \varphi_1, \ldots, \varphi_t. \quad (35)$$

Farber B. et al., Method of controlling the power element of the simulator Patent #2081643 (Bio-controlled FEPOL)







Фиг.1

Vadim Vladimirovich Gogosov-Professor, Doctor of Physical and Mathematical Sciences, Head of the Laboratory of Physical and Chemical Hydrodynamics of the Institute of Mechanics of M.V. Lomonosov Moscow State University

Introducing the magnetic scalar potential ϕ whose negative gradient equals the applied magnetic field, i.e. $\mathbf{H} = -\nabla\phi$, the scalar potential can be given by

$$\phi(x,y) = -\frac{I_0}{2\pi}\left(\tan^{-1}\frac{y+a}{x} + \tan^{-1}\frac{y-a}{x}\right),$$

where I_0 denotes the dipole moment per unit length and a is the distance of the line current from the leading edge. Then, the corresponding field components are given by

$$H_x = -\frac{\partial\phi}{\partial x} = -\frac{I_0}{2\pi}\left[\frac{y+a}{x^2+(y+a)^2} + \frac{y-a}{x^2+(y-a)^2}\right],$$
$$H_y = -\frac{\partial\phi}{\partial y} = -\frac{I_0}{2\pi}\left[\frac{x}{x^2+(y+a)^2} + \frac{x}{x^2+(y-a)^2}\right].$$

Moreover, the second derivatives are

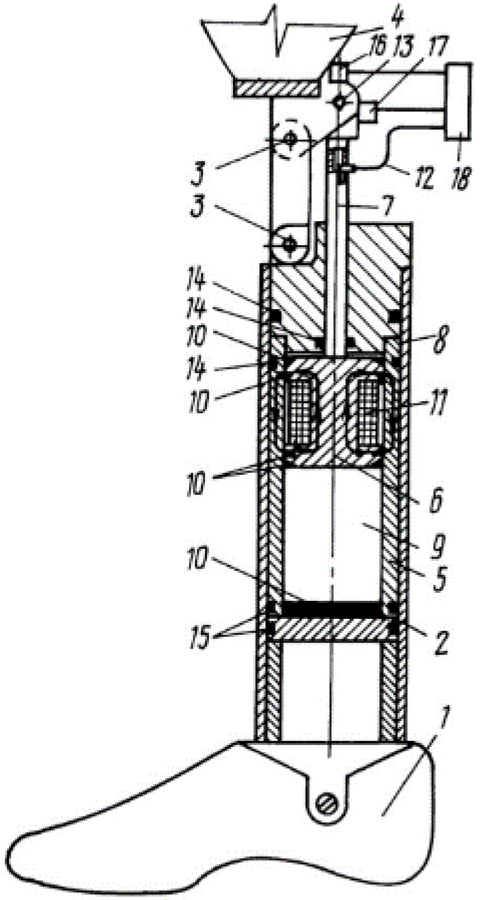
$$\frac{\partial^2\phi}{\partial x^2} = -\frac{\partial^2\phi}{\partial y^2} = -\frac{I_0}{2\pi}\left[\frac{2x\,(y+a)}{\left[x^2+(y+a)^2\right]^2} + \frac{2x\,(y-a)}{\left[x^2+(y-a)^2\right]^2}\right]$$

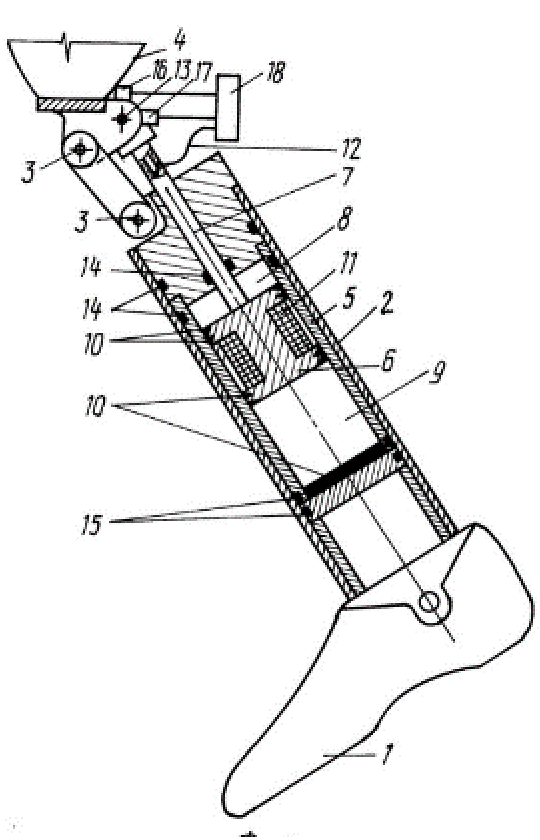
PART 4: Magnetic fluids in medicine

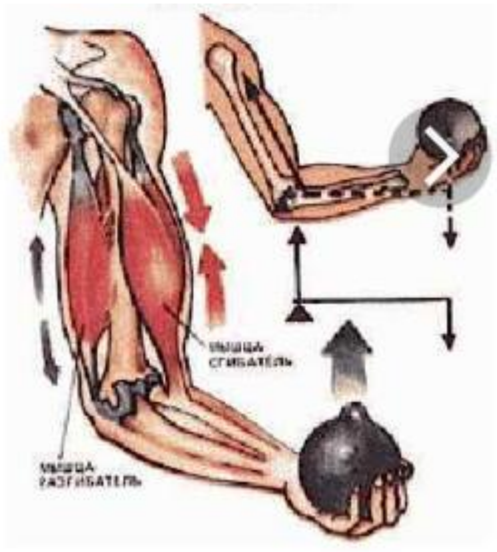
Farber B. et al., Patent 2032434, 1993

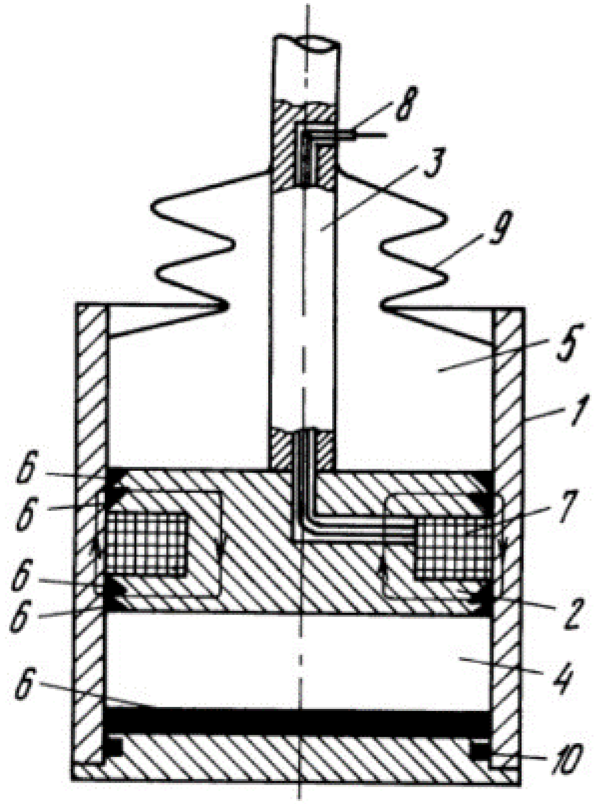
Magneto rheological device and method of control Farber B. et al.,

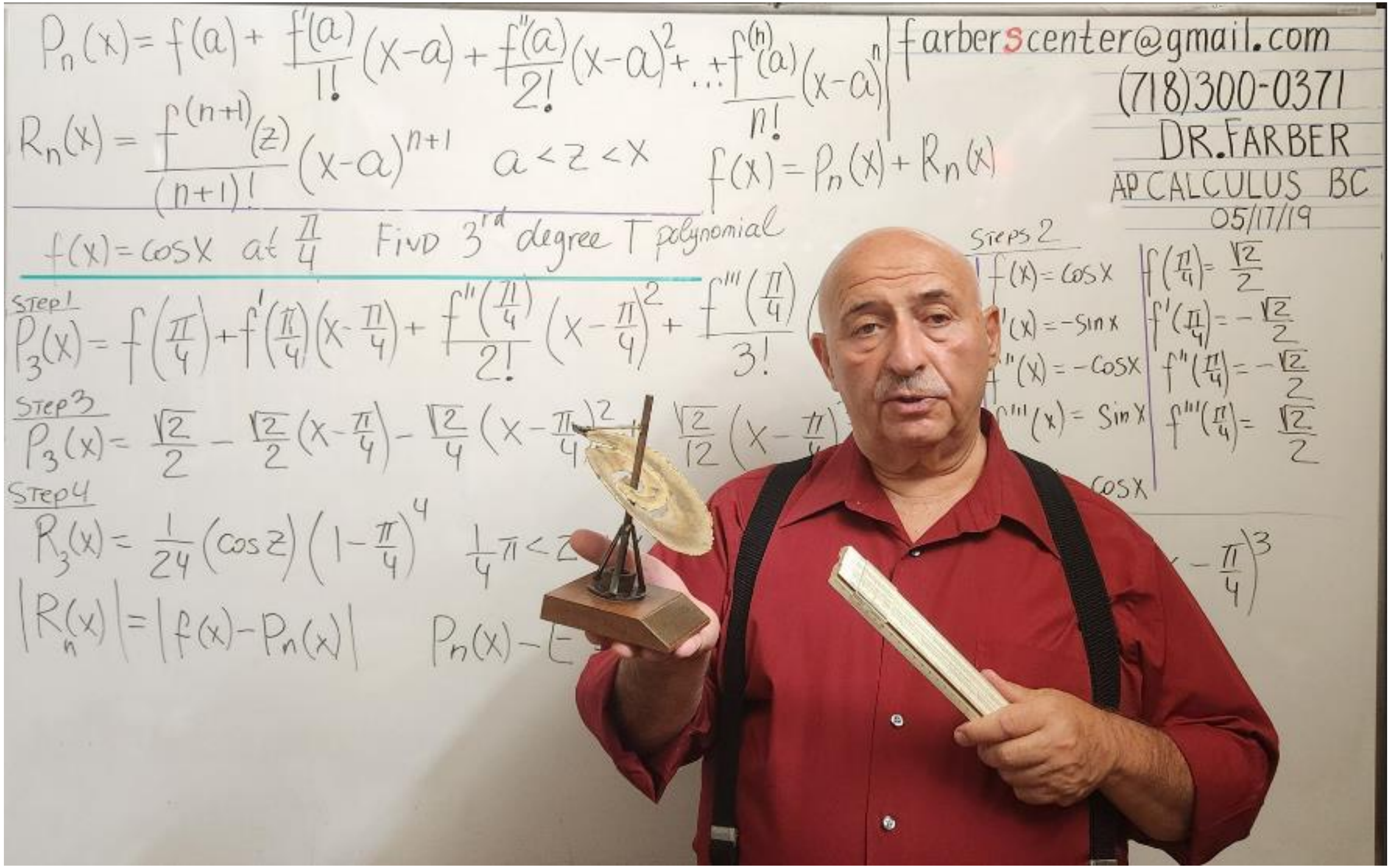
Rheomagnetic training device Patent 2081643,1993











$P_n(x) = f(a) + \frac{f'(a)}{1!}(x-a) + \frac{f''(a)}{2!}(x-a)^2 + \dots + \frac{f^{(n)}(a)}{n!}(x-a)^n$
$R_n(x) = \frac{f^{(n+1)}(z)}{(n+1)!}(x-a)^{n+1}$ $a < z < x$
$f(x) = P_n(x) + R_n(x)$
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05/17/19
$f(x) = \cos x$ at $\frac{\pi}{4}$ Find 3rd degree T polynomial
Step 1
$P_3(x) = f\left(\frac{\pi}{4}\right) + f'\left(\frac{\pi}{4}\right)\left(x - \frac{\pi}{4}\right) + \frac{f''\left(\frac{\pi}{4}\right)}{2!}\left(x - \frac{\pi}{4}\right)^2 + \frac{f'''\left(\frac{\pi}{4}\right)}{3!}$
Steps 2
$f(x) = \cos x$
$f'(x) = -\sin x$
$f''(x) = -\cos x$
$f'''(x) = \sin x$
$\cos x$
$f\left(\frac{\pi}{4}\right) = \frac{\sqrt{2}}{2}$
$f'\left(\frac{\pi}{4}\right) = -\frac{\sqrt{2}}{2}$
$f''\left(\frac{\pi}{4}\right) = -\frac{\sqrt{2}}{2}$
$f'''\left(\frac{\pi}{4}\right) = \frac{\sqrt{2}}{2}$
Step 3
$P_3(x) = \frac{\sqrt{2}}{2} - \frac{\sqrt{2}}{2}\left(x - \frac{\pi}{4}\right) - \frac{\sqrt{2}}{4}\left(x - \frac{\pi}{4}\right)^2 + \frac{\sqrt{2}}{12}\left(x - \frac{\pi}{4}\right)^3$
Step 4
$R_3(x) = \frac{1}{24}(\cos z)\left(1 - \frac{\pi}{4}\right)^4$ $\frac{1}{4}\pi < z$
$|R_n(x)| = |f(x) - P_n(x)|$ $P_n(x) - E$

Department of Veterans Affairs

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Biomechanical basis of choosing the rational mass and its distribution throughout the lower limb prosthesis segments

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https://www.rehab.research.va.gov/jour/95/32/4/pdf/farber.pdf

Abstract—A solution for finding a rational distribution of mass in lower limb prostheses has been considered based on the formal premise favoring the identification of the movements of a prosthetic and an intact leg. For the purpose of simplicity, an analysis has been carried out for only the swing phase, the data about the properties of moving segments being determined without integrating differential equations of motion. At the formation of equations of motion, an assumption that body segments are absolutely rigid and have constant moments of inertia and locations of the center of

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\theta}}\right) = \frac{\partial L}{\partial \theta}$$

Lagrange's equations of the second kind or the Euler Lagrange equations

It should be noted that the application of the principle of mechanical similarity does not exclude other reasonable assumptions leading to different solutions. Thus, Godunov (2) assumed that the masses of both the prosthetic and sound limb segments must be in the same proportion. This opinion can be recognized as valid only for those prosthetic limb segments which do not involve a residual limb, such as the shin section and artificial foot of an above-knee (AK) prosthesis.

Some research papers provide a priori recommendations on the prostheses mass. Roschin and Delov (3) consider the optimum weight of an AK prosthesis to be within 2.7–3.6 kg and the weight of a below-knee (BK) prosthesis to be 2.3–2.9 kg. Staros (4) stresses in his paper that he considers it incorrect to automatically assume greater energy expenditures for heavier prostheses. He asserts that the work of hip muscles is influenced by the distribution of mass throughout the prosthesis: that is why it is necessary to raise the total center of mass location of a prosthesis by reducing the weight of its distal portion.

METHODS

We shall consider the problem of rational distribution of mass by means of the similarity method.

Differential Equations of Motion

Figure 1 presents a dynamic model of human walking in the form of a 9-link biokinematic chain with 11 degrees of freedom. Lower limb segments (hip, shank, fore and hind sections of feet) are presented by four links; trunk, neck, head, and arms (presented as one link).

Movable links rotate around the axes of a coupling O_i with the centers of masses concentrated in the points C_i. The generalized coordinates are chosen to be X, Z, the horizontal and vertical displacements of the point O_1 (the center of the hip joint) and ϕ_i (the angular displacements of the pelvic and lower limb links from the vertical axis).

While formulating the equations, the following assumptions were admitted: the body segments are absolutely rigid, the distribution of masses within each link is constant and does not depend either on muscular tension or spatial interrelation of the links, and the links have constant inertial moments and the positions of centers of masses Ji=Const., l_i=Const. The couplings between the links are stationary and the system is

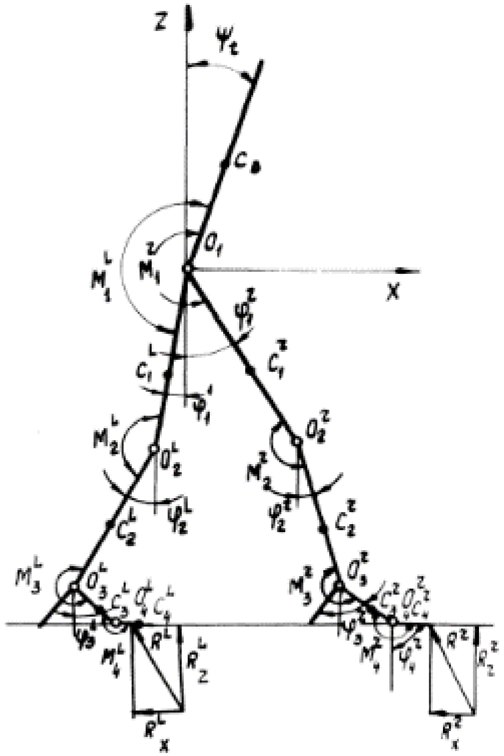


Figure 1.
Dynamic model of human gait.

incapable of being integrated. The motion is possible due to the muscular forces, called joint forces, the moments of which are applied in the centers of rotation.

On the basis of the mechanical principle of releasing from couplings, the interaction of lower limbs with the support surface is replaced by the ground reaction, the components of which are marked R_x and R_z. In that case, both R_x and R_z act as external forces. The differential equations of motion of the system are formulated using Lagrange II equations:

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i}\right) - \frac{\partial T}{\partial q_i} = Q_i$$

The motions of the suggested system are described by the second-order differential equations and in general can be presented as follows:

$$M_i = M_{i+1} + \sum_{j=1}^{4} \alpha_{ji}\left[\ddot{\varphi}_j Cos\left(\varphi_j - \varphi_i\right) + \dot{\varphi}_j^2 Sin\left(\varphi_j - \varphi_i\right)\right] +$$

$$c_i\left[\ddot{x} Cos\varphi_i + \left(\ddot{z} + g\right) Sin\varphi_i\right] - D_i\left(R_z Sin\varphi_i - R_x Cos\varphi_i\right);$$

$$\alpha_{ij} = \alpha_{ji} = \left(\frac{P_j}{g} l_j + \frac{\sum_{k=j+1}^{4} P_k}{g} L_j\right) L_i;\; D_i = \begin{vmatrix} L_1 \\ L_2 \\ L_R \\ x \end{vmatrix}; \qquad [1]$$

$$\alpha_{ii} = \frac{P_i}{g}\rho_i^2 + \frac{\sum_{k=i+1}^{4} P_k}{g} L_i^2;\; c_i = \frac{P_i}{g} l_i + \frac{\sum_{k=i+1}^{4} P_k}{g} L_i;$$

Here P_i = masses of segments;
L_i = lengths of segments;
l_i = static radii;
ρ_i = inertial radii of segments;
g = acceleration of the gravity force;
φ_i = generalized coordinates;
R_x, R_Z = horizontal and vertical ground reaction components;
x, y = load point coordinates.

The equations presented above can be considered as the formulae determining the moments of muscular forces, having the data on generalized coordinates, changes, ground reaction, and its load point. The necessary information can be obtained by an experimental method.

The Application of the Mechanical Similarity Method

Let us assume that each system of equations is recorded twice for two models, one of them imitating the motion of the sound limb (index "c"), the other, that of the prosthetic limb (index "p").

In that case, the main requirement of mechanical similarity (i.e., the requirement of the formal identity of equations of motion for both models will be observed) is met, provided that

$$x_p = x_c;\; z_p = z_c;$$
$$\frac{\alpha_{ijp}}{\alpha_{ijc}} = \frac{C_{ip}}{C_{ic}} = \frac{M_{ip}}{M_{ic}}, \qquad [2]$$

where K=Const, a_{ij}=C_{ij}=M_i are the coefficients of equations, the joint moments.

To prove the identity of equations, it is sufficient to make replacements in the equations for model II

$$\alpha_{ijp} = k\alpha_{ijc},\; C_{ip} = C_{ic},\; M_{ip} = M_{ic} \qquad [3]$$

to obtain the equations for model I.

The conditions of Equation 1 make it possible to work out a series of independent proportions, which are reduced to the system of three equations with six unknown quantities by means of using biomechanical constants (5).

It should be noted that the coefficients of the system of equations in Equation 1 present the combinations of inertial and geometric characteristics of the human body limb segments.

The results of numerous investigations in the fields of anthropology, anatomy, and biomechanics made it possible to establish regular relations between characteristics of separate segments and the human body as a whole (6,7). It is important to note that at the present time the investigations in this field are carried out to meet the needs of not only prosthetics manufacturing but robotics technology, aviation, and space medicine as well. Therefore, the following parameters are well known: the relative linear dimensions of the human body segments, expressed in relative units "P" (where "P" is 1/56 of human height); the relative masses of segments (the mass of the whole body = 100 percent); the coordinates of mass centers (the human height = 100 percent); and the coordinates of joint centers in percentages of the human height and the proximal joints. The positions of partial mass centers and the value of inertial radii of limb segments measured from a proximal joint are also determined. For the first time the calculations of the mass, the partial mass centers, and the inertial radii of a lower residual limb for different levels of amputation were carried out. It was performed using the approximation method with bodies of rotation recommended by reference books on mechanics (8).

Distribution of Masses Throughout a Prosthesis

The independent proportions obtained from conditions (9) are recorded as the system of equations solved in relation to P_2, l_2, ρ_2 (i.e., the mass, the static radius, and the inertial radius) related, respectively, to the human body mass P and the link length L. Note that the derived system of three equations has six unknown quantities, three of them having been chosen the mean as the result of a considerable number of measurements:

$$K_1 = \frac{P_{sb}}{P} = 0.016;\; K_2 = \frac{l_{sb}}{L_1} = 0.0598;$$
$$K_3 = \frac{\rho_{sb}}{L_1} = 0.662, \qquad [4]$$

where P_{sb}, l_{sb}, ρ_{sb} are the mass, the static radius, and the inertial radius of the AK socket, related, respectively, to the human body mass P and the hip length L_1. These amputations are described by the following equations:

$$\rho = \left(\frac{l_2}{L_2}\right)^2 = 0.310\left[\frac{0.010 + K_4K_5}{3.330K_4\left(K_5 - 1.30K_6^2\right)} + 1\right];$$

$$r = \frac{P_2}{P} = 3.330K_4\left(K_5 - 1.30K_6^2\right); \qquad [5]$$

$$\rho^2 = \left(\frac{\rho_2}{L_2}\right)^2 = 0.731\frac{l_2}{L_2},$$

where P_2/P, l_2/L_2, ρ_2/L_2 are the mass, the static radius, and the inertial radius of the complex chain "shank + foot + footwear" related, respectively, to the human body mass P and the distance "knee–floor" L_2.

$$K_4 = \frac{P_{kb}}{P};\; K_5 = \frac{l_{kb}}{L_1};\; K_6 = \frac{\rho_{kb}}{L_1}, \qquad [6]$$

where P_{kb}, l_{kb}, ρ_{kb} are the masses, the static radius, and the inertial radius of the AK residual limb, related, respectively, to the human body P and the hip length L_1.

It should again be stressed that the mean values of the AK socket inertial characteristics replaced in Equation 5 obviously do not depend on the level of amputation, for whatever the length of the residual limb may be, the AK socket depends only on the sound limb hip length, that is, on the human height.

However, it should be taken into account that a purposeful striving for reducing the mass of modern prosthetic parts is not an end in itself, but a method of rational distribution of mass with the help of balancing, for example. Balancing is possible in the case where the actual weight of a complex chain shank + foot proves to be less than the calculated weight.

Balancing is performed in the following way. First the mass of the patient, the level of amputation, and the distance knee–floor L_2 are measured. Then, with the help of a simple device, the scheme of which is given in **Figure 2**, the actual masses of a complex chain P_F and its static moment M_F are determined. The calculated mass (P_p), the static radius (l_p), and the calculated static moment (M_p) are determined with the help of nomograms (**Figures 3–5**) by the level of amputation, the mass, and the distance "knee–floor" of the patient. The nomograms have been worked out according to the known mathematic rules in logarithmic coordinates on the basis of **Tables 1** and **2.**

The value of a balancing load and the position in which it is fixed are determined by the following formulae:

$$\Delta P = P_p - P_F; \qquad [7]$$

$$l_0 = \frac{M_p - M_F}{\Delta P}, \qquad [8]$$

where the numerator presents the difference between the calculated and the actual static moments and the denominator shows the value of a balancing load. Usually strips of sheet lead 5–6 mm thick are used as a balancing load. A strip of lead plate, the mass of which is equal to the calculated value of a balancing load, should be riveted to the rear surface of a shank tube at the point, located at the distance l_0 from the knee joint axis.

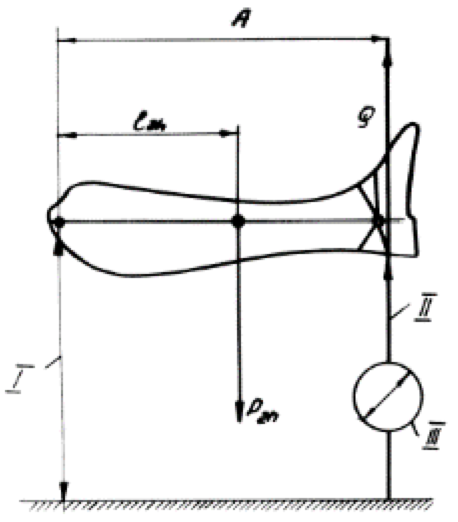
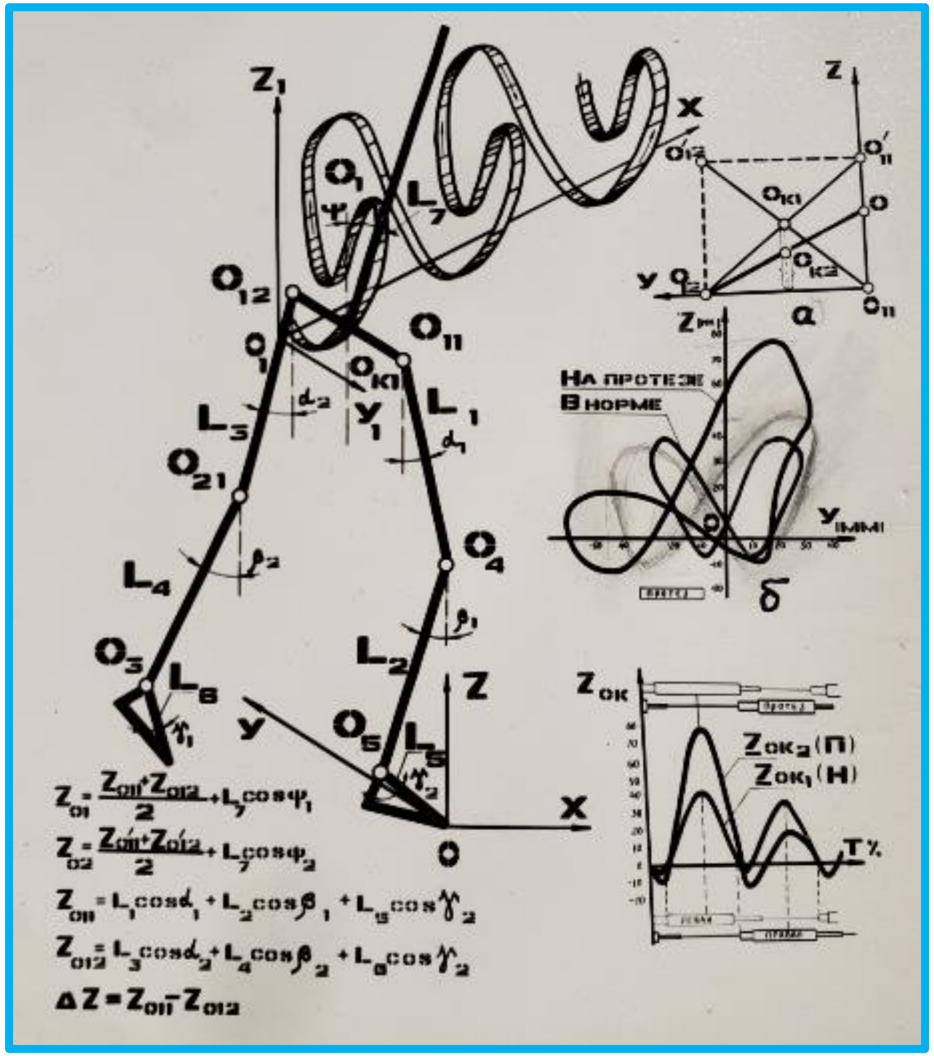
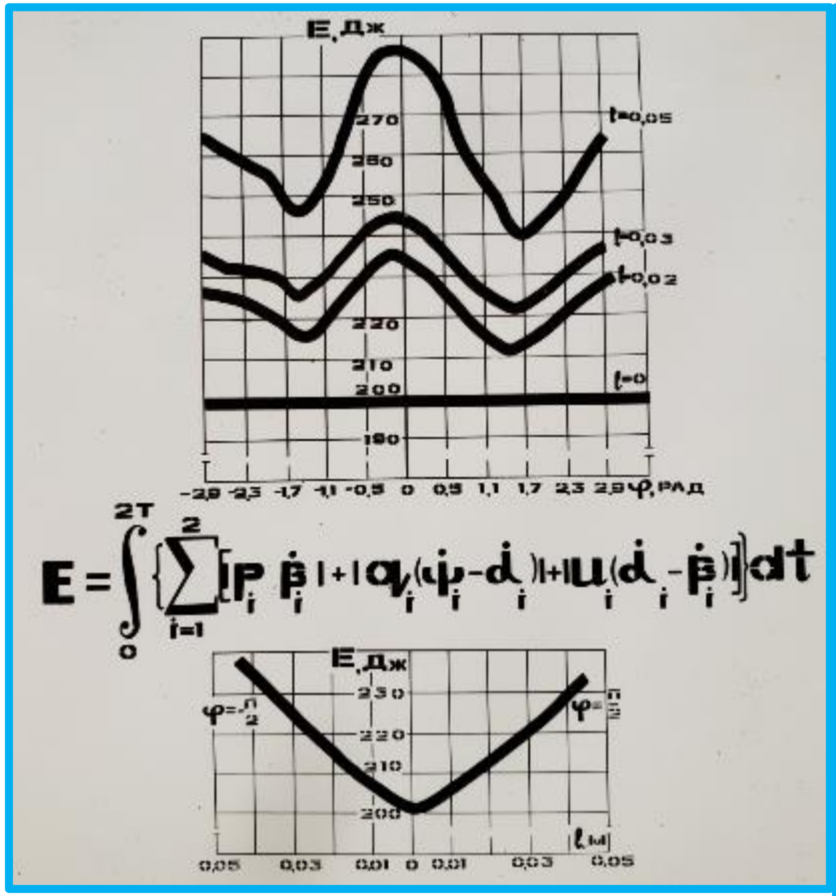
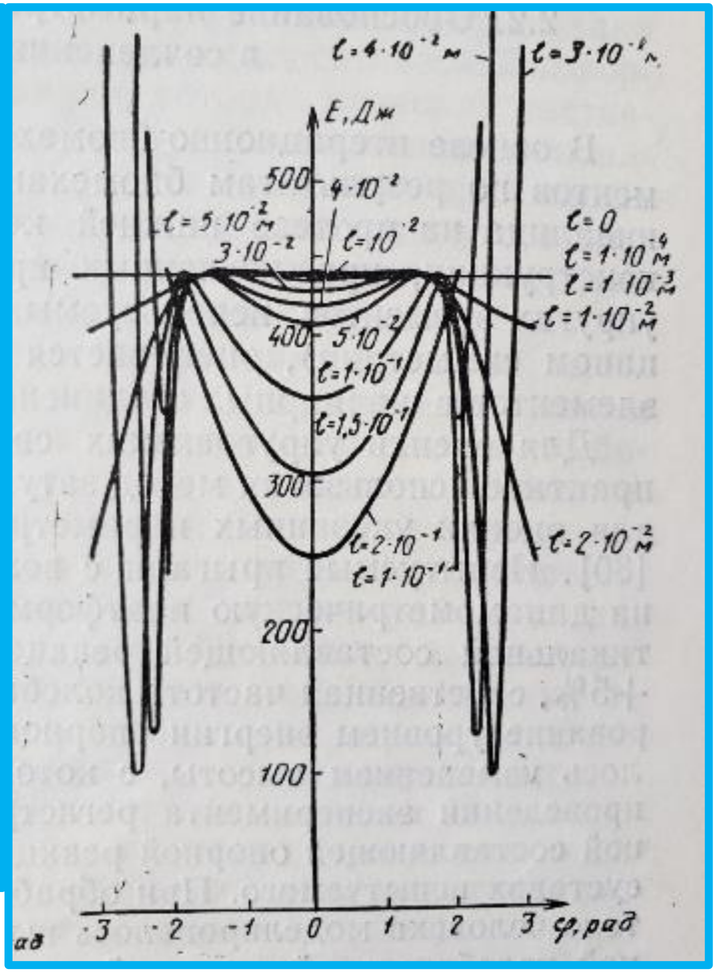


Figure 2.
Scheme of a device for determining the position of a center of mass of a chain.


Z1
O1
L7
O12
O11
OK1
L3
L1
O21
L4
O4
L2
O3
L6
O5
L5
Y
Z
X
O
На протезе
В норме
а
б
Zок
Zок2 (П)
Zок1 (Н)
T%
Z01 = (Z011+Z012)/2 + L7cosφ1
Z02 = (Z011+Z012)/2 + L7cosφ2
Z011 = L1cosα1 + L2cosβ1 + L5cosγ2
Z012 = L3cosα2 + L4cosβ2 + L6cosγ2
ΔZ = Z011 − Z012


E, Дж
l=0,05
l=0,03
l=0,02
l=0
φ, рад
E = ∫₀^2T {∑ᵢ₌₁² [|Pᵢ β̇ᵢ| + |qᵢ(φ̇ᵢ − α̇ᵢ)| + |uᵢ(α̇ᵢ − β̇ᵢ)|]} dt
E, Дж
φ = −π/2
φ = π/2
l, м


l = 4·10⁻² м
l = 3·10⁻¹ м
E, Дж
l = 0
l = 1·10⁻⁴ м
l = 1·10⁻³ м
l = 1·10⁻² м
l = 2·10⁻² м
l = 1·10⁻¹
l = 1,5·10⁻¹
l = 2·10⁻¹
φ, рад

Farber B. et al., Biomechanical basis of choosing the rational mass and its distribution throughout the lower limb prosthesis segments

https://www.rehab.research.va.gov/jour/95/32/4/pdf/farber.pdf

- Journal of Rehabilitation Research and Development Vol . 32 No. 4, November 1995 Pages 325-336

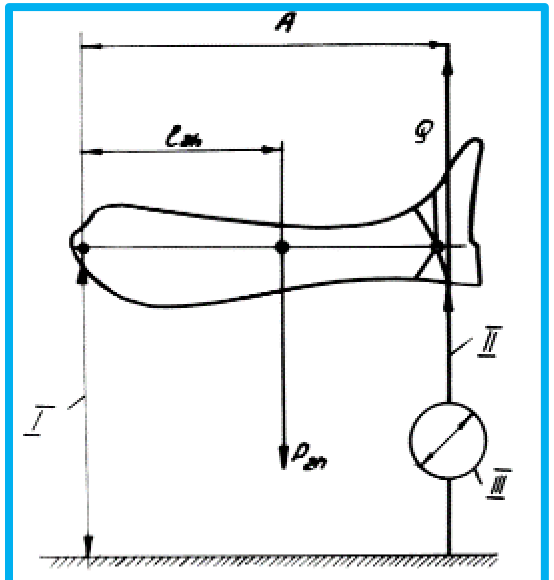


Figure 2.
Scheme of a device for determining the position of a center of mass of a chain.

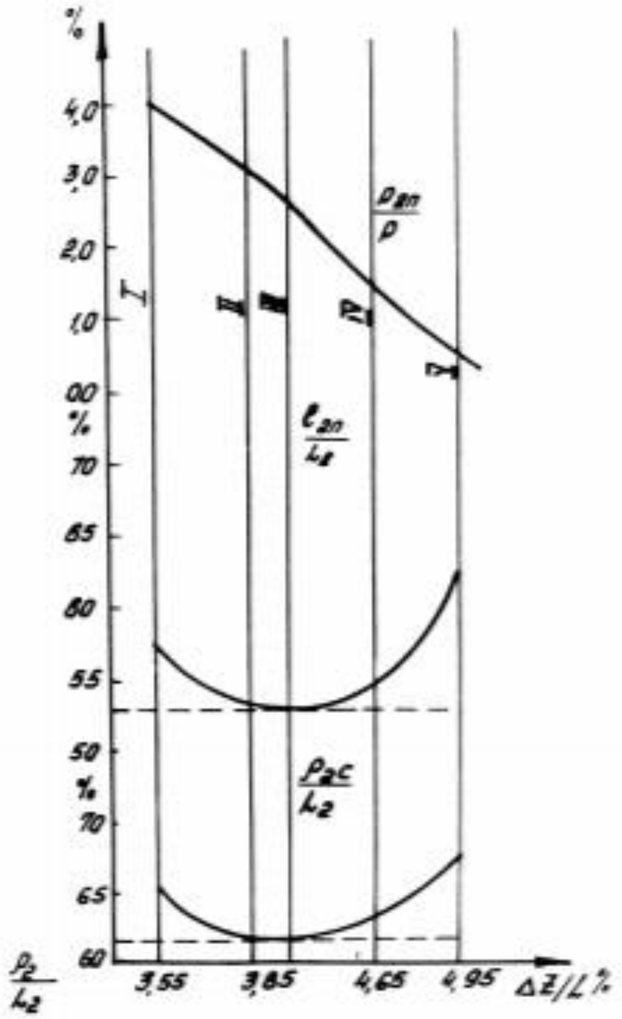


Figure 7.
Mass-inertial characteristics of a complex chain shank "+ foot + footwear" for AK prosthesis.
P_2 is the mass as a percentage of the human body mass; static radius l2 and inertial radius are expressed as a percentage of the distance "knee–floor" L2. On the X-coordinate is the frontal displacement of the total center of masses (TCM) related to the man's height.
I–Gritti stump; II–long stump; III–border of lower and middle third of a hip; IV–half of a hip; V–border of middle and upper third of a hip.

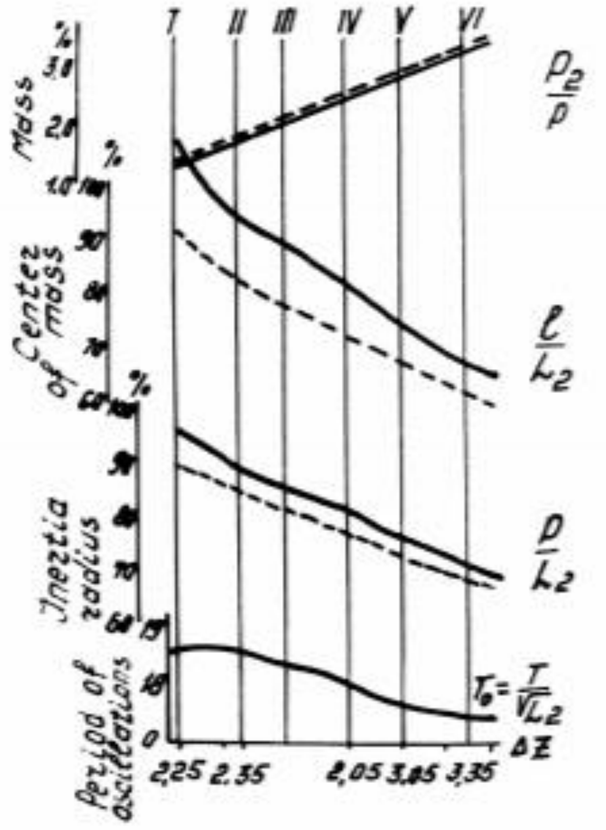


Figure 8.
Mass-inertial characteristics of a complex chain shank "+ foot + footwear" for BK prosthesis.
I–Pirogov stump; II–long stump; III–border of middle and lower third of a shank; IV–half of a shank; V–border of middle and upper third of a shank; VI–short BK residual limb.

S- curve for Prothesis Knee Units

АКАДЕМИЯ НАУК СССР
СИБИРСКОЕ ОТДЕЛЕНИЕ

Институт истории, филологии и философии
СО АН СССР

Философское общество СССР
Западно-Сибирское отделение

Новосибирский государственный университет
им. Ленинского комсомола

**МЕТОДОЛОГИЯ И МЕТОДЫ
ТЕХНИЧЕСКОГО ТВОРЧЕСТВА**

**Тезисы докладов и сообщений
к научно-практической конференции
30 июня — 2 июля 1984 г.**

Новосибирск
1984

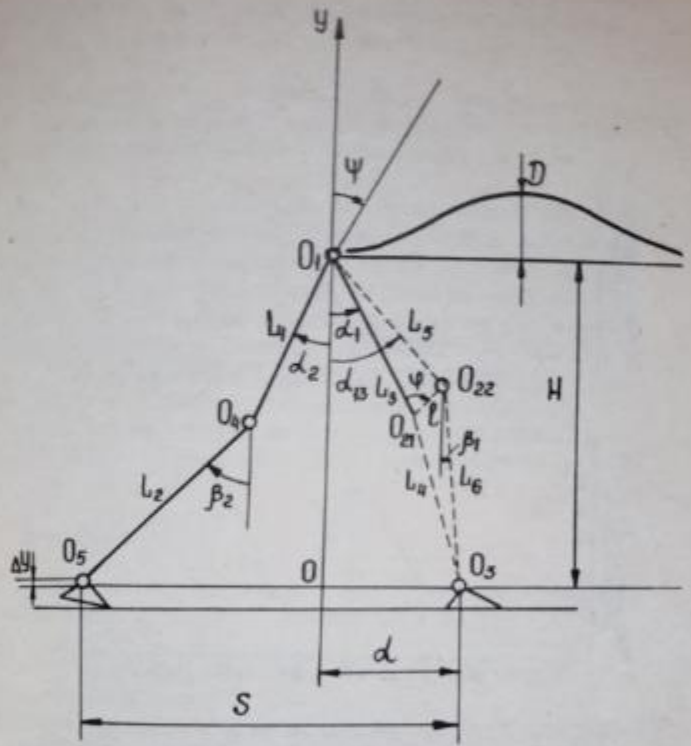


Рис. 1. Модель тела человека

жения. Качество оценивалось с помощью функционала энергозатрат Белецкого – Чудинова /1/:

$$E = \int_0^{2T} \sum_{i=1}^{2} \{ |p_i \dot{\beta}_i| + |q_i(\dot{\psi} - \dot{\alpha}_i)| + |u_i(\dot{\alpha}_i - \dot{\beta}_i)| \} dt$$

где:

p_i, q_i, u_i – моменты в суставах;

β_i, ψ, α_i – углы отклонения сегментов модели от вертикали.

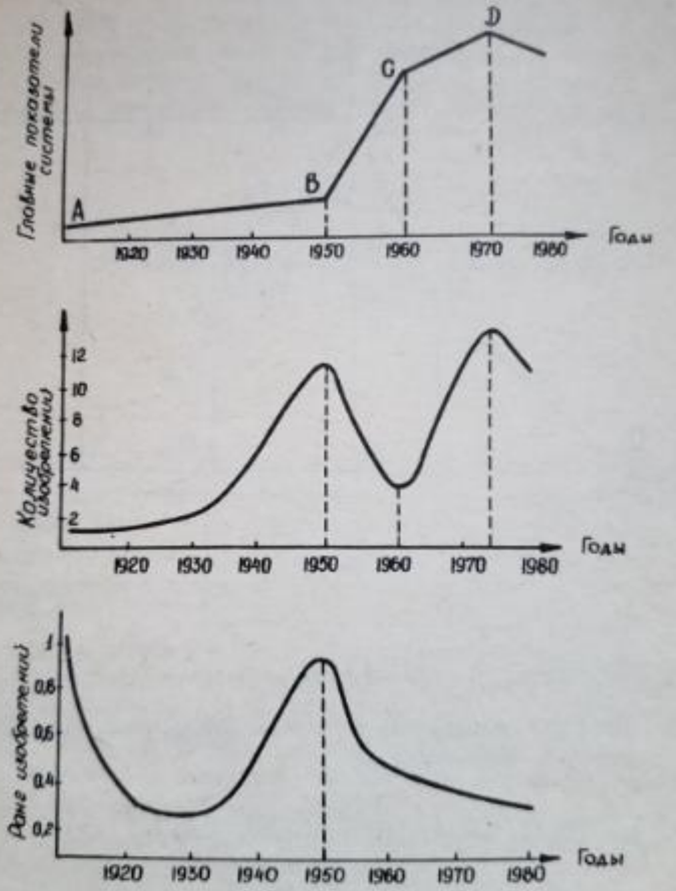
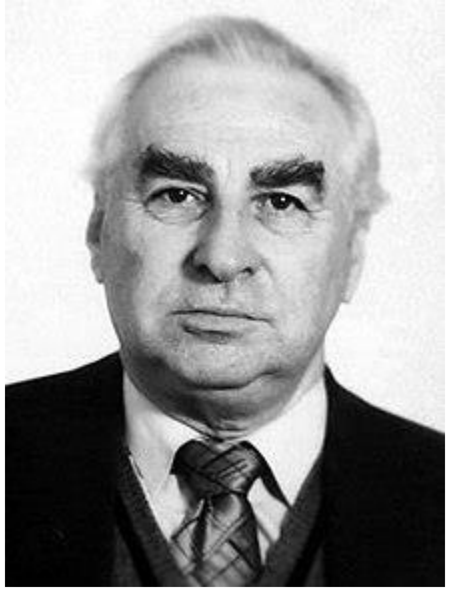


Рис. 2. Динамика патентования коленных механизмов

Член-корреспондент РАН, Профессор, Др Владимир Белецкий



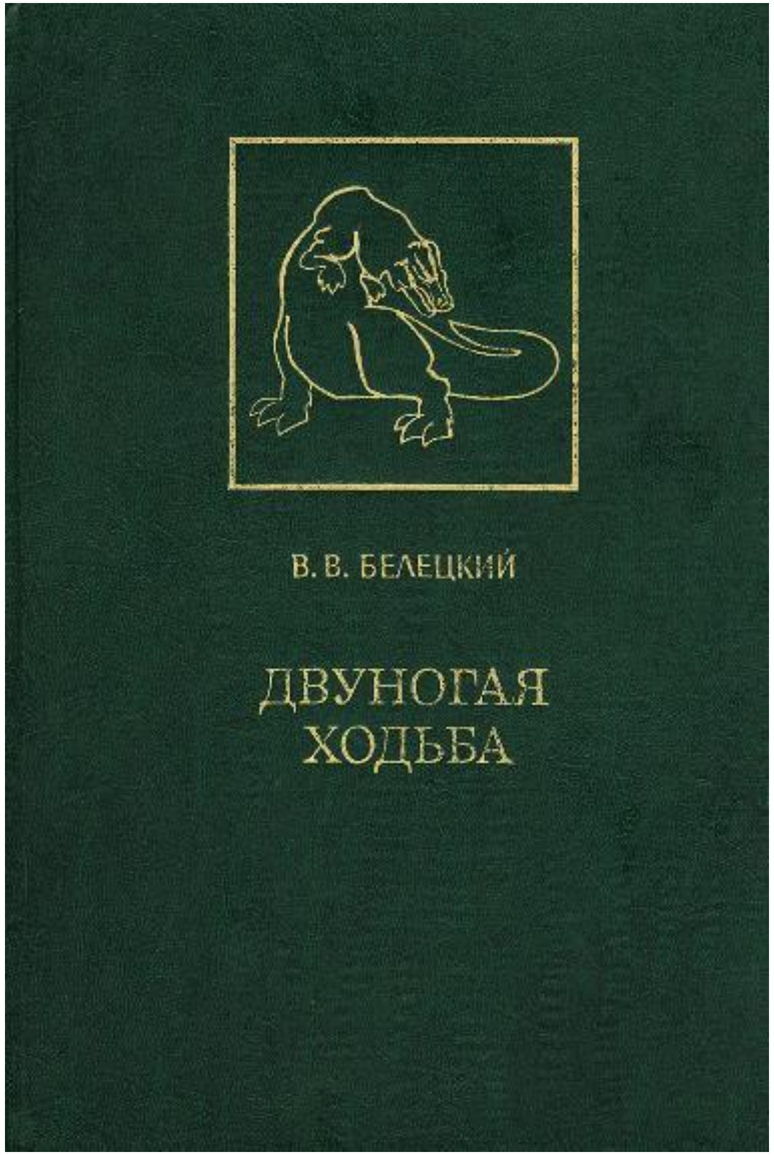
World-known Scientist in the field of celestial mechanics, dynamics, and astronautics, author of works on the theory of rotational motions of artificial and natural celestial bodies. Corresponding Member of the Russian Academy of Sciences, full member of the International Academy of Cosmonautics and the Russian Academy of Cosmonautics. K. E. Tsiolkovsky Institute of Applied Mathematics. Keldysh RAS, Moscow State University

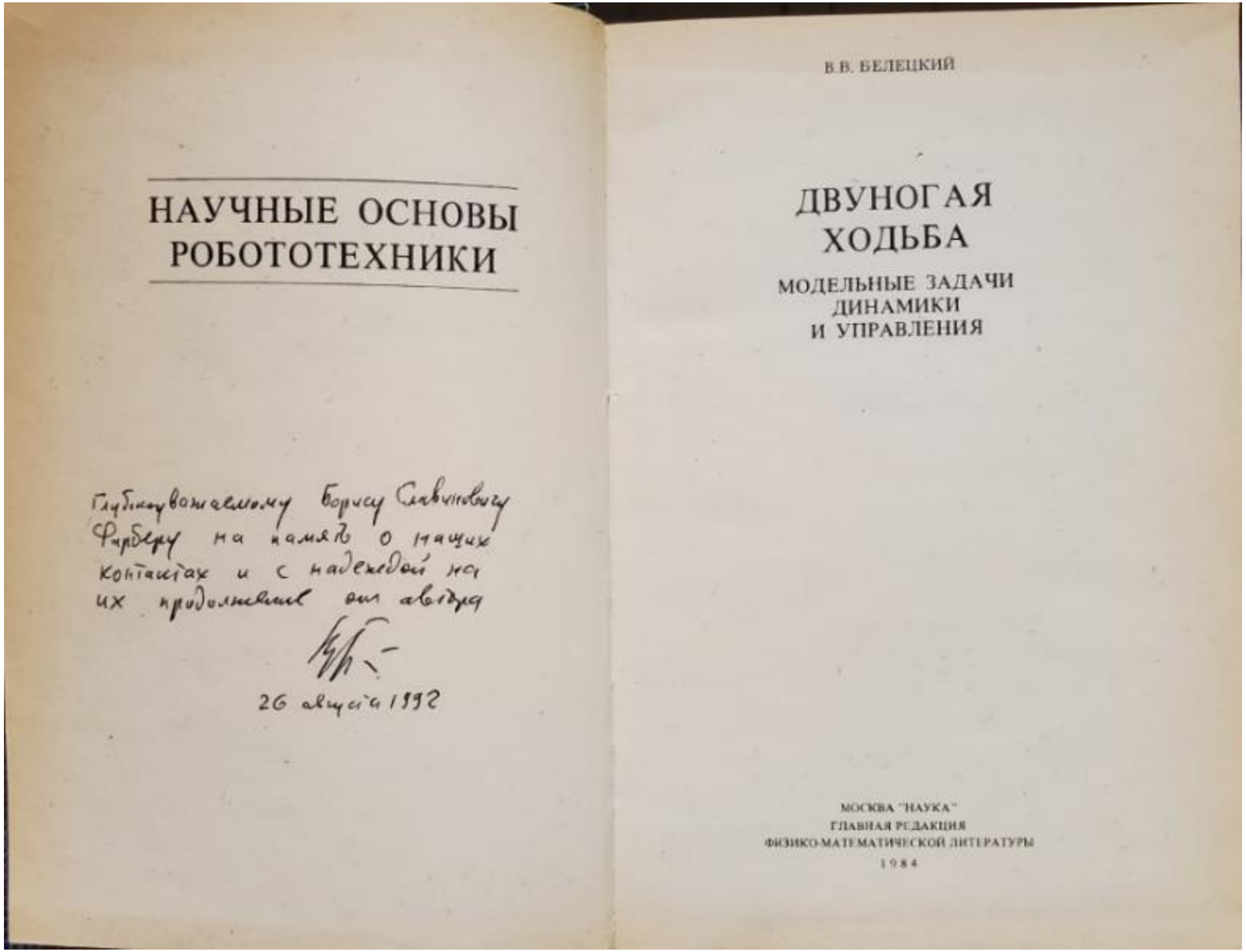
Official opponents: Doctor of Physical and Mathematical Sciences, Professor.
V. Beletsky

Doctor of Medical Sciences, Professor X. A. Janson

Doctor of Biological Sciences, Professor A. V. Zinkovsky

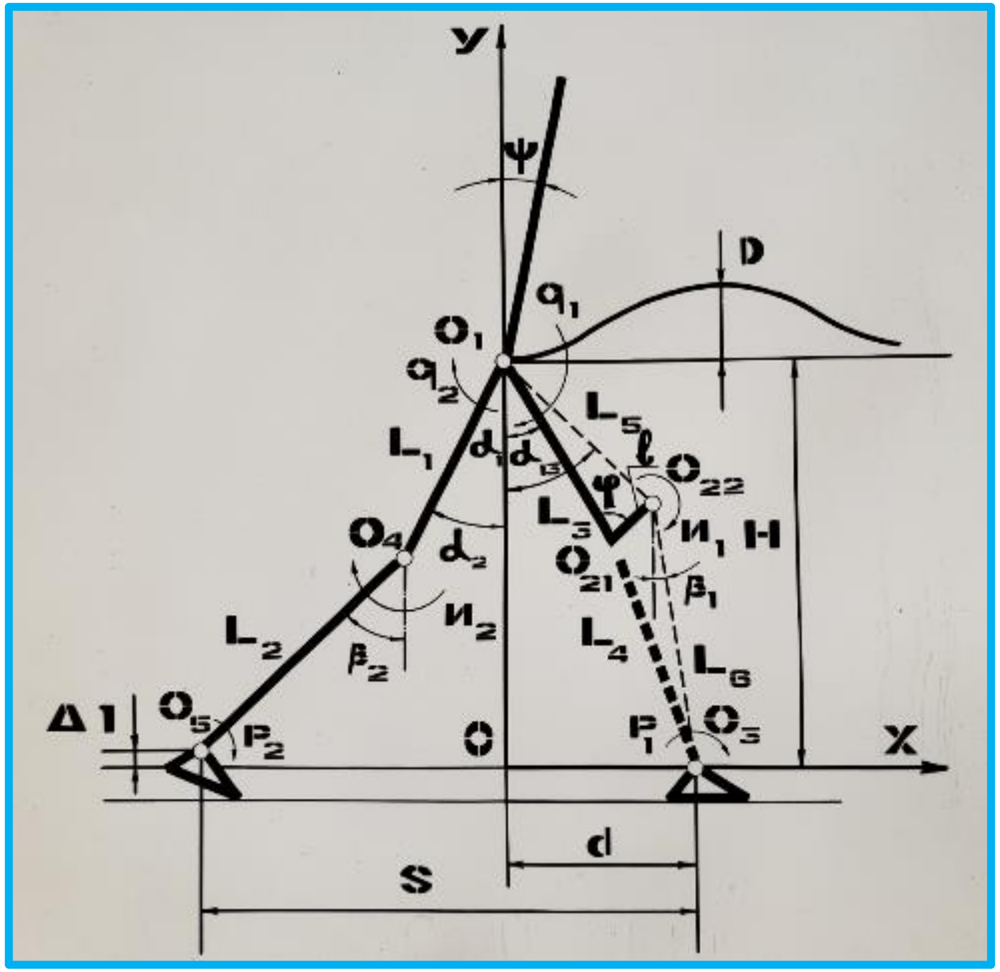
Dr. Professor V. Beletsky Bipedal Walking





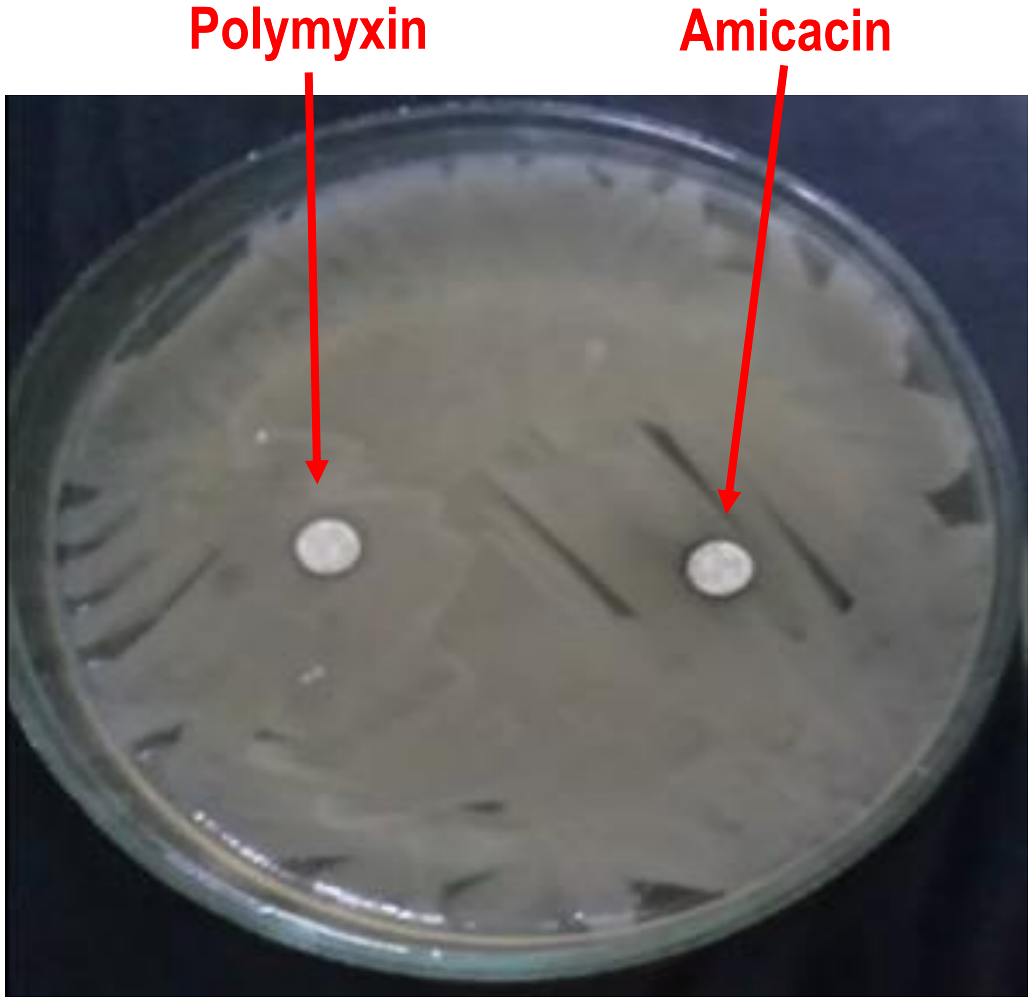
Dr. Farber's Dynamic Mathematical Model

$$M\ddot{x}+(m_1+2m_2)L'_1(\ddot{\alpha}_{22}\cos\alpha_2-\dot{\alpha}_2^2\sin\alpha_2)+(m_5+2m_6)L'_5(\ddot{\alpha}_{13}\cos\alpha_{13}-\dot{\alpha}_{13}^2\sin\alpha_{13})+$$
$$+m_2L'_2(\ddot{\beta}_2\cos\beta_2-\dot{\beta}_2^2\sin\beta_2)+m_6L'_6(\ddot{\beta}_1\cos\beta_1-\dot{\beta}_1^2\sin\beta_1)=R_{1x};$$
$$M\ddot{y}+(m_1+2m_2)L'_1(\ddot{\alpha}_2\sin\alpha_2+\dot{\alpha}_2^2\cos\alpha_2)+(m_5+2m_6)L'_5(\ddot{\alpha}_{13}\sin\alpha_{13}+\dot{\alpha}_{13}^2\cos\alpha_{13})+$$
$$+m_6L'_6(\ddot{\beta}_1\sin\beta_1+\dot{\beta}_1^2\cos\beta_1)=R_{1y}-Mg;$$
$$(J_1+4m_2L_1'^2)\ddot{\alpha}_2+2m_2L'_1L'_2\ddot{\beta}_2\cos(\alpha_2-\beta_2)+(m_1+2m_2)L'_1(\ddot{x}\cos\alpha_2+\ddot{y}\sin\alpha_2)+$$
$$+2m_2L'_1L'_2\dot{\beta}_2^2\sin(\alpha_2-\beta_2)+(m_1+2m_2)gL'_1\sin\alpha_2=q_2-u_2;$$
$$(J_5+4m_6L_5'^2)\ddot{\alpha}_{13}+2m_6L'_5L'_6\ddot{\beta}_1\cos(\alpha_{13}-\beta_1)+(m_5+2m_6)L'_5(\ddot{x}\cos\alpha_{13}+\ddot{y}\sin\alpha_{13})+$$
$$+2m_6L'_1L'_2\dot{\beta}_1^2\sin(\alpha_{13}-\beta_1)+(m_5+2m_6)gL'_5\sin\alpha_{13}=q_1-u_1+(R_{1x}\cos\alpha_{13}+R_{1y}\sin\alpha_{13})2L'_5$$
$$J_2\ddot{\beta}_2+2m_2L'_1L'_2\ddot{\alpha}_2\cos(\alpha_2-\beta_2)+m_2L'_2(\ddot{x}\cos\beta_2+\ddot{y}\sin\beta_2)-2m_2L'_1L'_2\ddot{\alpha}_2\sin(\alpha_2-\beta_2)+$$
$$+m_2gL'_2\sin\beta_2=u_2;$$
$$J_6\ddot{\beta}_1+2m_6L'_6L'_5\ddot{\alpha}_{13}\cos(\alpha_{13}-\beta_1)+m_6L'_6(\ddot{x}\cos\beta_1+\ddot{y}\sin\beta_1)-2m_6L'_6L'_5 d_{13}\sin(\alpha_2-\beta_2)+$$
$$+m_6gL'_6\sin\beta_1=u_1-p_1+2L'_6(R_{1x}\cos\beta_1+R_{1y}\sin\beta_1);$$
$$J\ddot{\psi}-M_7L_7(\ddot{x}\cos\varphi+\ddot{y}\sin\varphi)-M_7gL_7\sin\varphi=-q_1-q_2,$$

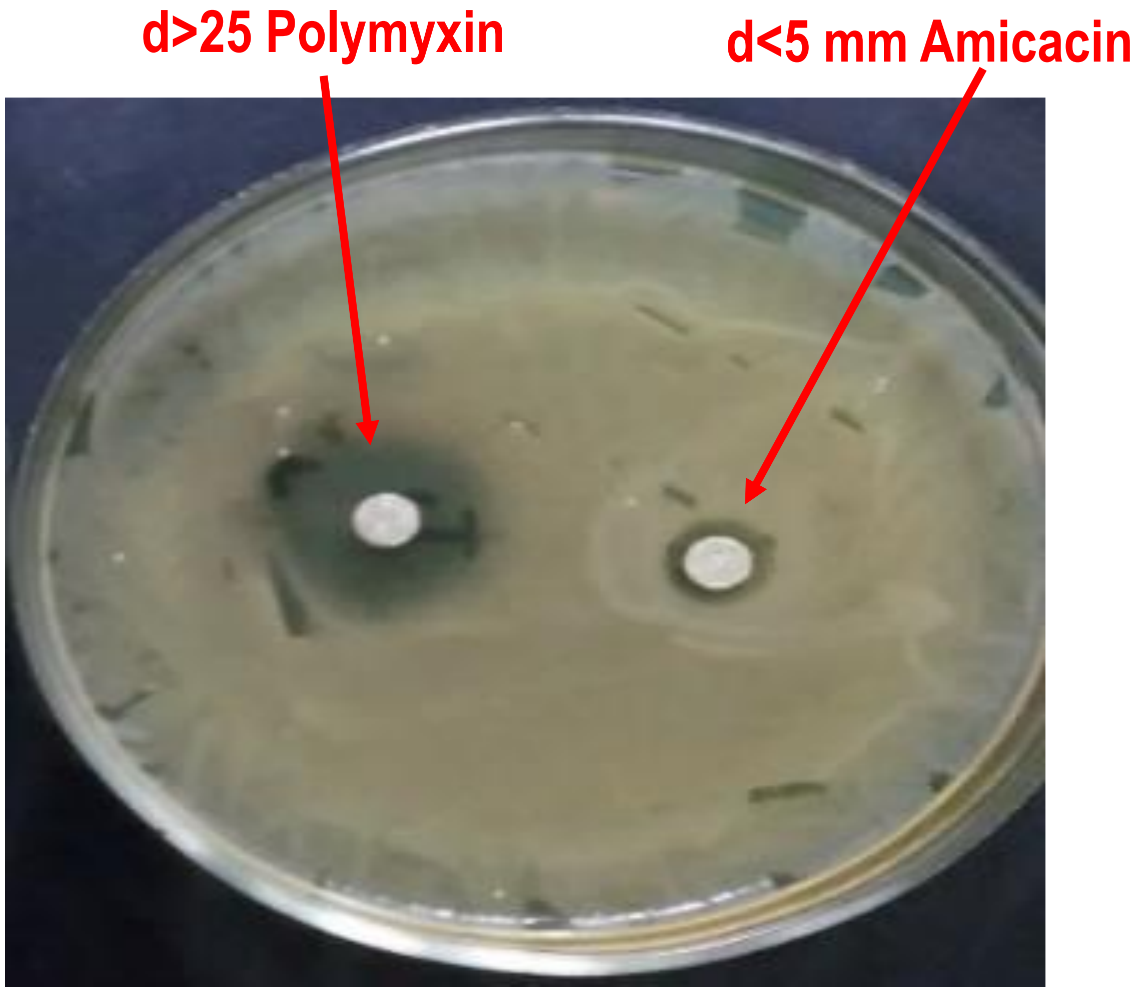


Application 4 : In molecular biology

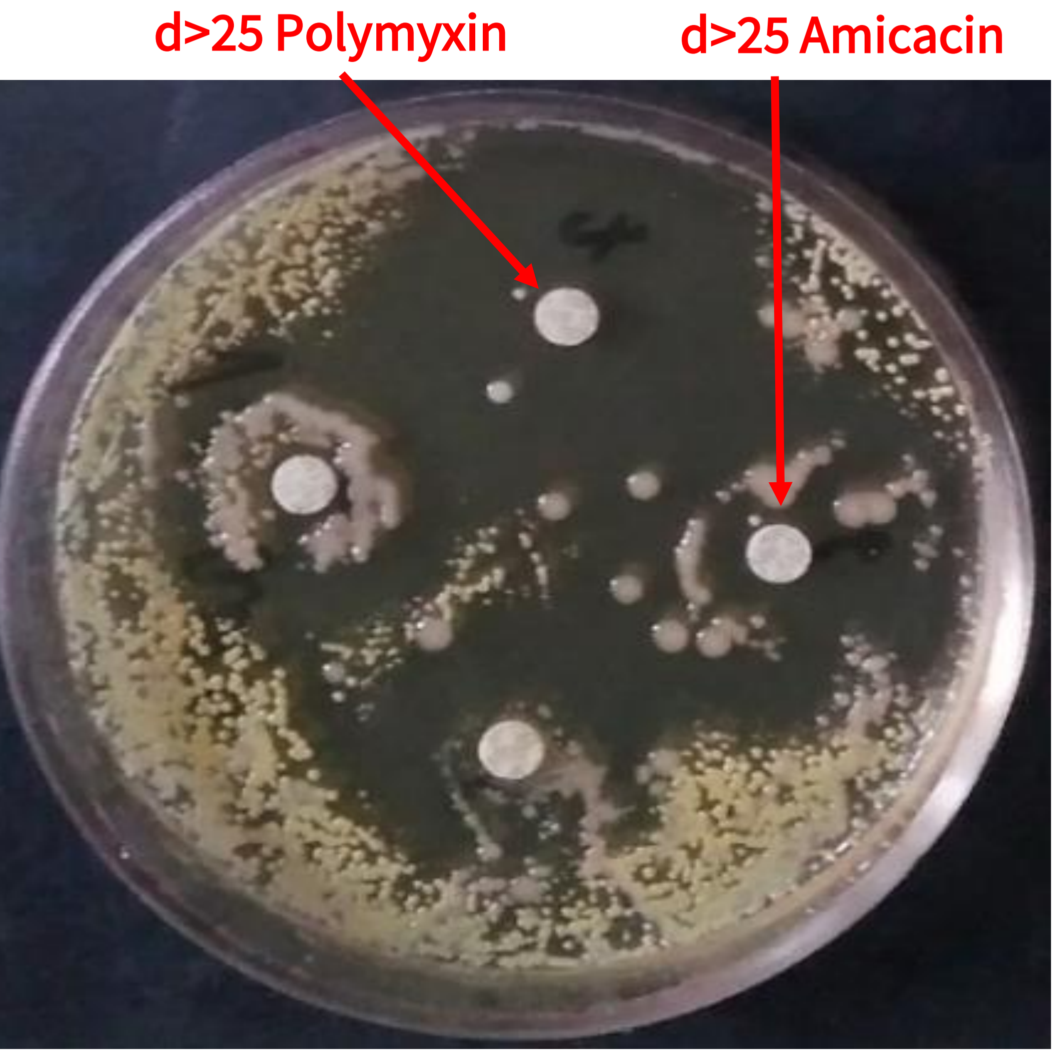
- Differential equations are of basic importance in molecular biology because many biological laws and relations appear mathematically in the form of a differential equation.
- The vast majority of quantitative models in cell and molecular biology are formulated in terms of ordinary differential equations.
- Mathematical cell biology is a very active and fast growing interdisciplinary area in which mathematical concepts, techniques, and models are applied to a variety of problems in developmental medicine and bioengineering.



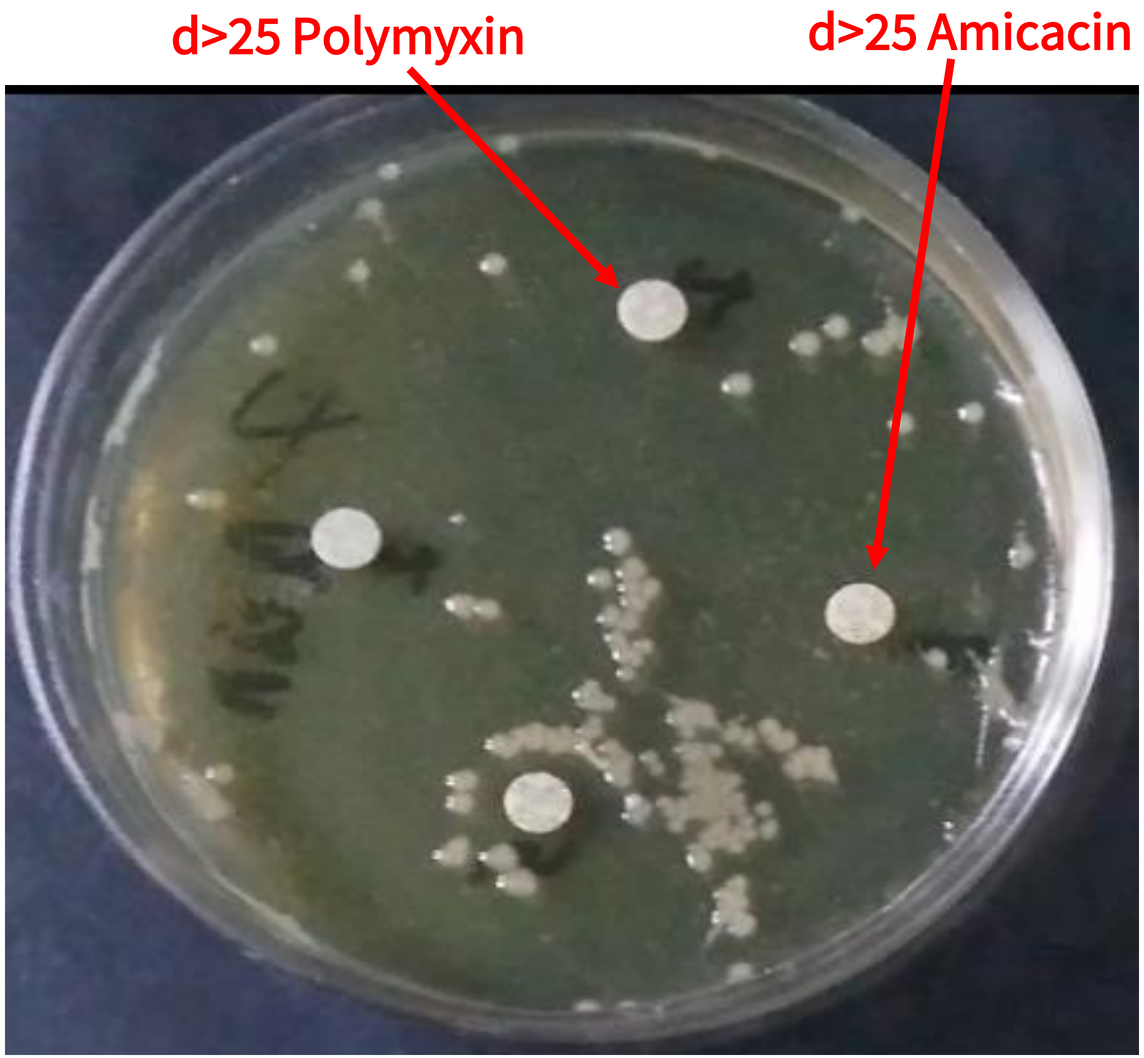
MDR *A.baumannii* growth **without NGL025:** 6 day growth, 2nd passage.



MDR *A.baumannii* growth **with NGL025**: 6 day growth, 2nd passage.



MDR *A.baumannii* growth **with NGL025:**
9 day growth, 3rd passage.

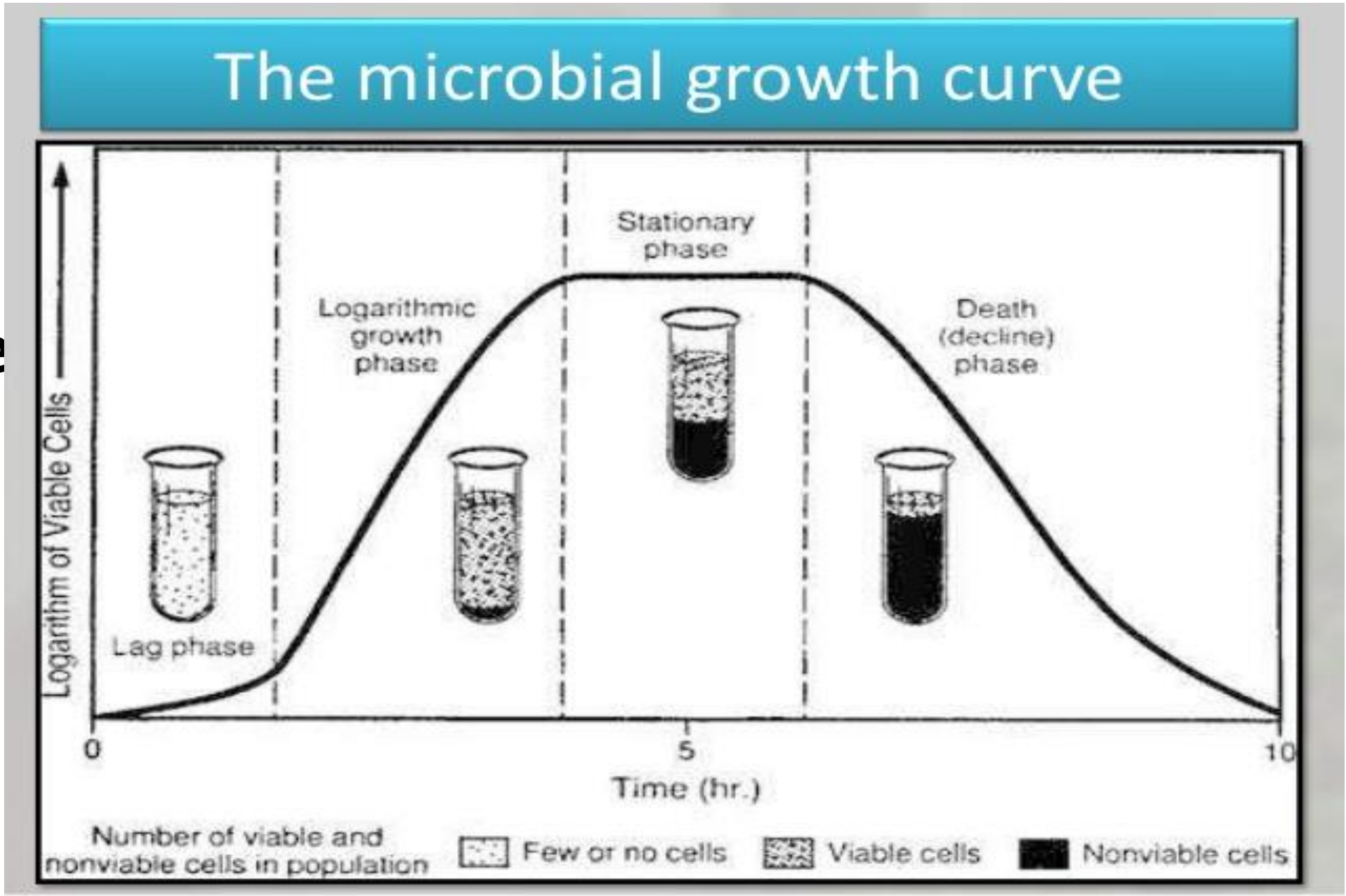


MDR *A.baumannii* growth **with NGL025:**
12 day growth, 4th passage.

The Key to NOIGEL’s breakthrough

Logarithmic growth-
bacteria in the absence of competition with each other **"dump" the majority of virulence factors** and toxin formation (including factors of acquired antibiotic resistance)

Log phase –
The most perspective phase as a target by antimicrobials.



López, S., Prieto, M., Dijkstra, J., Dhanoa, M. S., & France, J. (2004). Statistical evaluation of mathematical models for microbial growth. International Journal of Food Microbiology, 96(3), 289-300

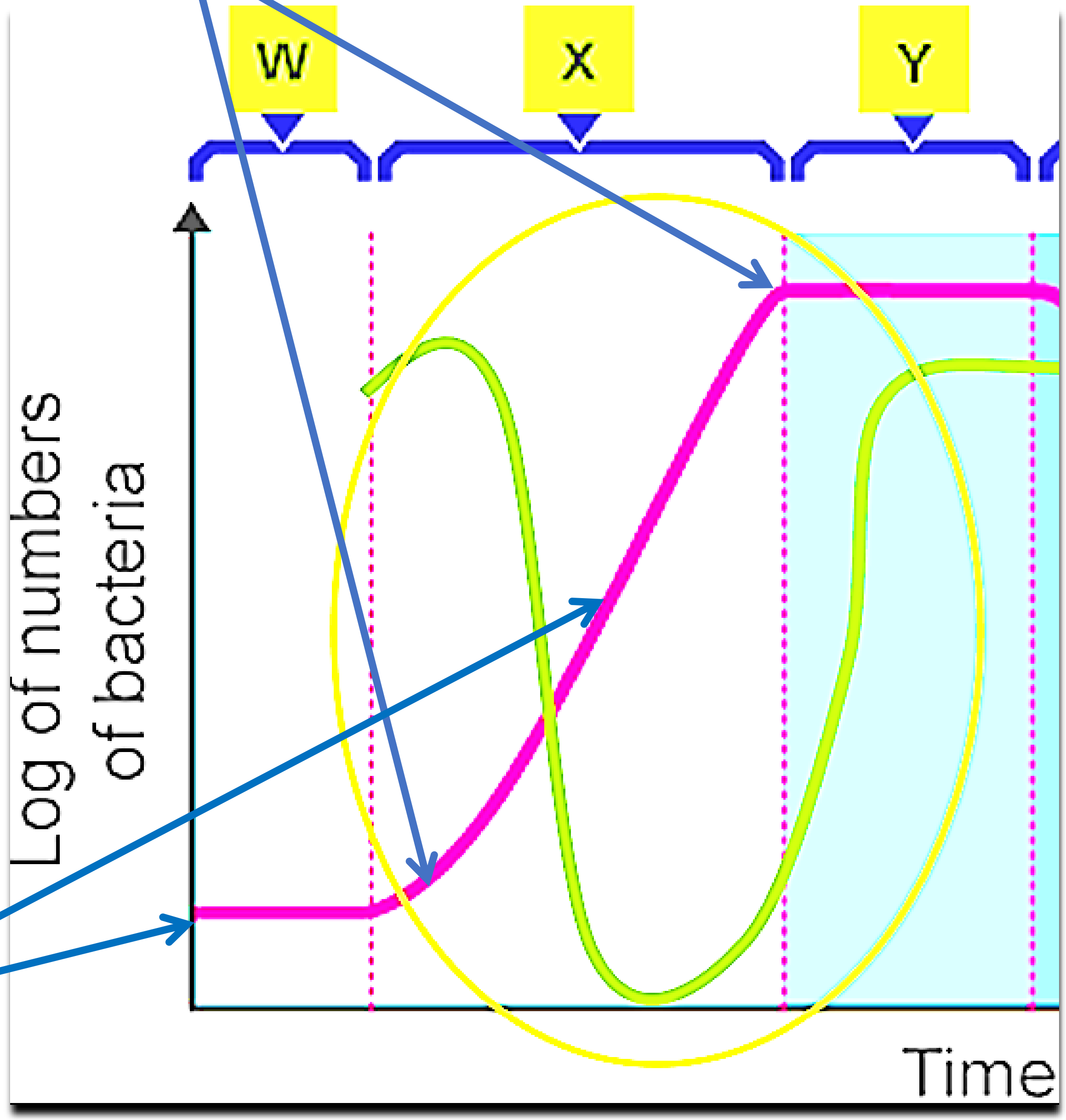
What ARE STRATEGIES ?

- Our strategy is **to“fool" bacteria** in order to eliminate biofilms and to destroy multiresistant bacteria by sending false signals making them think that there is an absence of danger. It will bring to initiation of logarithmic phase of bacterial growth.

- It is well known fact that the intensive growth of the bacterial mass in Log-phase does not cause a release of more toxins, virulence factors or cause a formation of biofilm.
  Based on this phenomenon, a combination of well known medications and compositions expressed in synergistic effect to stimulate growth of bacteria we were able to find a method to stop bacterial toxicity and virulence.

long-known classical antibacterial

Our synergistic composition from well-known drugs



Application 1 : Exponential Growth - Population

- One of the most basic examples of differential equations is the Malthusian Law of population growth $\frac{dp}{dt} = rp$ shows how the population (p) changes with respect to time. The constant r will change depending on the species.
- More complicated differential equations can be used to model the relationship between predators and prey. For example, as predators increase then prey decrease as more get eaten. But then the predators will have less to eat and start to die out, which allows more prey to survive. The interactions between the two populations are connected by differential equations.

Population Dynamics of a Continuous Propagator for Microorganisms

R. K. FINN and R. E. WILSON[1]
University of Illinois, Urbana, Ill.

As continuous fermentation offers economic advantages over the usual batchwise process, the present work was undertaken to provide a better understanding of the characteristics of a continuous propagator. Laboratory apparatus was developed which allowed sterile propagation of aerobic microorganisms in a stirred-tank reactor of the overflow type. Using *Ps. fluorescens, B. linens,* and a strain of *S. carlsbergensis* a theoretical relation was shown between the mean retention time of the cells in the propagator and their growth rate. By proper adjustment of the flow rates, steady populations were attained. In incompletely buffered media, a steady cycling in yeast population was observed, which was traced to steady fluctuations in the pH which were 90 degrees out of phase with fluctuations in population. The phenomenon appears to arise from the inherent feedback in the system coupled with a metabolic lag. Fermentation of the medium was not complete, as only the propagation of cells was of interest. In a practical process additional holding tanks would be provided, so that end products could be obtained in high yield.

MOST STUDIES OF CONTINUOUS FERMENTATION have been concerned with producing consistently high yields of alcohol, yeast, or other specific materials (*3, 17, 19*). It is appropriate that academic research in the field of bioengineering should undergird these applied studies with a more detailed inquiry into the behavior of living cells held in continuous culture. The purpose of this paper is to begin such an inquiry.

When fermentation is carried out in a cascade of two or more stirred tanks connected in series, the first tank constitutes a propagator. Fresh nutrient is added to the propagator at constant rate and a constant level of liquid is maintained in the propagator by arranging an overflow at the desired height. The rate of withdrawal is at all times equal to the feed rate and is generally so rapid that fermentation within the propagator is not complete, and all nutrients remain in excess of the cell requirements. Under such conditions, the cell population is limited solely by the washout of cells.

Novick and Szilard (*14, 15*) utilized a continuous propagator to study microbial genetics, especially mutation rates. Their apparatus, which they chose to call a chemostat, was operated in such a manner that growth was limited by deficiency of a particular nutrient, rather than by the washout rate.

The present work follows more closely that of Adams and Hungate (*1*). Using a continuous yeast propagator these investigators showed how the flow rate could be predicted from the growth curve of the organism. Several points raised in their paper, however, seemed to warrant further study. In the first place, Adams and Hungate did not observe any appreciable constant-rate phase of growth for yeast in their media. With organisms that show logarithmic growth, the estimation of flow rates could be simplified.

Furthermore, steady populations were not always obtained in the yeast propagator. Although Adams and Hungate (*1*) did not call attention to the possibility of cyclic fluctuations, their data suggested such an occurrence. More recently Maxon and Johnson (*10*) have confirmed the cycling phenomenon in a yeast propagator.

The present research concerns the propagation in the logarithmic phase of two aerobic bacteria, *Bacterium linens* and *Pseudomonas fluorescens;* cycling was also investigated, using a strain of *Saccharomyces carlsbergensis.*

Theory of Continuous Propagation With Logarithmic Growth

In batchwise cultivation single-celled organisms usually exhibit a phase of logarithmic growth which can be characterized by the equation

$$\frac{dN}{d\theta} = kN \qquad (1)$$

in which

N = the total number of cells
θ = time
k = a characteristic growth constant for the organism, which depends also on the environment—temperature, nature of medium, etc. Units are reciprocal time.

The rate constant, k, is conveniently measured by the slope of the growth curve when plotted on semilogarithmic coordinates.

$$k = \frac{(\text{slope})}{2.303} \qquad (2)$$

To achieve constant population in a flow system, the retention time within the propagator must equal $1/k$. Most investigators have been content simply to state this fact, but Monod (*12*) has provided rigorous proof based on a differential material balance.

By a material balance on the total cells, making use of Equation 1,

(In + growth) − out = accumulation

$$0 + kNd\theta - q\frac{N}{V}d\theta = dN \qquad (3)$$

in which V is the volume of liquid in the propagator and q is the volumetric flow rate.

[1] Present address, Corn Products Refining Co., Argo, Ill.

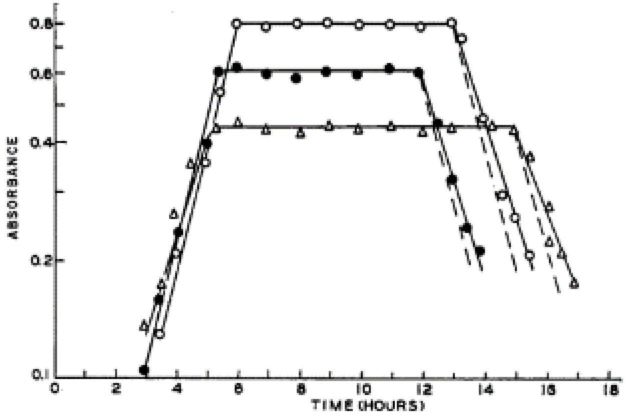


Figure 1. Verification of Equation 4 by substituting toxic reagents for nutrients being fed

$k = 0$
Three separate tests are shown. Substitution of phenol begun at 11.5 hours, of peroxide and sulfuric acid at 12.5 hours.
Ps. fluorescens. θ_g, 1.5 hours. Temperature, 23° C.
○ Saturated phenol
● 30% hydrogen peroxide
△ Concentrated sulfuric acid
--- Theoretical washout rates, Equation 4

From Equation 3 the rate of change of population is

$$\frac{dN}{d\theta} = N(k - q/V) \qquad (4)$$

An alternate form of Equation 4 is

$$\frac{dN}{d\theta} = N\left(\frac{\ln 2}{\theta_g} - \frac{1}{\theta_r}\right) \qquad (4a)$$

where θ_g is the familiar generation time of the organism, and θ_r is the mean retention time in the apparatus.

For the population to remain constant in a continuous propagator, the flow rate must be set so that

$$\theta_r = \frac{1}{k} = \frac{\theta_g}{\ln 2} \qquad (5)$$

If this condition is not met, the level of growth will change with time in accord with Equation 4.

It is assumed in the above analysis that flow rates are truly constant, and that mixing within the propagator is instantaneous and complete. The last assumption is generally not so severe a restriction as might be supposed (*9*).

Experimental

The propagator itself was not of unusual design. It consisted of a 500-cc. gas-scrubbing bottle appropriately modified to allow for inoculation and the subsequent feeding of nutrients. The overflow was of capillary glass tubing. The entire propagator was immersed in a water bath held at constant temperature, and there was provision for blowing sterile air at measured rates through a sintered-glass disk within the propagator. Dissolved oxygen, measured polarographically, was always in excess of the critical concentration for cellular uptake. No auxiliary agitation was required because of the high air rates used.

Of more interest to those wishing to study continuous fermentation was the use of a Sigmamotor pump (E and M Enterprises, Middleport, N. Y.) to provide constant flow rates of sterile nutrient. This pump has a cam arrangement, which moves fingerlike pieces of metal so as to press fluids through rubber or Tygon tubing, which passes between these fingers and a metal plate within the pump. Positive pumping at flow rates as low as 2 cc. per minute is easily possible. Changes in the flow rate may be made either by using rubber tubes of different size, or by modifying the speed of the pump. Freedom from contamination and ease of control recommend the use of such a pump over any variations of the Mariotte bottle as a means of attaining constant flow rates.

Growth was followed by measurements of absorbance (optical density), using a Coleman Nephocolorimeter (red filter No. 6-215). The linear response of the instrument was checked by plate counts, and when necessary dilutions were made before taking absorbance readings. The pH measurements were made with a Beckman line-operated meter. Sugar and carbon dioxide were measured by standard analytical methods.

The operating procedure was simple. To start the propagator, growth was allowed to proceed batchwise until, at an appropriate level of population,

Figure 2. Verification of Equation 4 by altering flow rate in two tests

B. linens. Temperature 26° C.
△ Curve 1
○ Curve 2

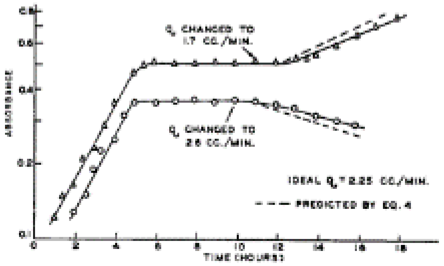
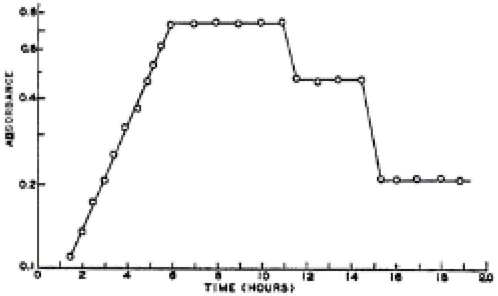
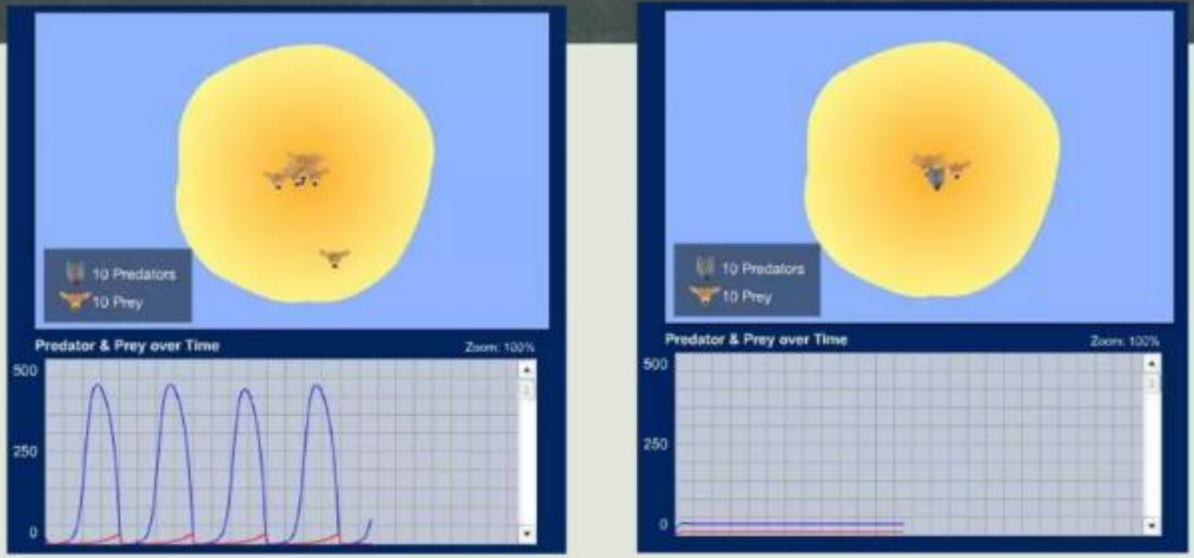


Figure 3. Verification of Equation 4 by altering population level

B. linens. Temperature 26° C. θ_r, 2.4 hours



Graph of Growth Population



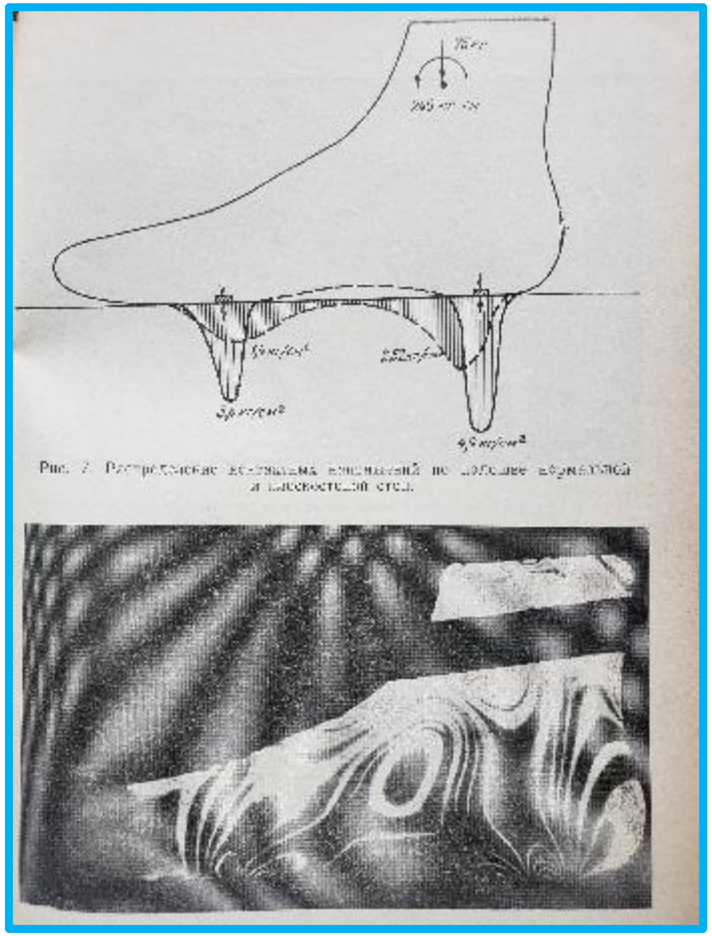
- First Graph shows when the predator is both very aggressive it will attack the prey and rapidly eat the prey population, growing rapidly – before it runs out of prey to eat and then there will be no other food, thus dying off again.
- Then predators will be less aggressive and it will lead to both populations in a stable position (Graph two).

Some Other Applications of Differential Equations

- Some Other Applications of Differential Equations are,

  1) In medicine for modelling cancer growth or the spread of disease
  2) In engineering for describing the movement of electricity
  3) In chemistry for modelling chemical reactions
  4) In economics to find optimum investment strategies
  5) In physics to describe the motion of waves, pendulums or chaotic systems.

Farber B. et al., Photo elasticity for Foot Studies



Grand Idea LINE - 2

NOVEL Drugs with dynamic structures (Dynamic drugs) based on TRIZ

To survive, rate of Pathogen Microorganisms "innovations" faster than rate of new classical drugs development.

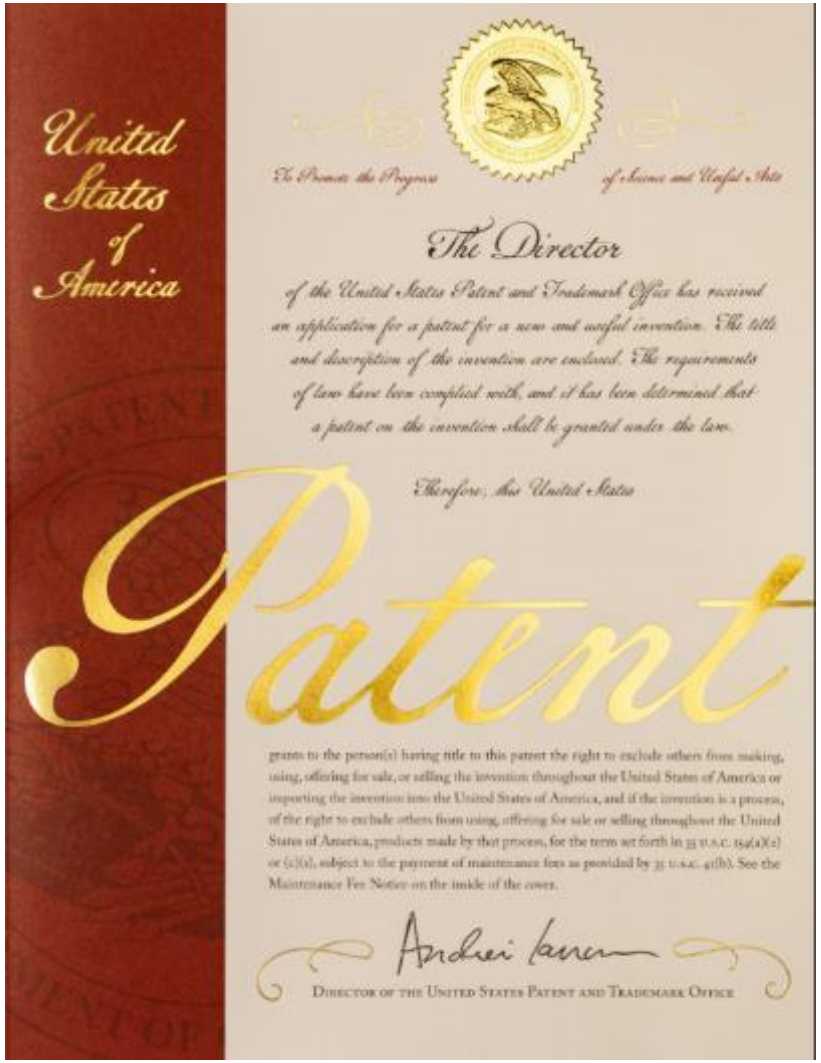
This is time to find another, Dynamic way to fight Patogen Microorganisms

Illustration

Instead of one "key" for one "lock" (the principle of a classic drug with a conservative structure), we propose a selection of "skeleton keys": a group of many similar molecules that "open" many "locks" and adapt to the target. This facilitates a practically 100% effectiveness rate and a maximally wide spectrum of drug activity

Вместо одного «ключа» на один «замок» (принцип классического препарата с консервативной структурой) мы предлагаем набор «скелетных ключей»: группу из множества одинаковых молекул, которые «открывают» множество «замков» и адаптируются к цели. Это обеспечивает практически 100% эффективность и максимально широкий спектр действия препарата.

https://zenodo.org/record/2547580#.XGVsUlVKiWE
https://zenodo.org/record/2639505#.XLMwluj7SUk



Annals of Mechnikov Institute, N 4, 2018 15
www.imiamn.org.ua /journal.htm

CREATION OF NEW MEDICAL DRUGS BASED ON TRIZ AND COMPUTER MATHEMATICAL MODELING

Farber B.S., Martynov A.V., Kleyn I.R

Noigel, LLC; TRIZ Biopharma International, LLC New York; Mechnikov Institute of Microbiology and Immunology (Kharkov, Ukraine).

In memory of Genrich Altshuller, creator of TRIZ philosophy and a Teacher, with whom we discussed the most significant of our trends and inventions.

TRIZ (the theory of inventive problem solving) is a new philosophy of thinking, created by Genrich Altshuller and further developed by his followers [1]. One of the authors

area which affects almost every family, and each and every one of us. Namely, the development of new effective drugs, [12].

To use TRIZ principles in drug development necessitates broad knowledge in several areas rooted in the molecular modeling method. This method includes the application of the laws of quantum physics and quantum chemistry. Additionally, it requires knowledge of the behavior of molecules in various situations and their interaction with each other at different temperatures, as well as in the presence of salts and other compounds.

Truly effective drugs can be developed only on the basis of a systematic approach and in-depth knowledge of the fields of medicine; pharmaceutical chemistry, medical chemistry, physical chemistry, analytical chemistry, pharmacognosy, chemistry of natural compounds; plant medicine technology; biochemistry, molecular biology; pharmacology; and many other disciplines.

Over the last 100 years the pharmaceutical sciences

Annals of Mechnikov Institute, N 1, 2019
www.imiamn.org.ua /journal.htm 47

APPLICATION OF SYNERGETIC SET OF TRIZ PRICIPLES FOR DEVELOPING cAMP - ACCUMULATION ACTIVATORS AND THEIR INFLUENCE ON MULTI-DRUG RESISTANCE MICROORGANISMS

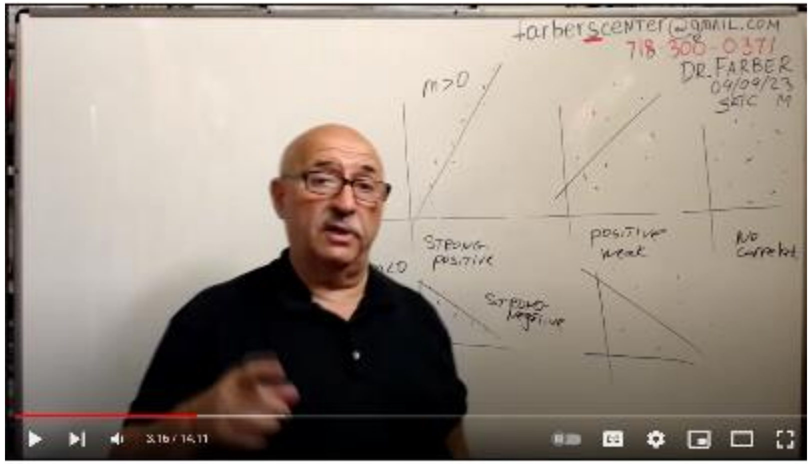
Farber B [2]., Martynov A.[1,2], Osolodchenko T[1]., Kleyn I[2].

out the reverse action. For example, a burn can be attained not only from extreme heat, but also from extreme cold, and expansion process can occur not only by heating, but also by freezing water. Overcoming psychological inertia allowing you to use the opposite action sometimes allows you to find novel solutions. In our case this would mean that instead of killing bacteria we should enhance them.

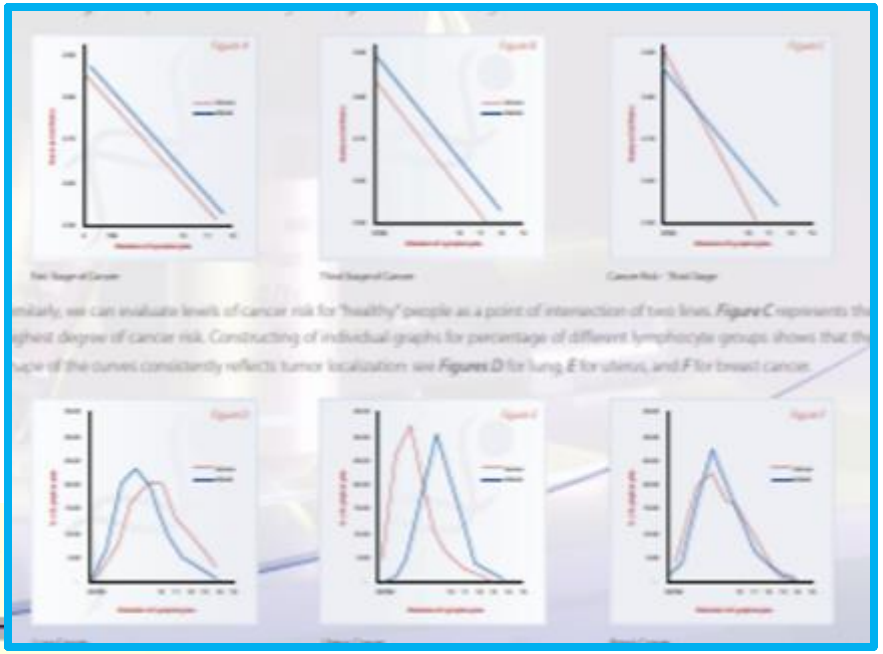
2. TRIZ principle of "Preliminary anti-action." (#9). This means that when you know that an undesirable situation

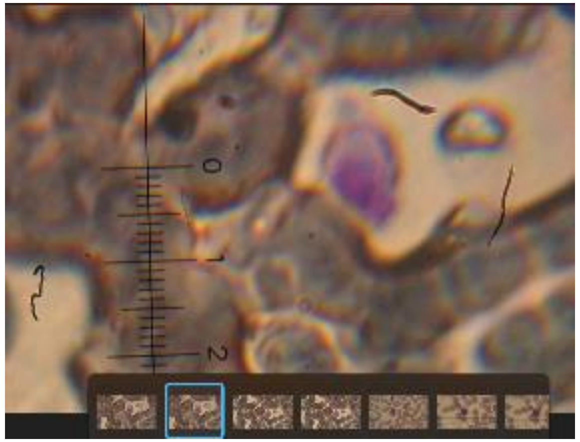
The connection between SAT problem and Cancer Diagnostics Blood Cells Morphometric Method

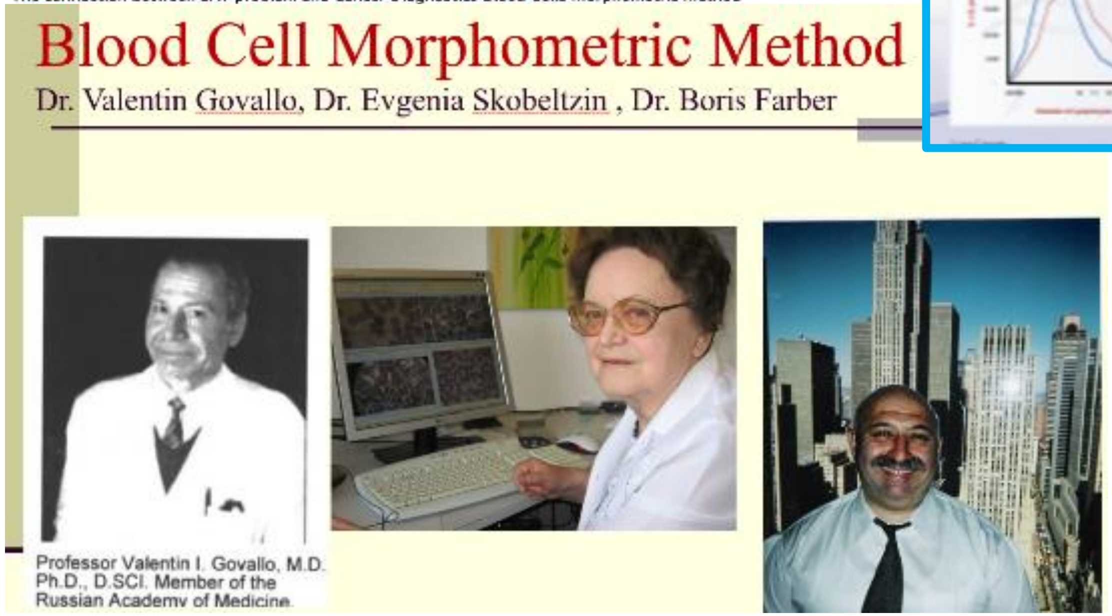
https://www.youtube.com/watch?v=XelQsJHz49g&t=634s&ab_channel=Farber%27sCenter



The connection between SAT problem and Cancer Diagnostics Blood Cells Morphometric Method







METHOD FOR DIAGNOSTICS OF HUMAN TUMOR DISEASES Blood Cell Morphometric Method (BCMM) 2005 PCT WO 2007/021211

(12) МЕЖДУНАРОДНАЯ ЗАЯВКА, ОПУБЛИКОВАННАЯ В СООТВЕТСТВИИ С ДОГОВОРОМ О ПАТЕНТНОЙ КООПЕРАЦИИ (PCT)

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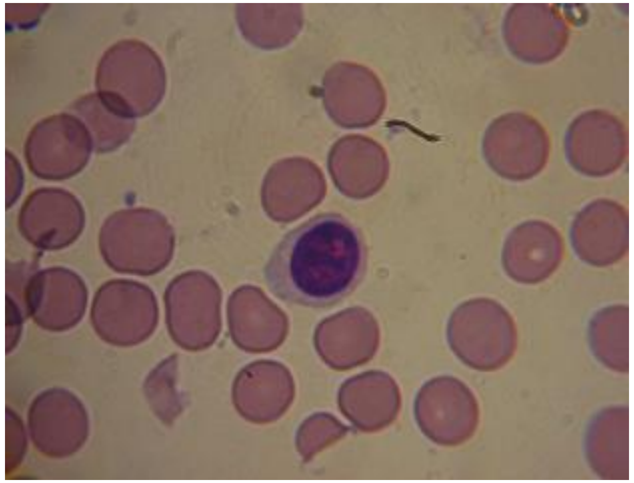
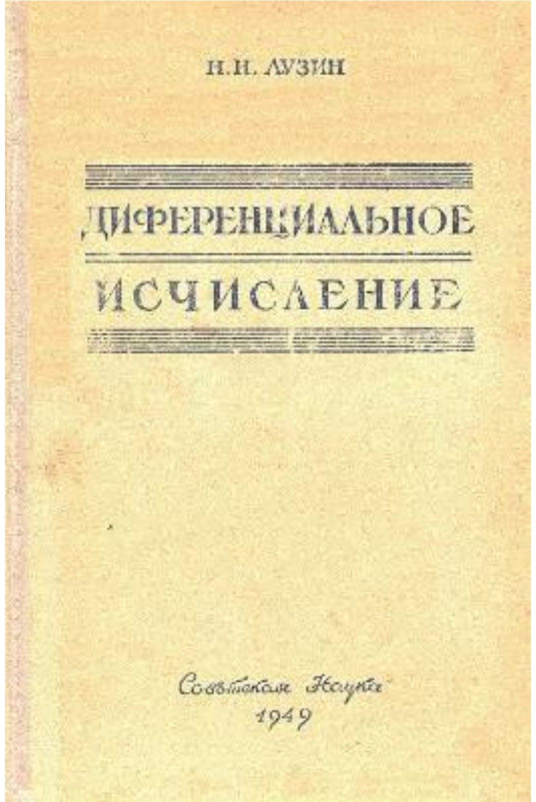
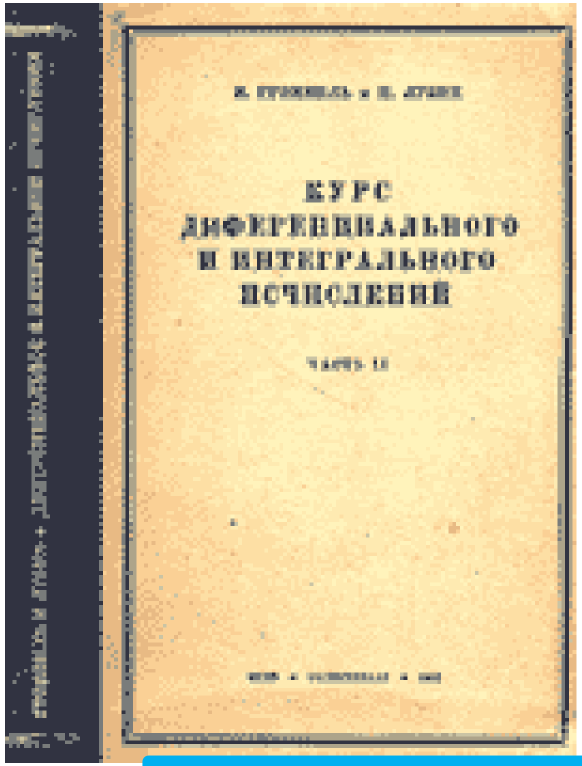


Grenville, W.A., Luzin, N.N. Course of differential and integral calculus (“LUSITANIA”).





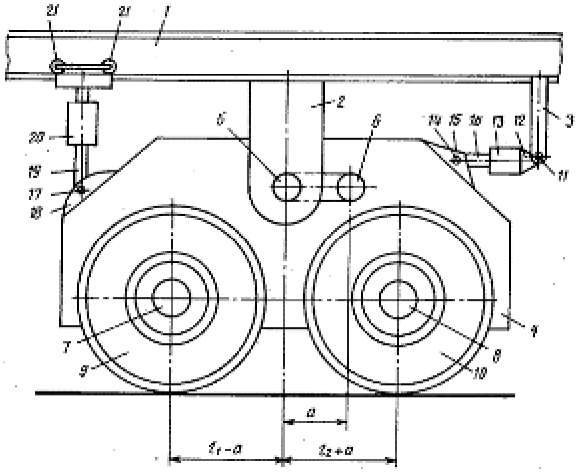
LUZIN Nikolai Nikolaevich (1883-1950) - Russian mathematician, founder of the scientific school of function theory, academician of the USSR Academy of Sciences

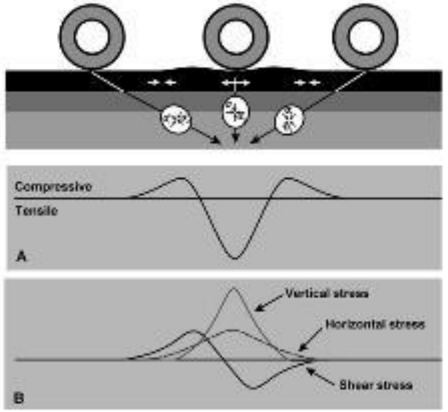
АКАДЕМИК КОНСТАНТИН ФРОЛОВ- вибротехнические и биомеханические системы

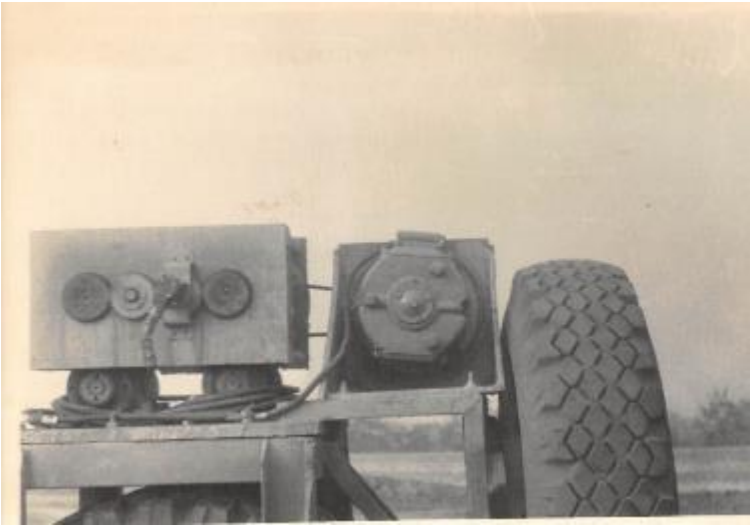
Советский и российский ученый в области машиностроения. Вице-президент Российской академии наук, Академии наук СССР.

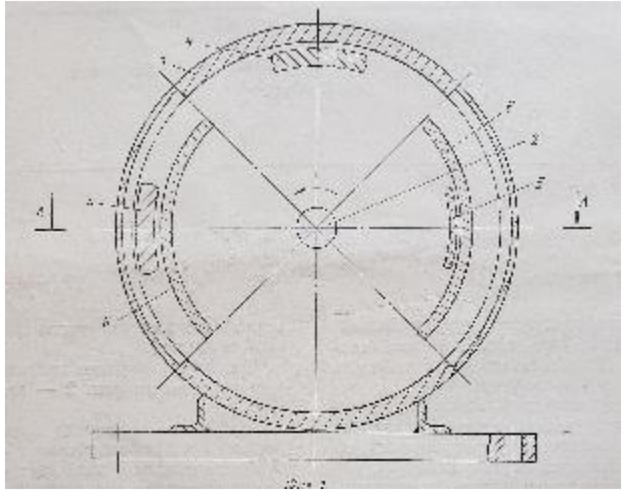
АКАДЕМИКУ К.В. ФРОЛОВУ 75 ЛЕТ

TRIZ Principle 15. Dynamicity
Farber B. et al., Multi axes Dynamic Vehicle Patent #1199885 Farber B. et al., Unbalanced Vibrator Patent # 649478









Противоречие: чтобы быстрее восстановиться, пациенту следует выполнять легкие упражнения, в том числе ходить, но он не может ходить. Как ходить, не ходя? «Умная обувь» -Вибросканер // Временная диаграмма управления вибратором в Вибросканере.

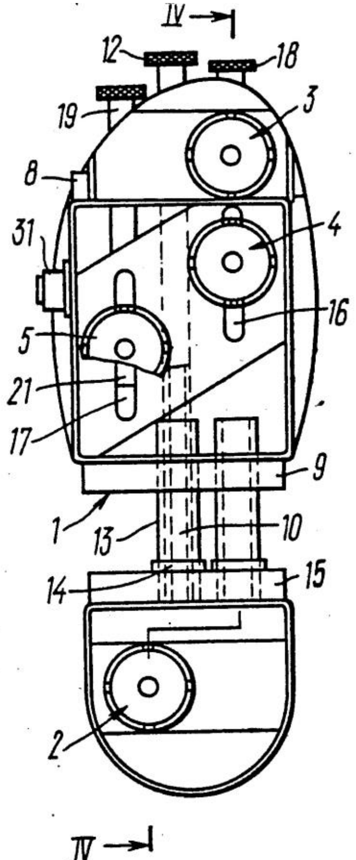


FIG.3

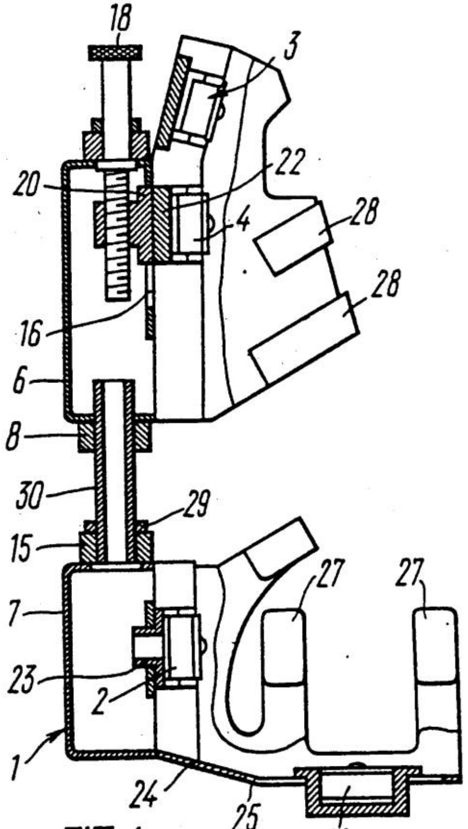
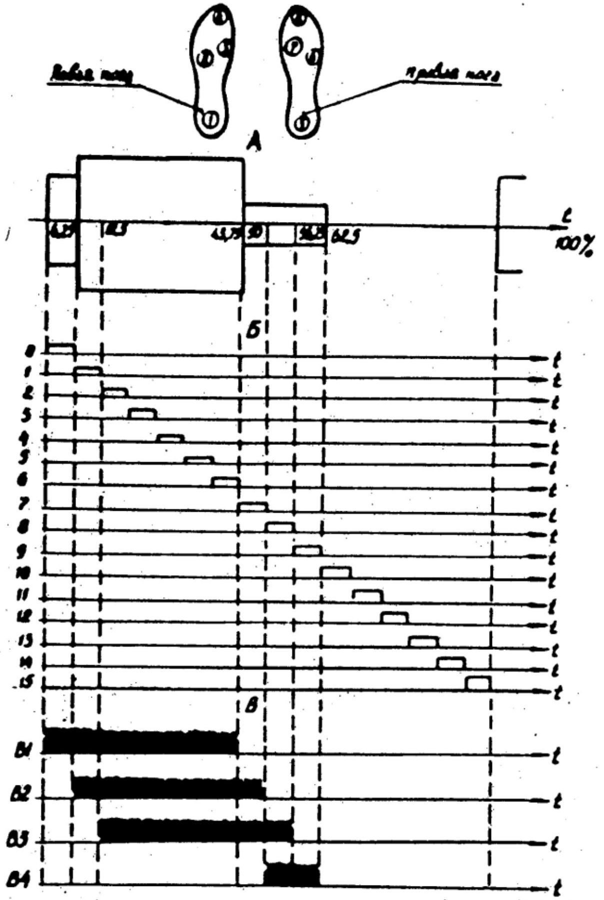
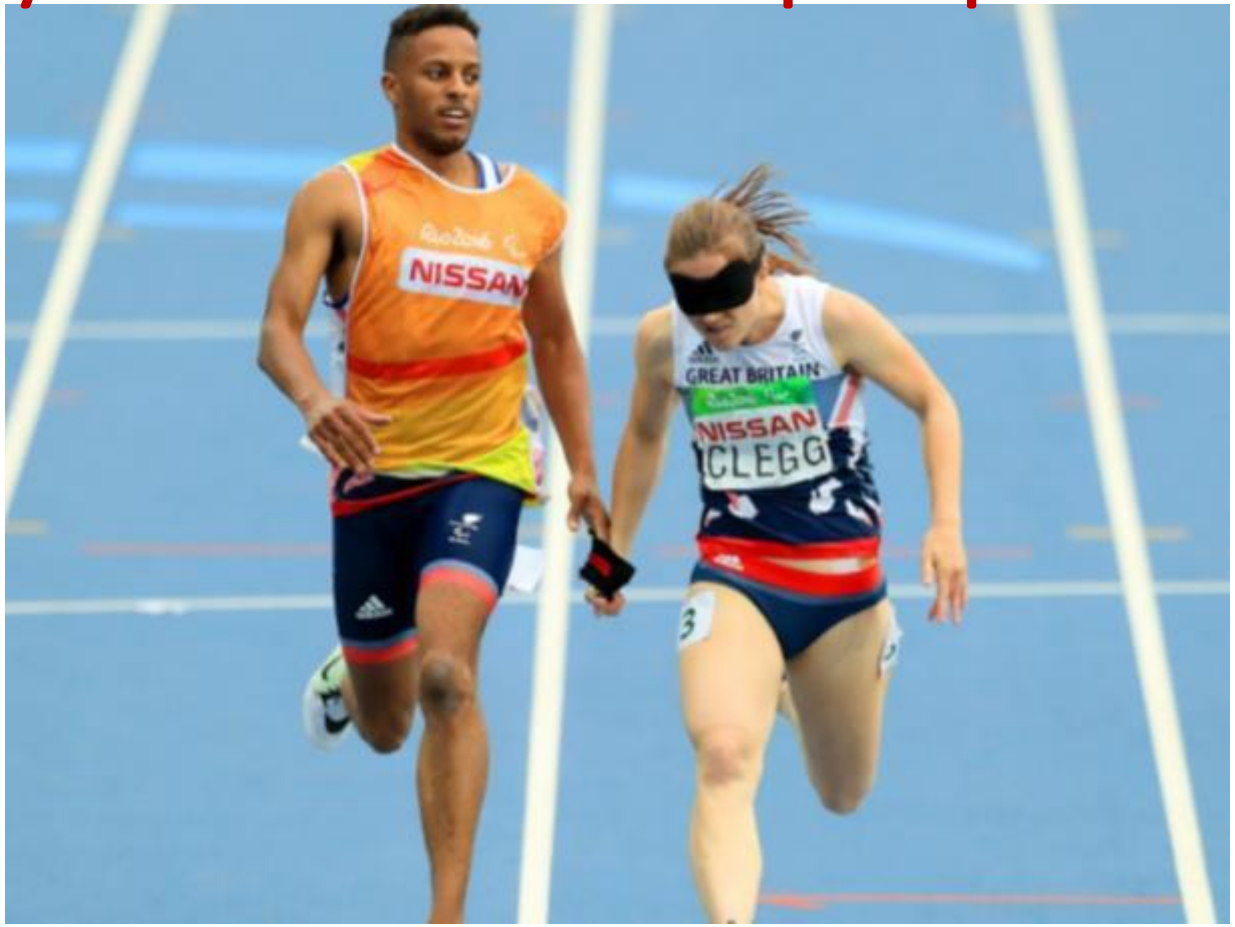
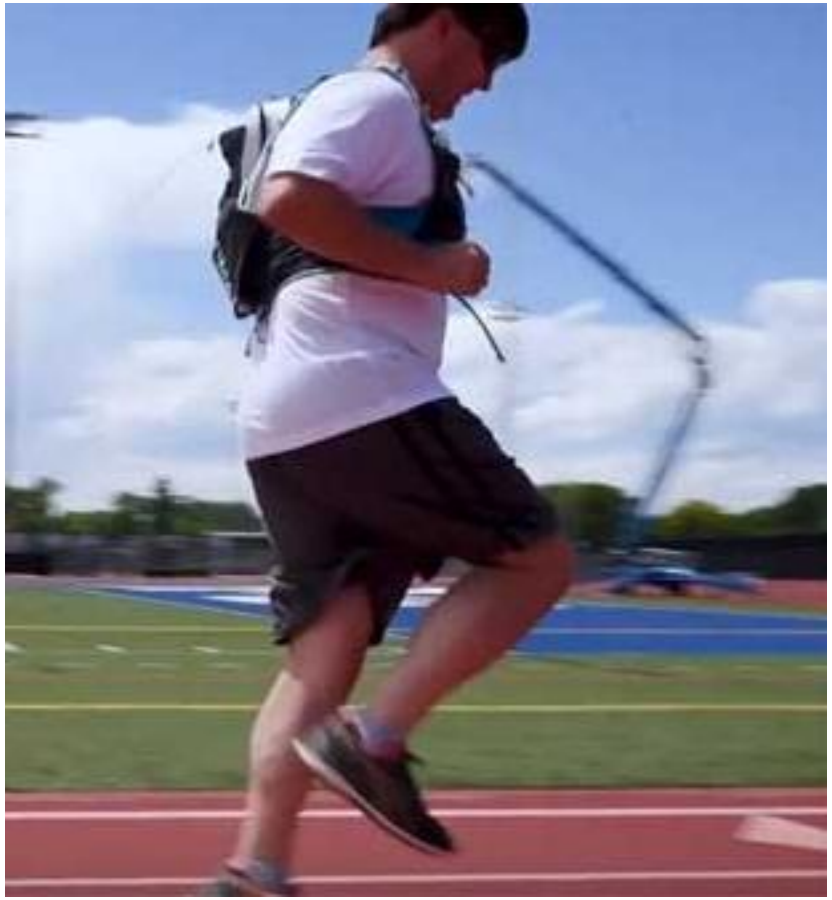


FIG.4

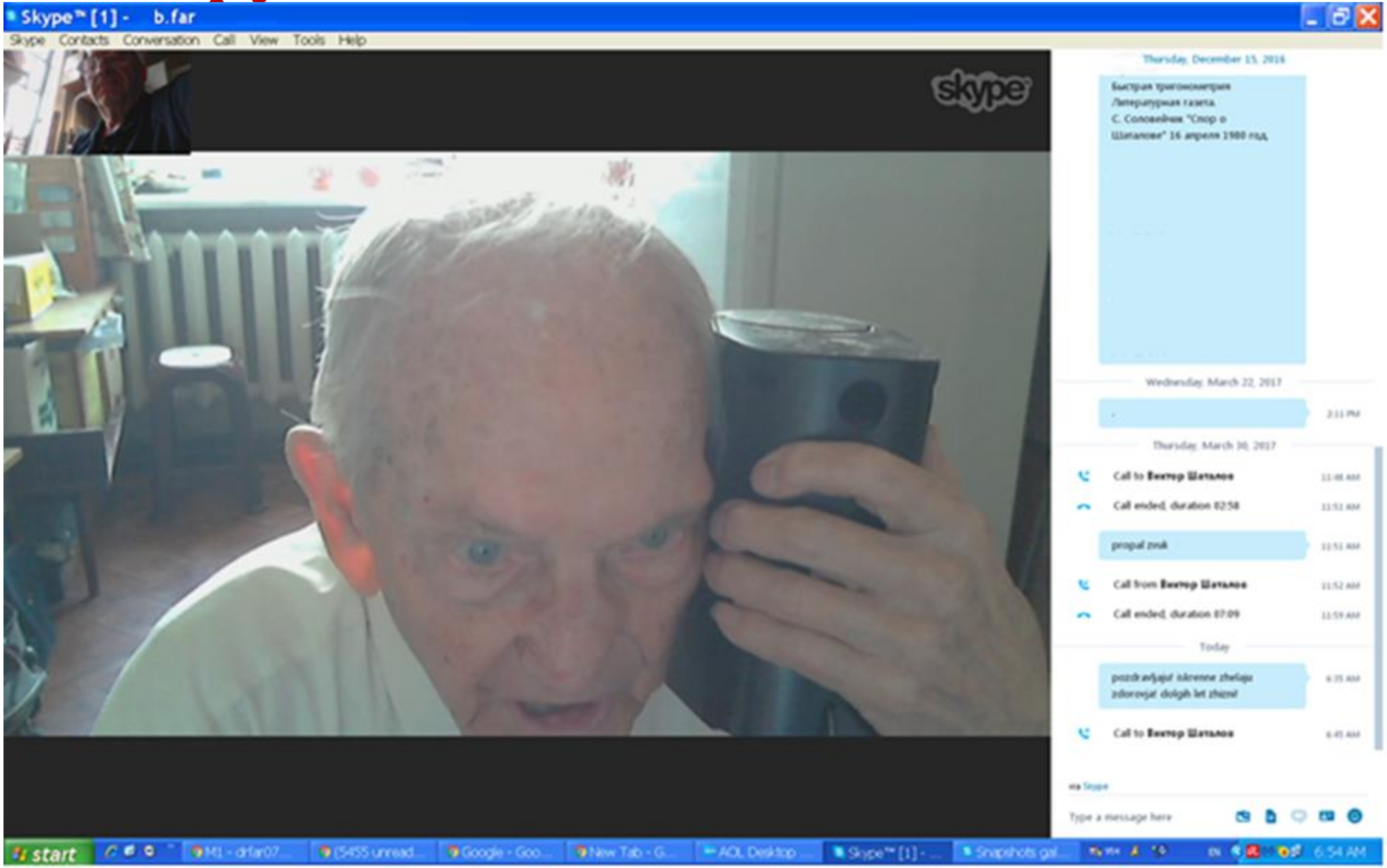


Принцип ТРИЗ №23. Обратная свьязь №18. Механическая вибрация Бегущие слепые-немые-глухие и наше «вибро» решение.

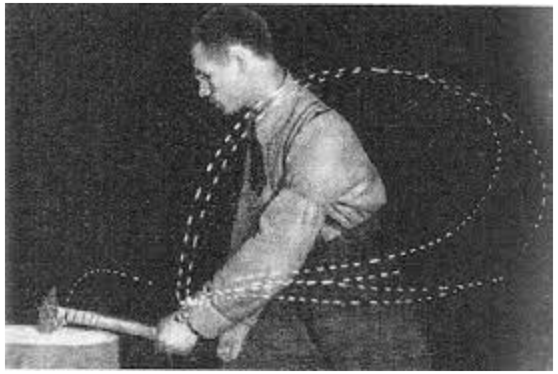


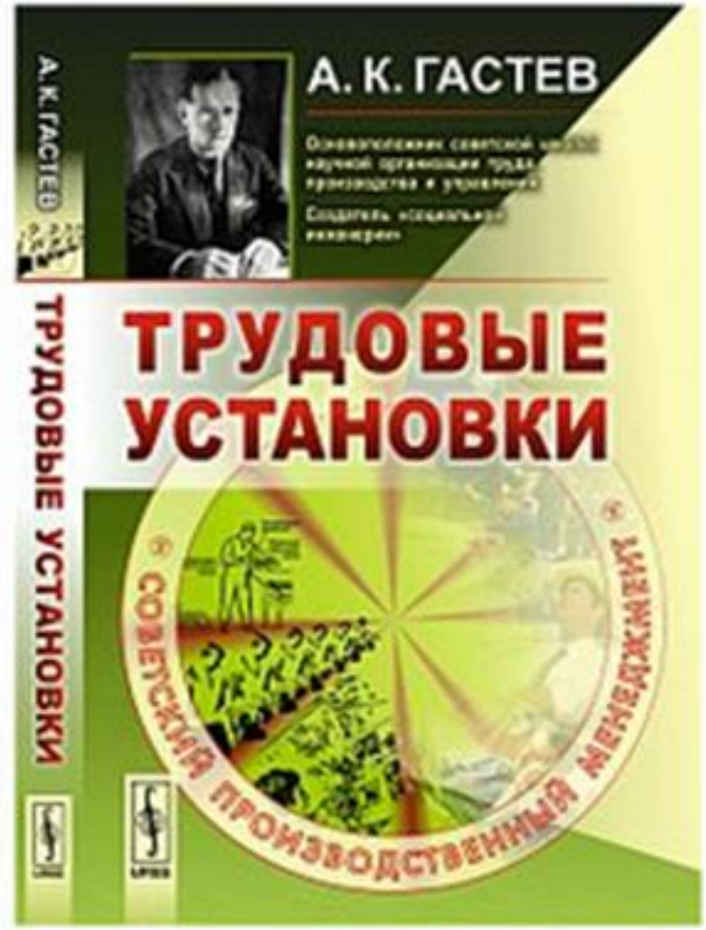


49 лет дружбы «С 90-летием»!



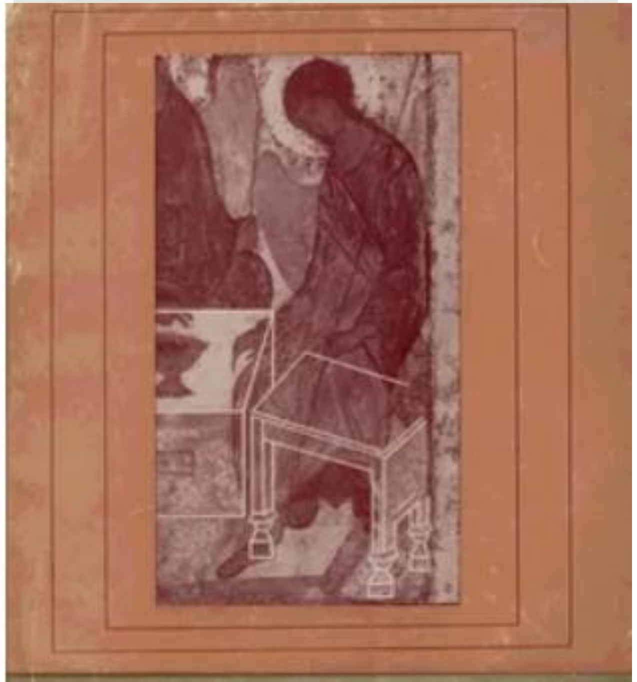
Наследие Алексея Гастева



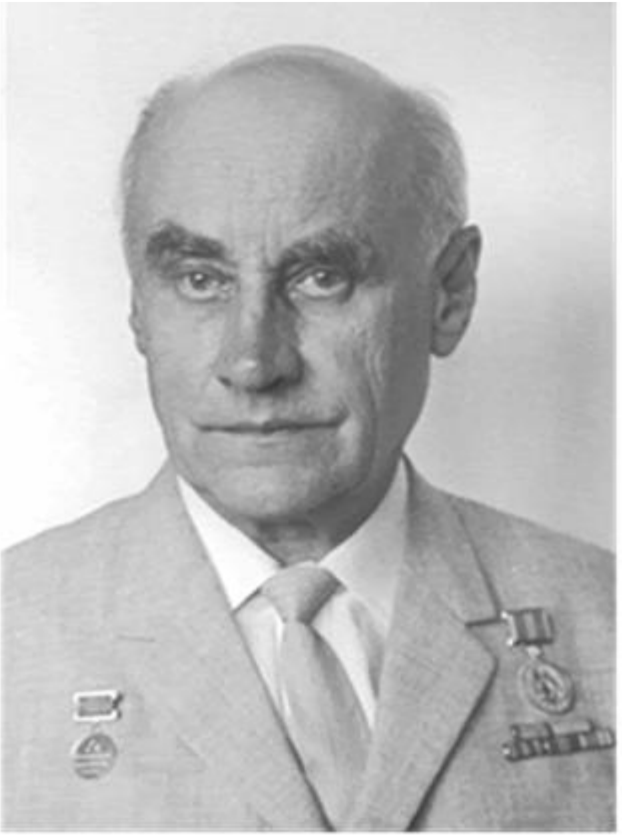


Алексей Гастев - один из пионеров научного менеджмента - теории менеджмента, которая анализирует и синтезирует рабочие процессы. Его основная цель - повышение производительности труда.


Б.В. Раушенбах
ПРОСТРАНСТВЕННЫЕ ПОСТРОЕНИЯ В ЖИВОПИСИ

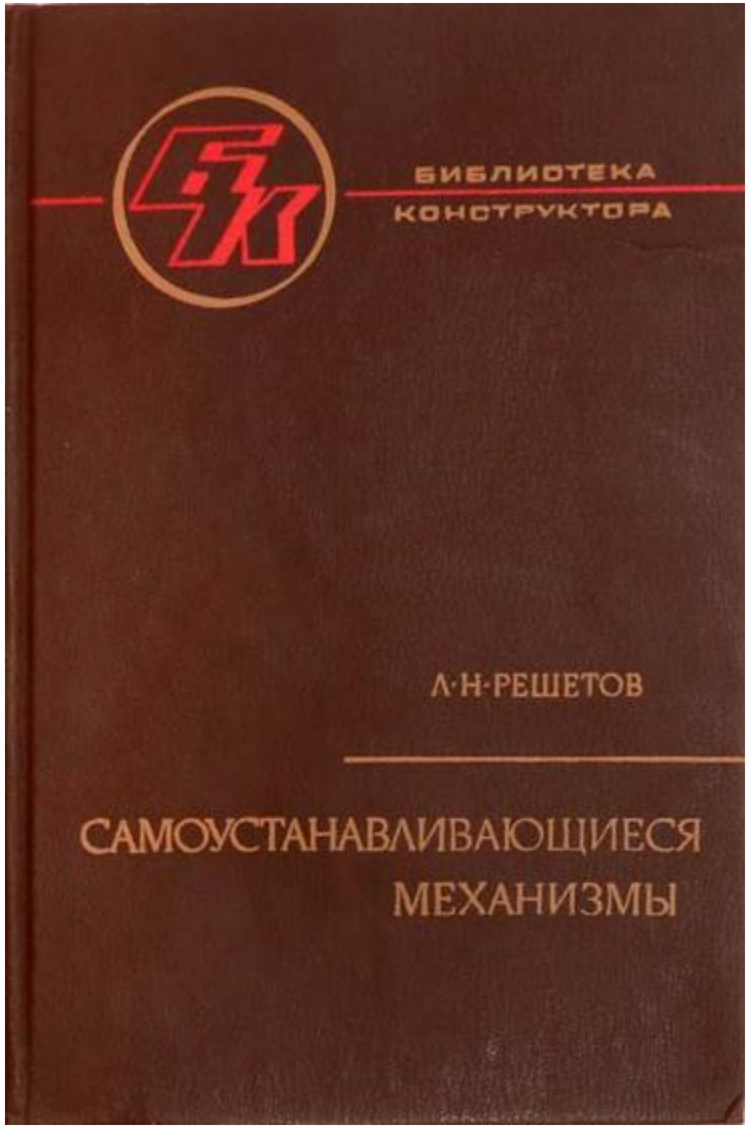


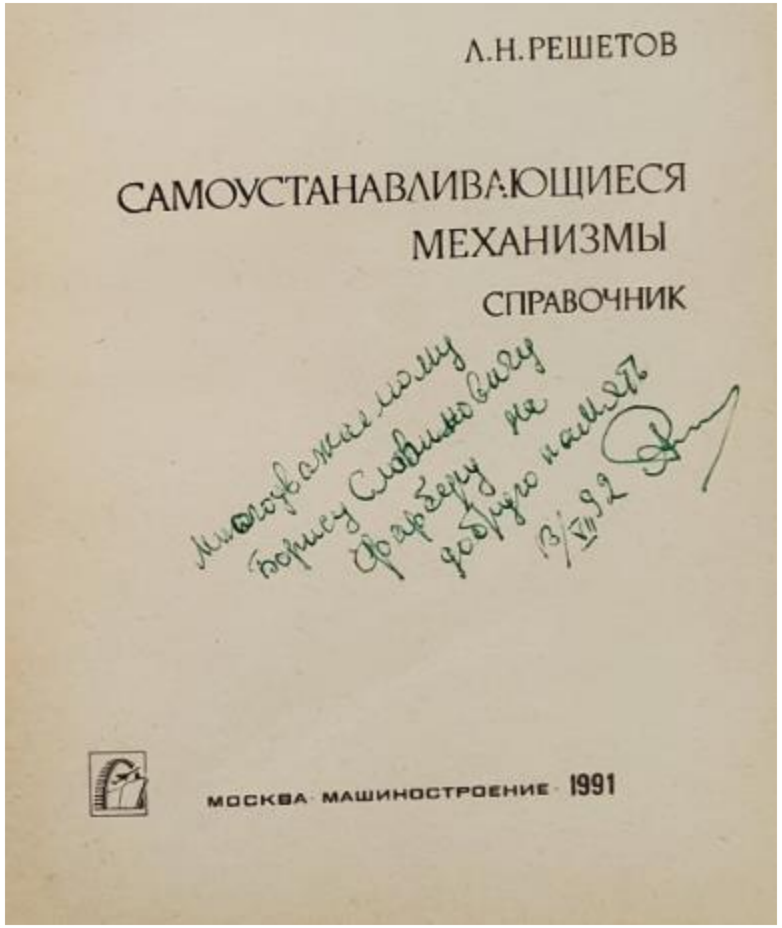
Д-р Леонид Решетов - самостоятельно настроенные системы



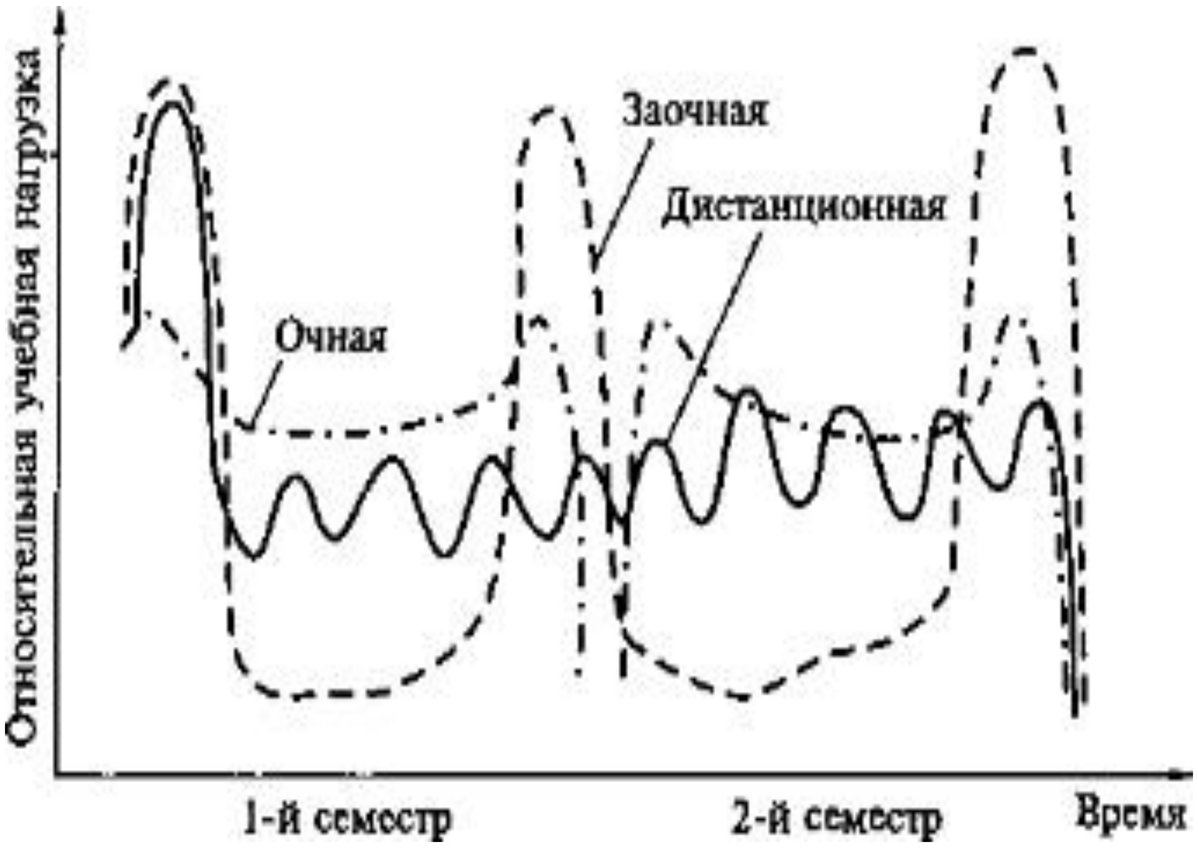
Л.Н. Решетов

1906-1998





Изменение учебной нагрузки студента в течение года по различным формам. по критериям формирования знаний, умений и навыков, а также вследствие более равномерного распределения учебной нагрузки студента в течение года технология дистанционного обучения сопоставима с очной формой обучения и значительно превосходит по качественным параметрам заочную форму обучения.

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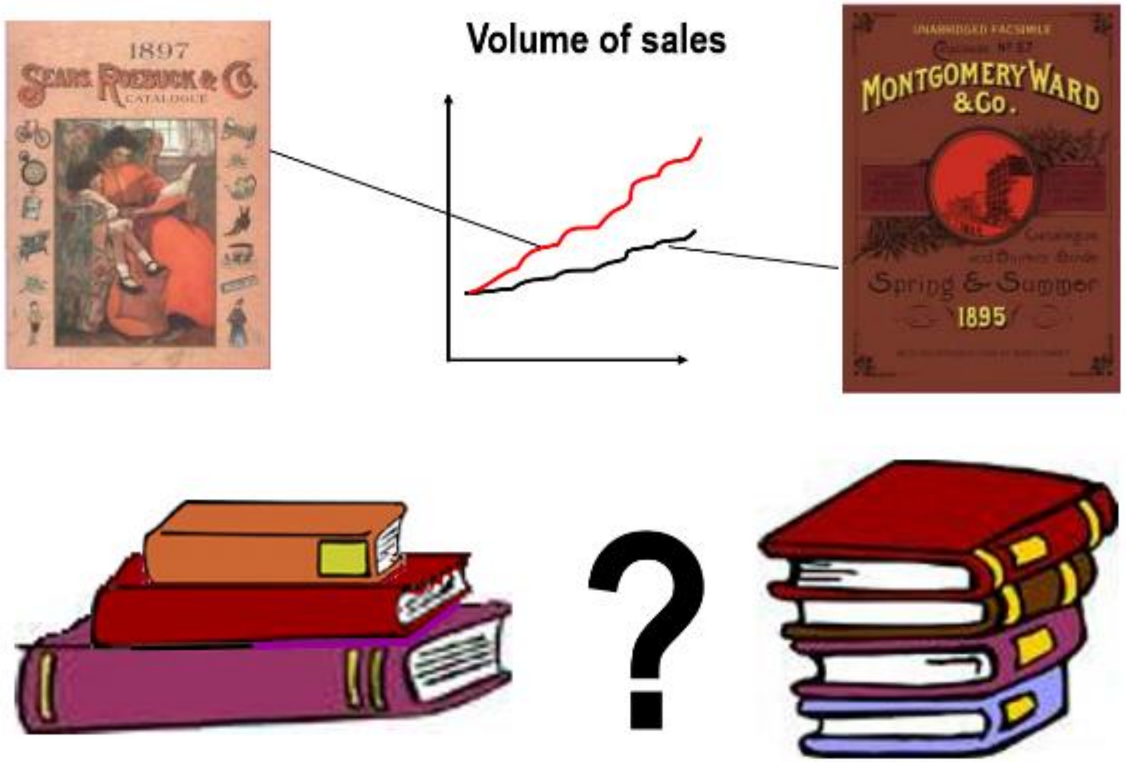
Geometry and Business (Morphometry)

TO BUY, OR NOT TO BUY: THAT IS THE QUESTION



Internship Introductory Meeting (Part 1 & Part2) Dr.Farber, Dr. Kleyn 07-17-2023

https://www.youtube.com/watch?v=msWhJmG1nso&ab_channel=Farber%27sCenter

Internship at Dr. Farbers' corporations:

Farber's Center for Academic Success, Inc
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2023

Q&A

SESSION

TRIZ SUMMIT 2023

THANK YOU!

TRIZ BIOPHARMA RUSAL