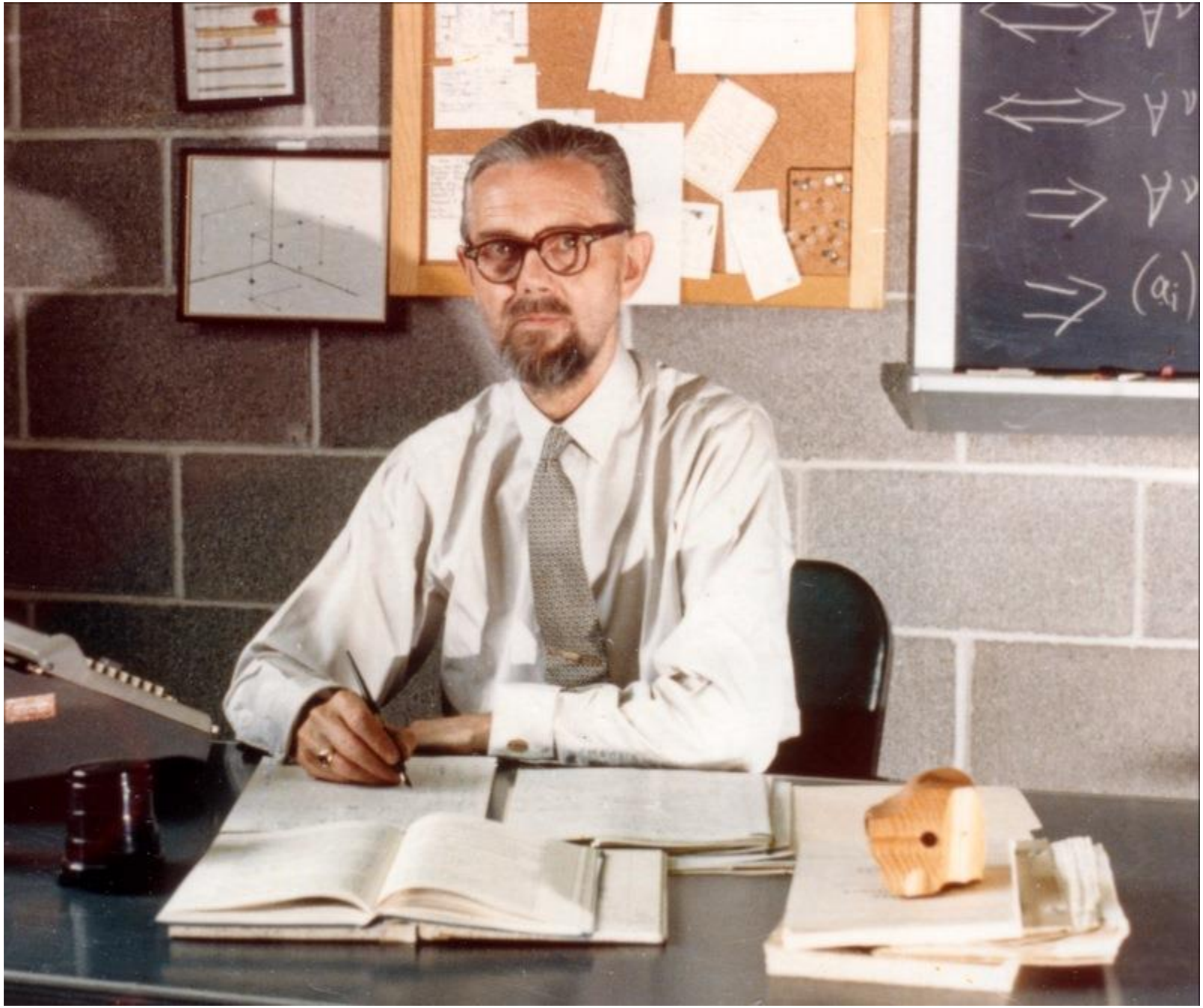
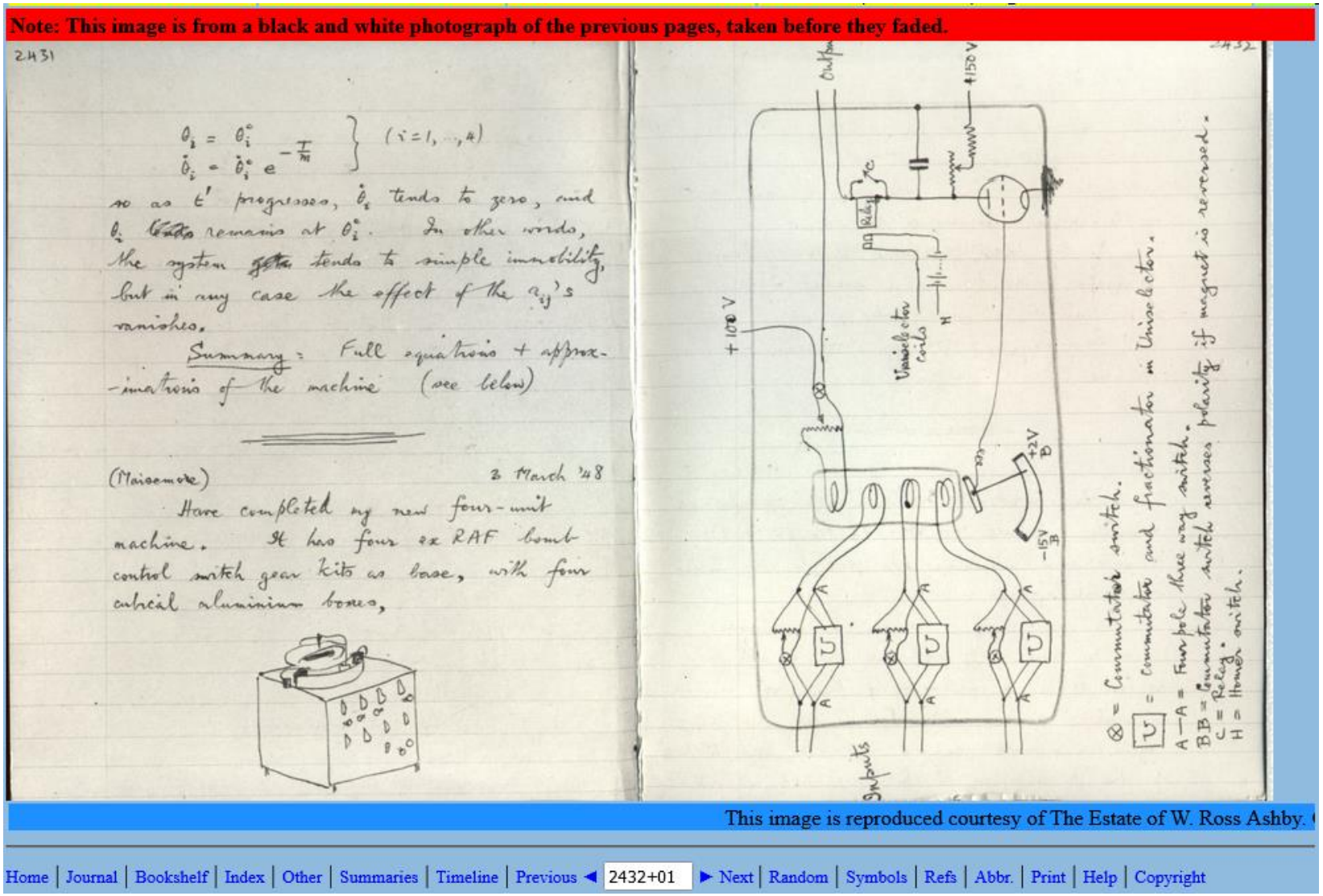
Гомеостат Эшби

Неоконченная история одной дерзкой идеи



Страница из рабочей тетради У.Росс Эшби, датированная 7 марта1948 г



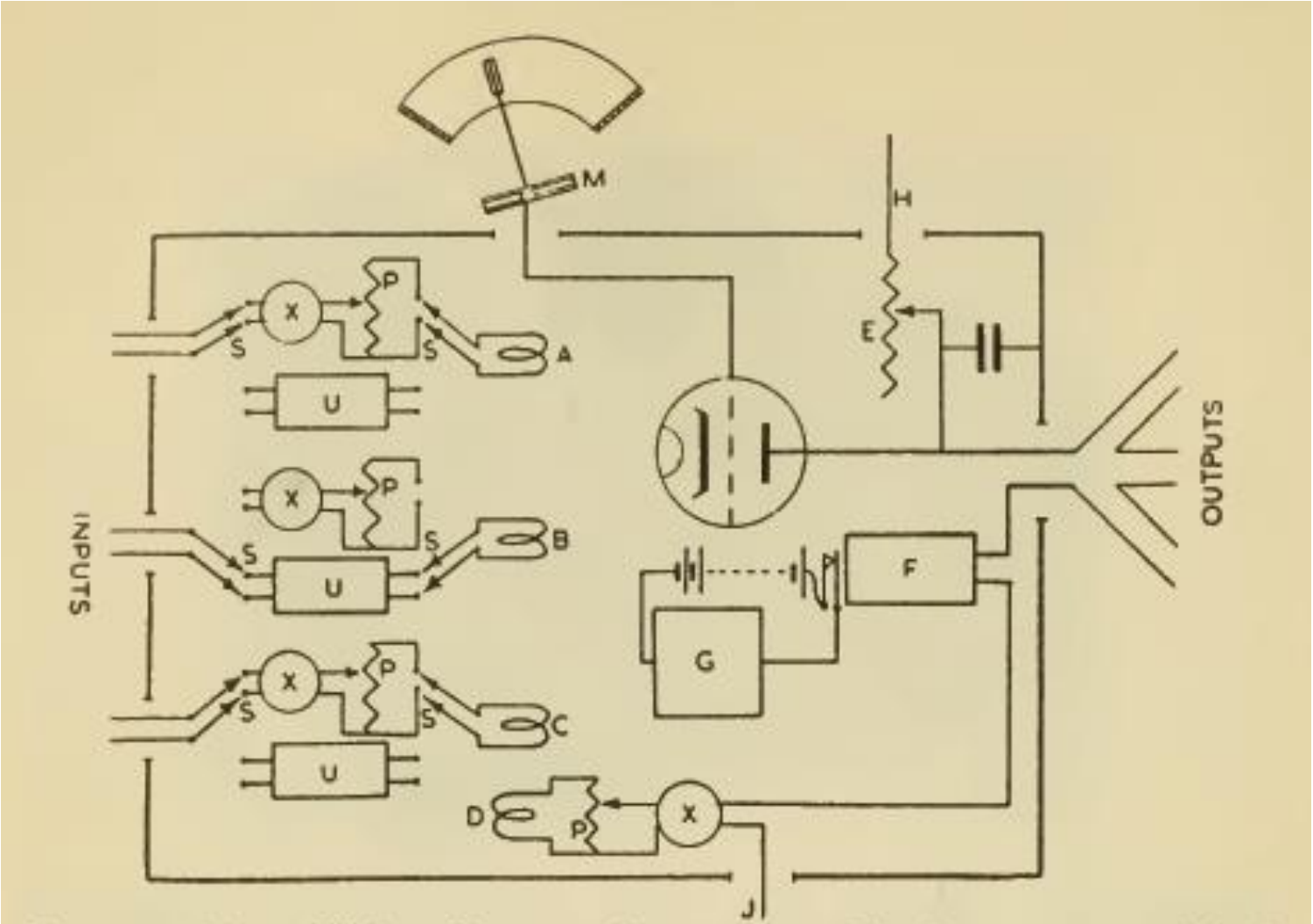


FIGURE 8/2/3: Wiring diagram of one unit. (The letters are explained in the text.)

Схема гомеостата, приведённая в “Design for a brain”

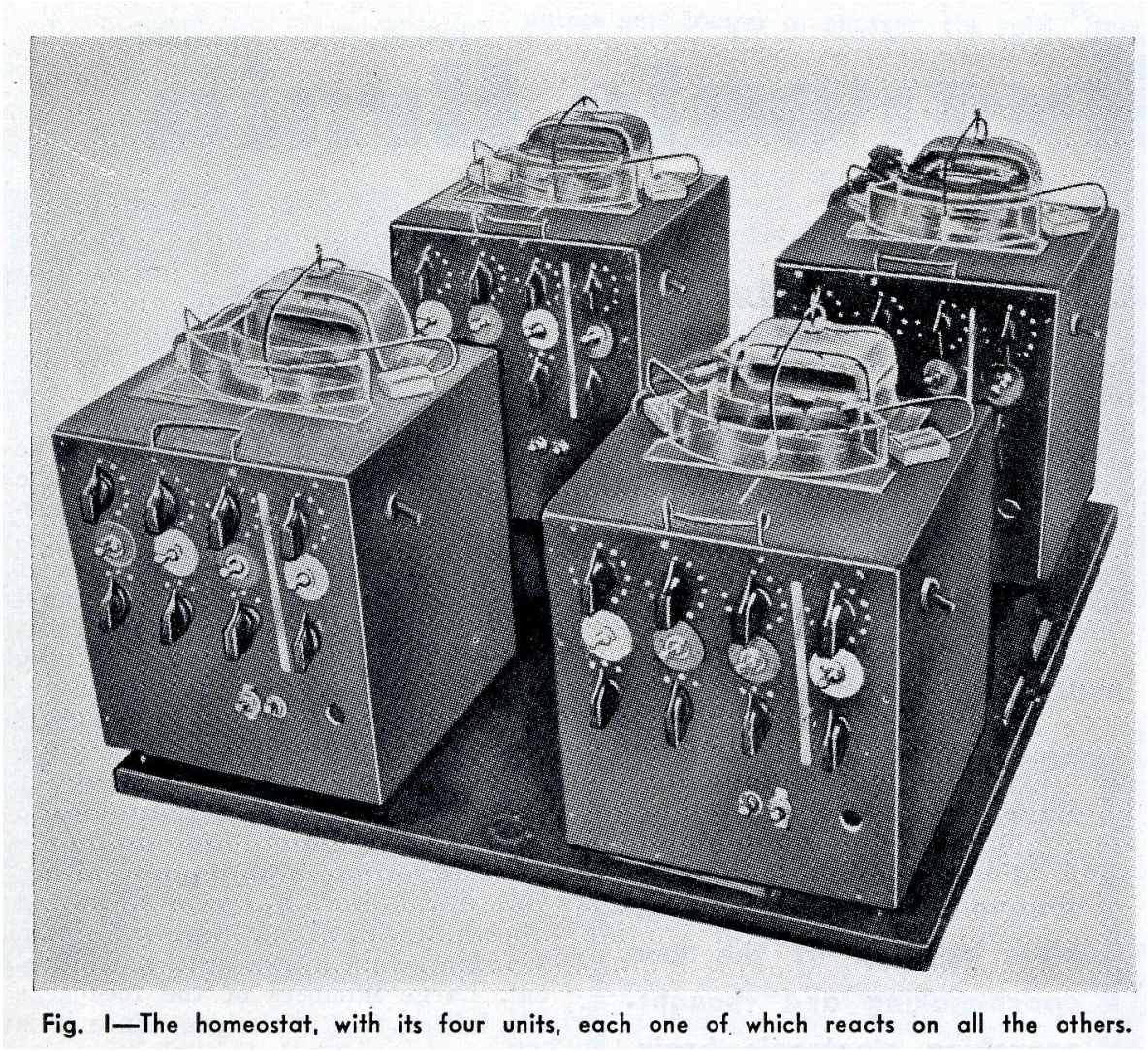
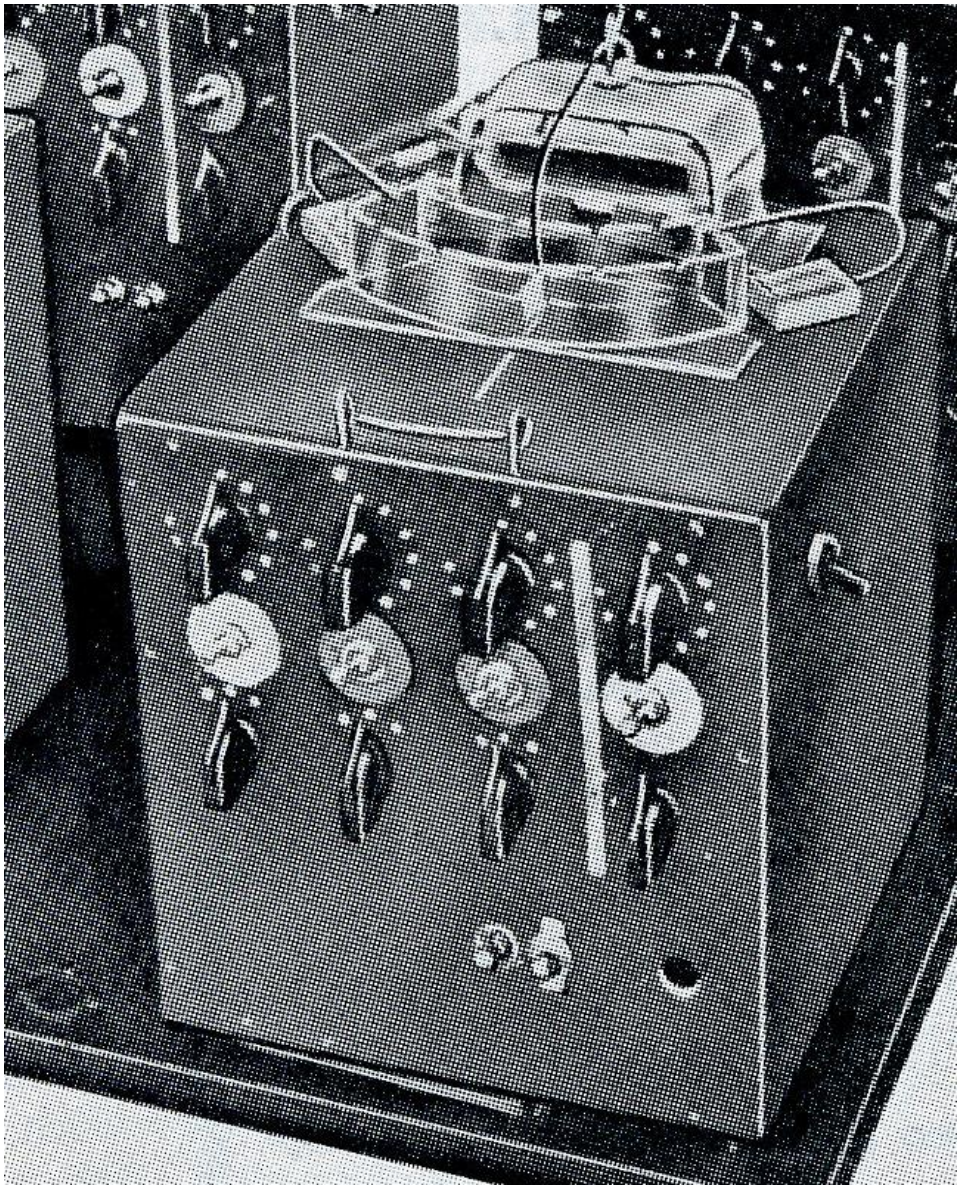


Fig. 1—The homeostat, with its four units, each one of which reacts on all the others.

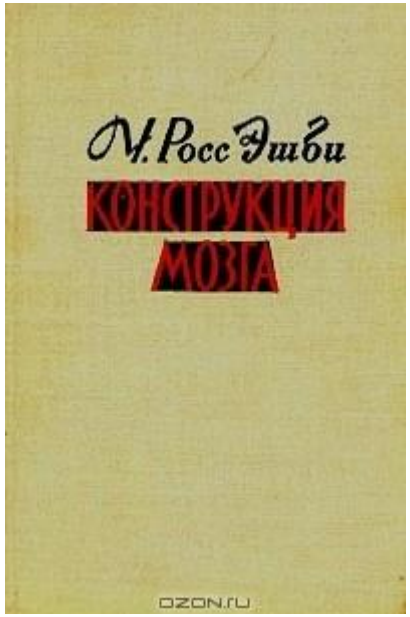
…it exhibited behaviours such as habituation, reinforcement and learning through its ability to maintain homeostasis in a changing environment. (WikipediA)

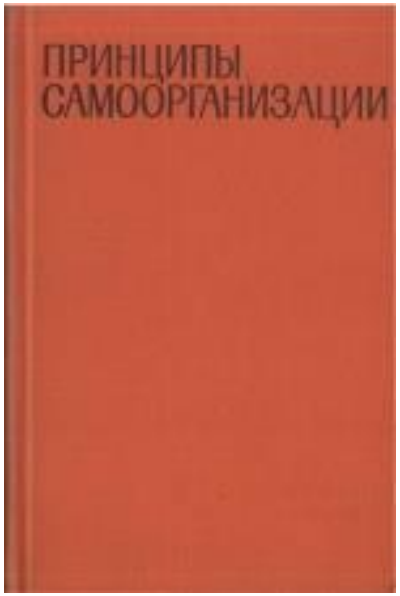
Из какого сора…



«В зимнее воскресенье 23 января 1949 года в одном из восторженных обзоров «Кибернетики» газета The New York Times рассказала о смелых предсказаниях Винера – по-настоящему думающих машинах будущего. Никто не ожидал, что это случится так скоро. В тот же вечер журнал Time возвестил, что будущее уже наступило и первая в мире «думающая машина» построена[89]. И не в МТИ или в лаборатории Bell, а в психиатрической больнице в Барнвуде, английской деревеньке неподалеку от Глостера….»

(так начинается глава о гомеостате Эшби)





«…Так как ни об одной системе нельзя строго утверждать, что она является самоорганизующейся, и так как выражение «самоорганизующаяся» ведёт к укоренению весьма путаного и противоречивого представления о данной проблеме, это выражение, вероятно, вообще не следовало бы употреблять». (У.Росс.Эшби)

М
А
К
С
И
М
Ы

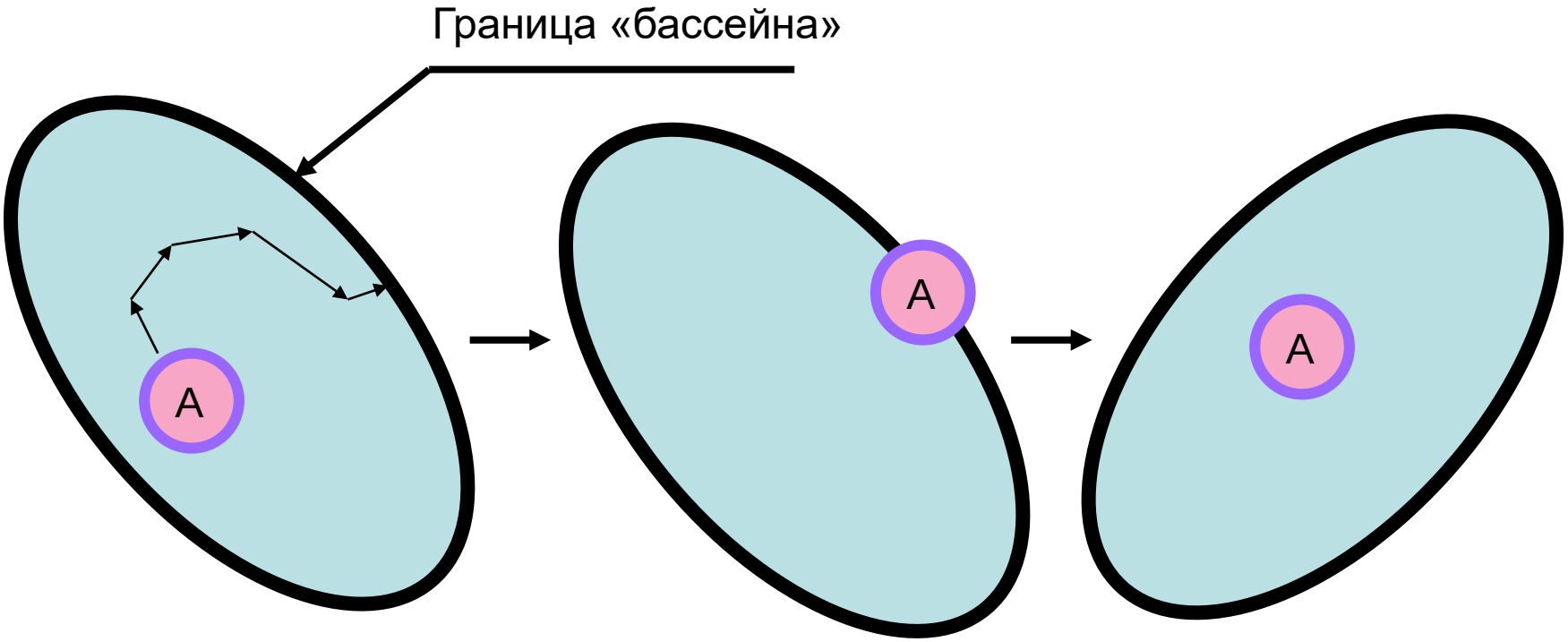
Э
Ш
Б
И

Гомеостат – живая машина со встроенной средой
Между средой и организмом нет различия и границ
Машина изменяет среду, то есть себя
Нет управляющего и управляемого
Нет высшего и низшего
Мозг не думает, а действует
Мозг определён настолько, насколько и как он связан
Гомеостат меняет поведение и в этом его обучаемость
Организм – принципиально неразборный «чёрный ящик»
Мыслимое равноценно возможному. Доказательства необязательны
Предметная область кибернетики – все возможные машины
Все успешные адаптации - результат случайного процесса
Двоичный искусственный разум невозможен, а аналоговый возможен и неизбежен
Ультрастабильность – это перестройка структуры

«Сделать систему, которая ищет цель, очень просто: сформируйте случайным образом динамическую систему, определяемую состоянием - она будет стремиться к некоторому предпочтительному для неё состоянию». (Это вообще воспринималось как кибернетика наоборот)

Логическая схема гомеостата Эшби и вообще сложной адаптивной системы

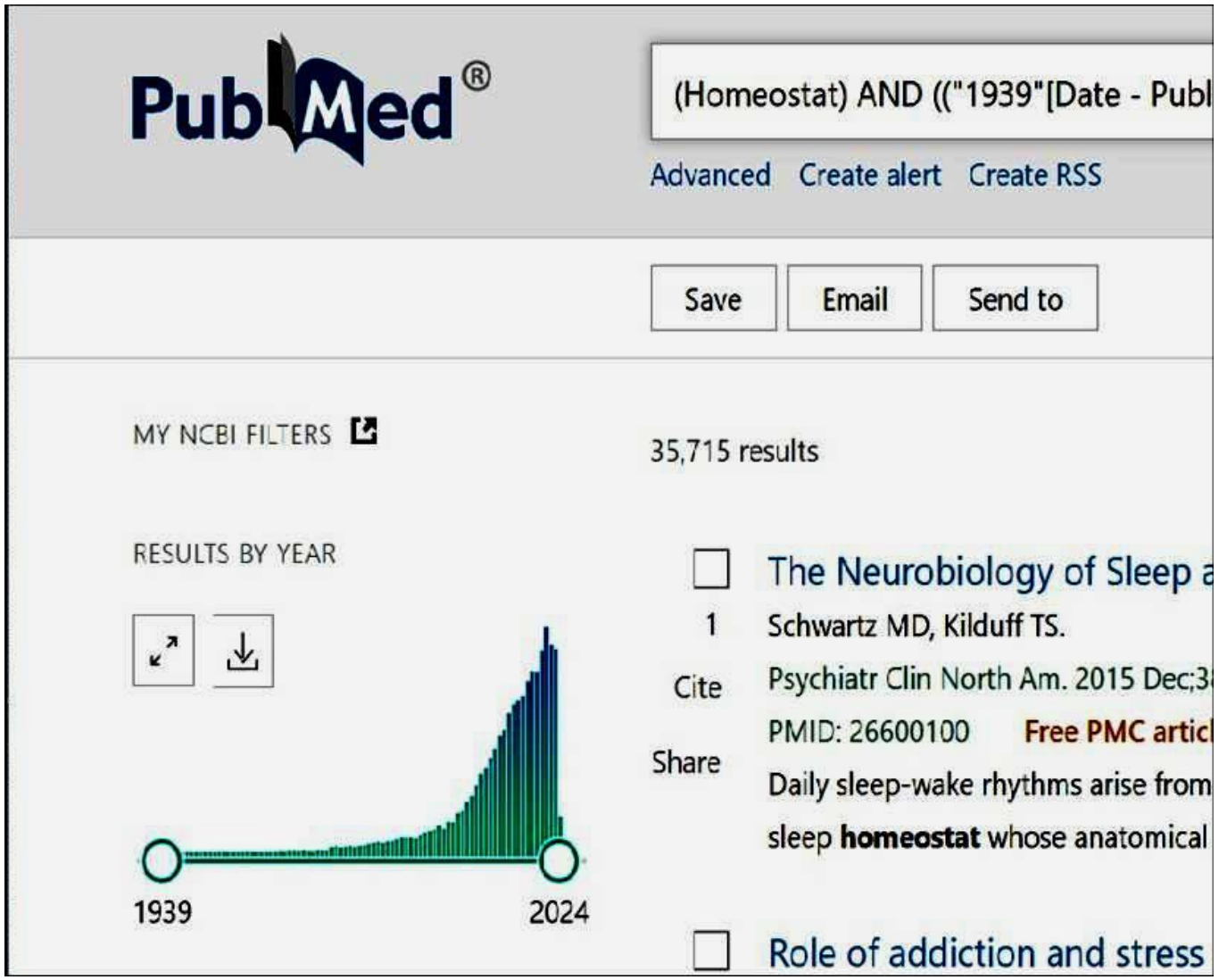
Возможный зрительный образ поведения гомеостата
А – аттрактор



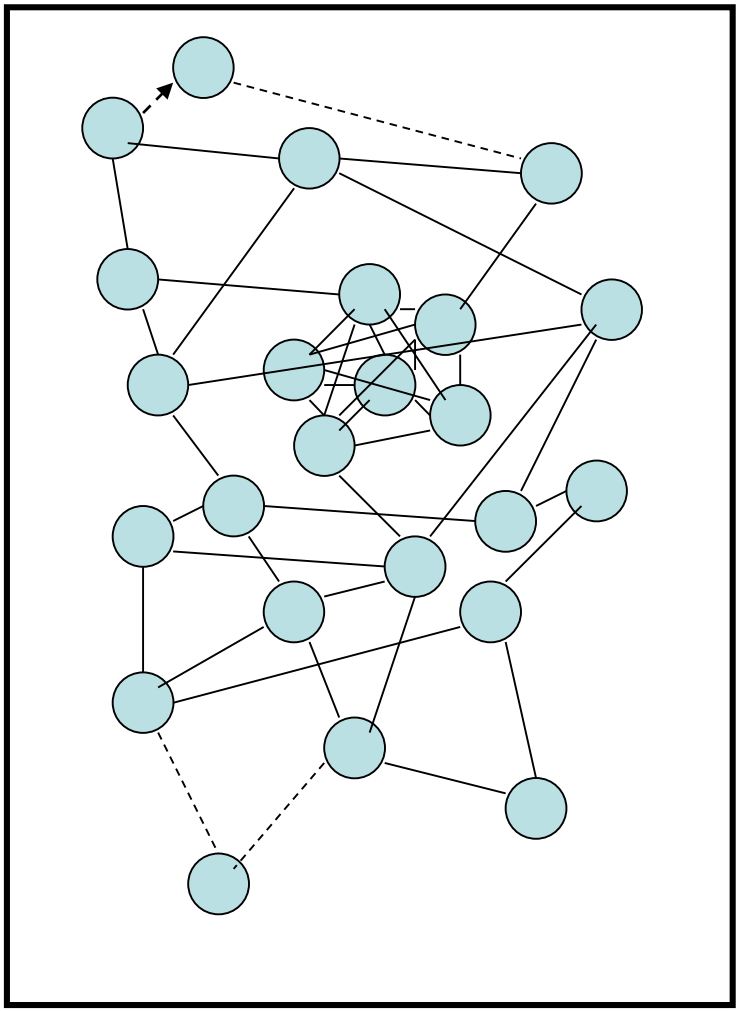
Блуждание аттрактора в «бассейне допустимого»

Переключение

Рост числа публикаций, использующих термины «гомеостат» или «гомеостатика»



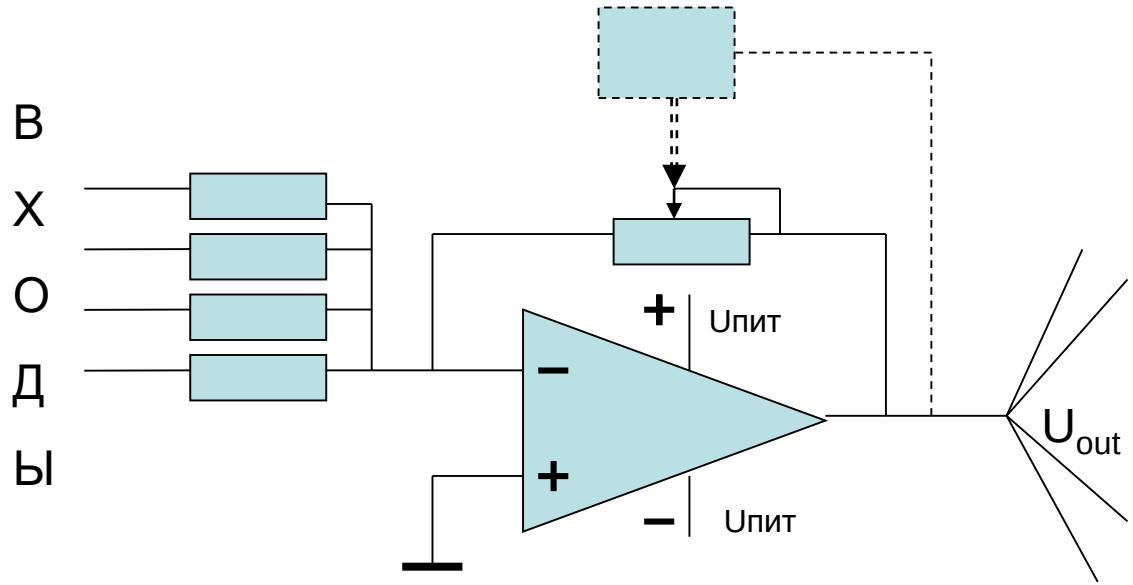
Несоответствие цели и средств

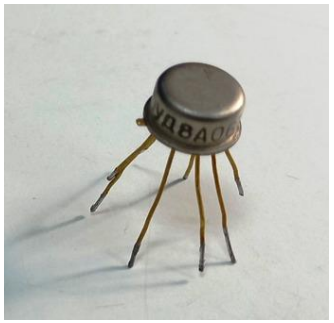


?

Нужны большие перестраиваемые аналоговые интегральные схемы (БПАИС), которых нет

Если бы Эшби работал над своей идеей 30-40 годами позднее, он использовал бы операционные усилители





$$U_{out} = - (k_1 U_{in1} + k_2 U_{in2} + k_3 U_{in3} + k_4 U_{in4} + \ldots)$$

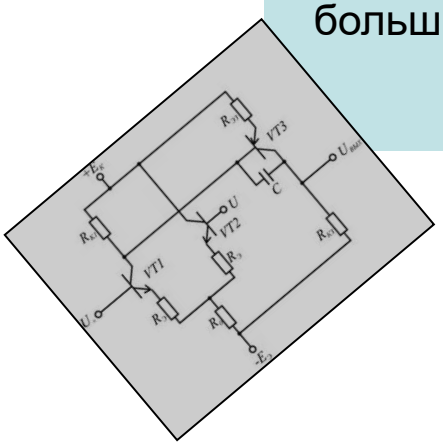
Один узел гомеостата на ОУ

Так выглядела аналоговая машина МН-14 (1960-е годы)

Возможные реализации

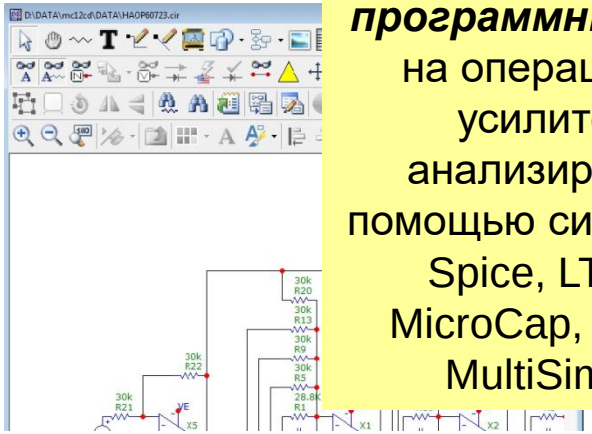
Аппаратные : на электромеханике, пневмонике, гидравлике и пр.

Аппаратные: с использованием современной электроники – операционных усилителей и больших микросхем на их основе

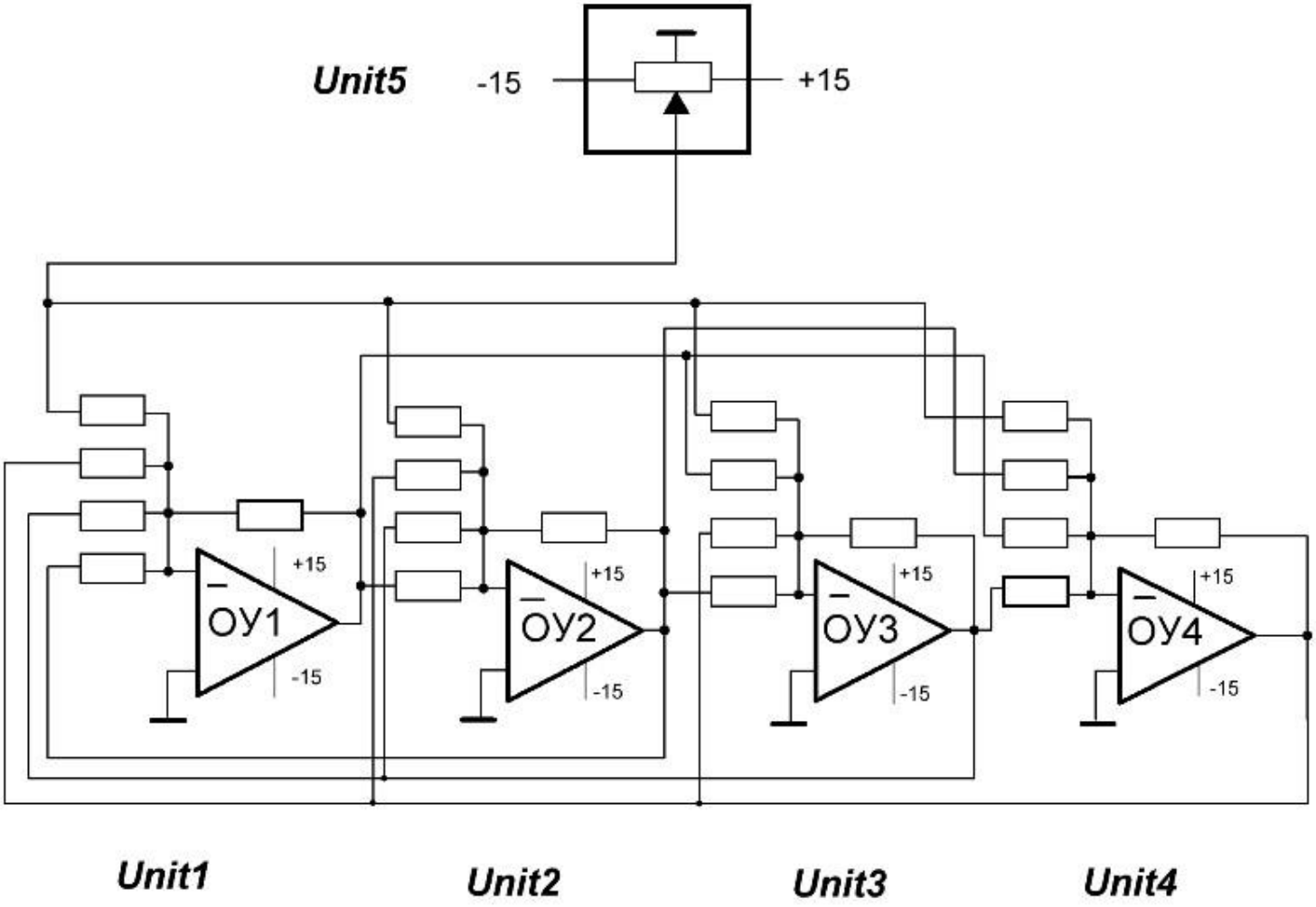



```
for i:=0; i<=n-2; i++ {
        v[i+1]= a*(v[i]+w[i]+x[i]+y[i]+z[i])
        w[i+1]= b*(v[i+1]+w[i]+x[i]+y[i]+z[i])
        x[i+1]= c*(v[i+1]+w[i+1]+x[i]+y[i]+z[i])
        y[i+1]= d*(v[i+1]+w[i+1]+x[i+1]+y[i]+z[i])
        e*(v[i+1]+w[i+1]+x[i+1]+y[i+1]+z[i+1])
        fmt.Printf("%v  %.4f  %.4f  %.4f  %.4f  %.4f  %.4f  %.4f  %.4f  %.4f  %.4f  %.4f\n" ,i,v[i],w[i],x[i],y[i],z[i],v[i]/w[i],w[i]/x[i],x[i]/y[i],y[i]/z[i],z[i]/v[i])
```

Программные



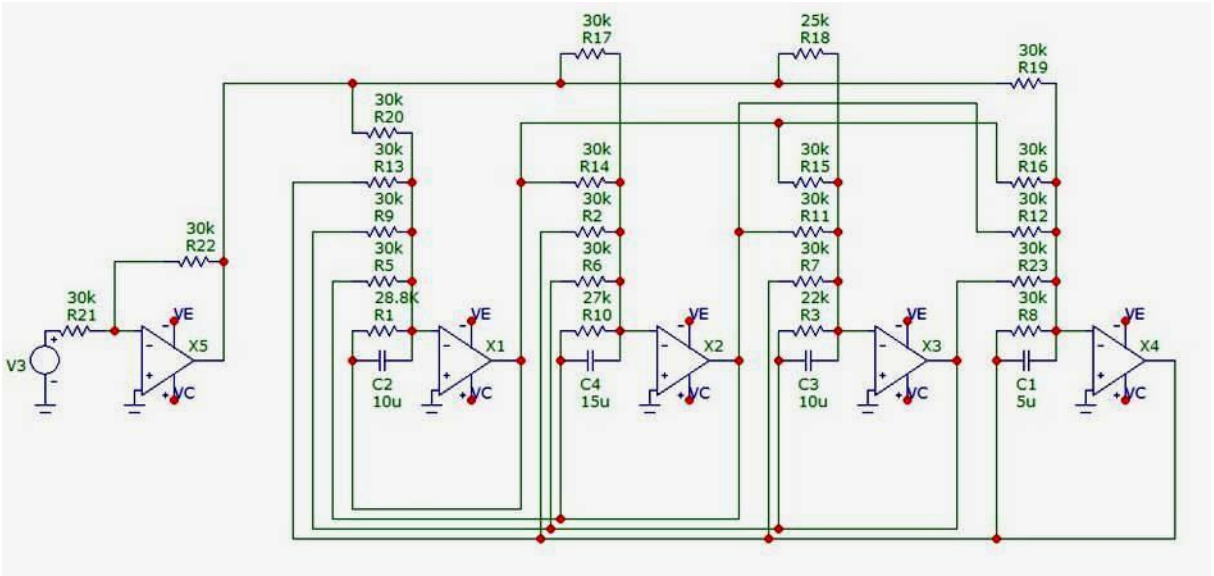
Аппаратно-программные: схемы на операционных усилителях, анализируются с помощью симуляторов Spice, LTSpice, MicroCap, LogiSim, MultiSim и т.п

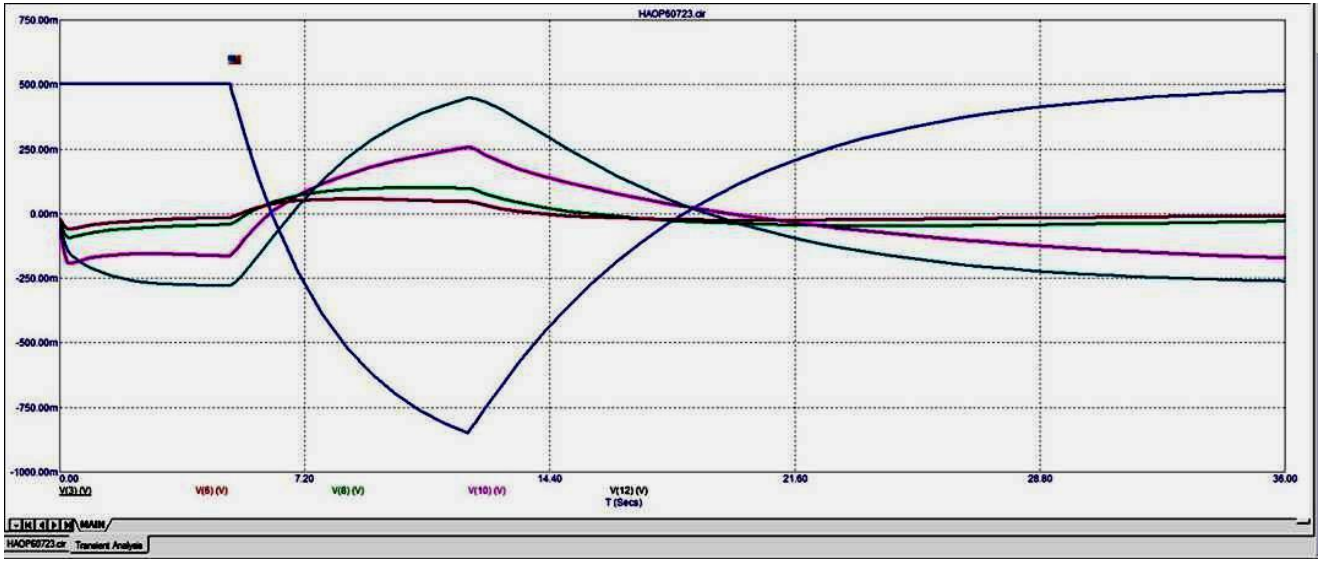


5-узловой гомеостат на операционных усилителях - сумматорах.
Пятый узел заблокирован и только посылает сигнал о своём состоянии четырём активным.

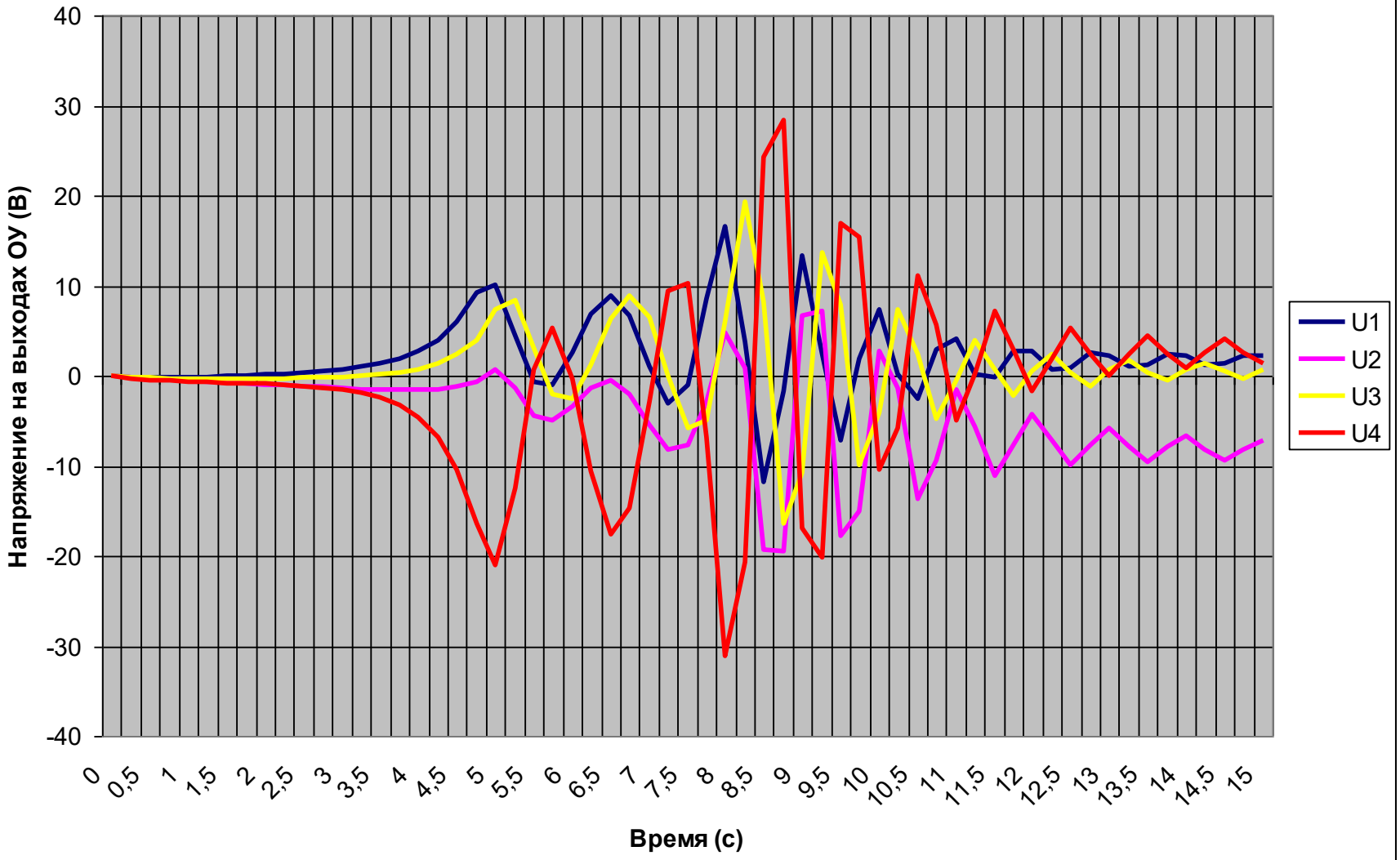
Возможная современная реализация гомеостата Эшби

5-узловой гомеостат на операционных усилителях и его ответ на экспоненциальное воздействие с узла X5, играющего роль «внешней среды», в течение 36 с. Снимки с экрана симулятора MC12





Пример компьютерной реализации гомеостата на 4 ОУ с одним внешним источником ("среда"), воздействующим на все ОУ, но по-разному. Резисторы всех ОУ выбраны случайным образом и лежат в диапазоне 15 - 40 кОм, а конденсаторы - от 50 до 200 мкФ



М
А
К
С
И
М
Ы

Э
Ш
Б
И

Гомеостат – живая машина со встроенной средой
Между средой и организмом нет различия и границ
Машина изменяет среду, то есть себя
Нет управляющего и управляемого
Нет высшего и низшего
Мозг не думает, а действует
Мозг определён настолько, насколько и как он связан
Гомеостат меняет поведение и в этом его обучаемость
Организм – принципиально неразборный «чёрный ящик»
Мыслимое равноценно возможному. Доказательства необязательны
Предметная область кибернетики – все возможные машины
Все успешные адаптации - результат случайного процесса
Двоичный искусственный разум невозможен, а аналоговый возможен и неизбежен
Ультрастабильность – это перестройка структуры

«Сделать систему, которая ищет цель, очень просто: сформируйте случайным образом динамическую систему, определяемую состоянием - она будет стремиться к некоторому предпочтительному для неё состоянию». (Это вообще воспринималось как кибернетика наоборот)

International Journal of General Systems
Vol. 38, No. 2, February 2009, 139–154

Taylor & Francis
Taylor & Francis Group

The homeostat as embodiment of adaptive control

Peter A. Cariani*

Department of Otology and Laryngology, Harvard Medical School, Newton, MA, USA

(*Received 13 February 2008; final version received 30 September 2008*)

W. Ross Ashby was a founder of both cybernetics and general systems theory. His systems theory outlined the operational structure of models and observers, while his cybernetics outlined the functional architecture of adaptive systems. His homeostat demonstrated how an adaptive control system, equipped with a sufficiently complex repertoire of possible alternative structures, could maintain stability in the face of highly varied and challenging environmental perturbations. The device illustrates his 'law of requisite variety', i.e. that a controller needs at least as many internal states as those in the system being controlled. The homeostat provided an early example of how an adaptive control system might be ill-defined *vis-à-vis* its designer, nevertheless solve complex problems. Ashby ran into insurmountable difficulties when he attempted to scale up the homeostat, and consequently never achieved the general purpose, brainlike devices that he had initially sought. Nonetheless, the homeostat continues to offer useful insights as to how the large analogue, adaptive networks in biological brains might achieve stability.

Keywords: W. Ross Ashby; cybernetics; general systems theory; homeostat; requisite variety

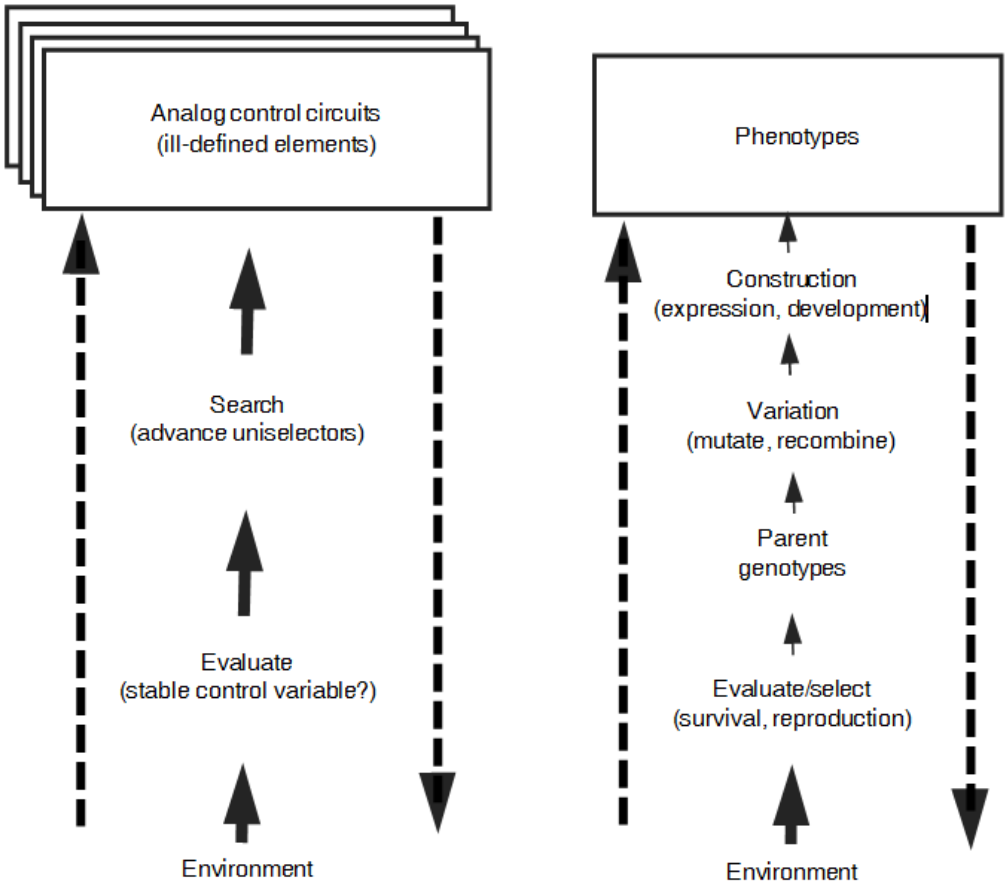


Figure 2. Operational structure of adaptation in the homeostat and evolution of biological organisms. Left: homeostat. Bidirectional interactions with the environment (stippled lines) result in fluctuations of a control variable in each homeostat module. When the variable's value exceeds prescribed bounds over a threshold time duration, the uniselector switch associated with that module is advanced and another analogue control circuit is chosen. The search process stops when stability is achieved. Right: biological evolution. Bidirectional interactions of a population of organisms with

Ashbian Homeostasis as non-Autonomous Adaptation

Stefano Franchi
Texas A&M University
College Station, TX, USA
Email: stefano@tamu.edu

***Abstract*—The paper argues that the approach to adaptation developed by W.R. Ashby in *Design for a Brain* and partially revived in evolutionary robotics is orthogonal to the traditional distinction between autonomy and heteronomy that underlies much recent work in cellular biology, evolutionary robotics, ALife, and general AI. Ashby's theory of adaptation claims that homeostasis is the only principle grounding sub-cognitive as well as all cognitive functions. Ashby's generalized homeostasis thesis does not fit the traditional conception of autonomy nor its converse (heteronomy). The traditional conception generates a dualism opposing human autonomous life to its non-human heteronomous counterpart. The dualism is usually overcome by claiming that human life is actually heteronomous although it does not appear so, as the "masters of suspicion" once claimed (Freud, Marx, and Nietzsche); or, conversely, by claiming that *non*-human life is actually fully autonomous in spite of its outlook (as suggested by Hans Jonas and his enactivist followers). Ashby's theory offers a genuine alternative by rejecting the very opposition of autonomy vs. heteronomy that both strategies rely on. The joint effect of Ashby's unorthodox philosophical stance and the practical shortcomings of the simulating technology at his disposal has prevented a true evaluation of his theory. We can assess the philosophical and technical viability of the general homeostasis thesis Ashby advocated through the construction of virtual cognitive agents (i.e. simulated robots in a physically plausible environment) that provide an integral and faithful digital replica of the architecture of Ashby's original homeostat that reproduces the homeostat's dynamics and its stochastic rewriting mechanism through a CTRNN-like network architecture, whose outline implementation is then discussed.**

***Index Terms*—W.R. Ashby; Adaptation; Autonomy; CTRNN; Enactivism;**

Ashbian non-autonomy may be, it is necessary to introduce a precise definition of the *technical* vs. the *philosophical* concepts of autonomy and heteronomy.

I. Autonomy, heteronomy, mind, and body

In the AI, Robotics, and ALife literature, "autonomy" has a very broad meaning. In a widely adopted textbook, for instance, George Bekey [3], defines it as the capacity to operate in the real word without any form of external control. Maes [4] is more specific and identifies autonomy with an agent's capacity to decide for itself how to relate its sensor data to motor outputs in such a way that the agent's goals are satisfied. Autonomous agents are adaptive when the ability to fulfill their goals improves over time, i.e. with experience. Living beings are the canonical examples of adaptive autonomous systems, since they are capable of maintaining their internal structures and, within limits, adapt to environmental change. "Autonomy" is a synonym for "living" and "adaptive autonomous" designates successful life, i.e survival.

Commentators (e.g. Ziemke [5]) have noted that this definition is somewhat at odds with the most common used understandings of "autonomy" in non-technical disciplines and in ordinary language. In those contexts, "autonomy" is a logically higher-level concept that designates an agent's capacity to set its own goals. Thus, the philosophical literature distinguishes between agents whose goals arise as pure reactions to environmental pressure and those who set their goals in

One

LIFE, DEATH, AND RESURRECTION OF THE HOMEOSTAT

Stefano Franchi

The Homeostat, a device that W. Ross Ashby put together of military surplus equipment just after WWII in order to demonstrate his theory of cognitive behavior, enjoys a peculiar reputation within the history of AI and cognitive science. Scholars have regularly cited it as one of the most famous machines that early cybernetic tradition built. Yet, they often remark that, because the Homeostat's main behavioral goal is to keep its interactions with the surrounding environment to a minimum, it embodies a quite strange—if not outright weird—model of cognitive functions. Since Ashby explicitly presented the Homeostat as a prototypical example of *all* behavior (indeed, of all living functions), the resulting model has been at once fascinating and disturbing. Fascinating, because Ashby was able to set up his odd device to perform tasks appearing to indicate that the machine had the ability to learn and to adapt to its environment. Disturbing, because the theoretical model, and its physical implementation, were so at odds with customary models of cognition that observers of the Homeostat's feats found them to be beyond comprehension.

The distinguished audience on attendance at one of the 1952 Macy's conferences where Ashby presented his machine granted his creature a less than enthusiastic reception. Cybernetic concepts like negative feedback were crucial to the design of the Homeostat, but its performance genuinely puzzled several among the cyberneticians and cybernetic-inspired scientists assembled in the room—a group that included Warren McCulloch, Gregory Bateson, Margaret Mead, Karl Lashley, Julian Bigelow, among others. Cybernetics sought to understand behavior, both in animals and in artifacts, as the complex set of mechanisms that allow the organism to achieve its goals by taking effective steps that incrementally reduce the distance between the current state of the organism and the goals it pursues. Complex, "intelligent" behavior, they claimed, was goal-seeking. Cybernetics was an effort to explain in rigorous scientific terms the mechanisms that make goal-seeking possible. From the cybernetic standpoint, the Homeostat represented a puzzling contraption: while it implemented the physical mechanisms of goal-*seeking* in its electronic circuitry, it lacked any externally-assigned or internally-generated *goal*—in essence, the Homeostat strove to do nothing. Indeed, it was a *goal-less goal-seeking machine*, a characterization that partially

J.M.Herrmann, M.Holicki and R.Der

On Ashby's homeostat: A formal model of adaptive regulation (2004)

...Presently, we are witnessing a revived interest in the concept of homeostasis in various fields ranging from synaptic plasticity (e.g.Turrigiano, 1998) to the control of autonomous robots (Di Paolo, 2000)

P.A.Cariani

The homeostat as embodiment of adaptive control (2008)

…W.Ross Ashby was a founder of both Cybernetics and general systems theory

Stefano Franchi

Homeostats for the 21st Century? Simulating Ashby Simulating the Brain (2013)

Steve Battle «Ashby's Mobile Homeostat» (2006)

…The homeostat is much more than a historical curio, it remains a practical device for approaching key questions in AI including the nature of autonomy and cognition.

Что дальше?


Связность
Число узлов
Топология
Мерность узлов
Активность и реактивность
Индивидуальность связей
Внутриузловая обратная связь
Эволюция «среды»
Деградация, слияние и деление узлов
Возникновение новых узлов
Ограниченность ресурсов
Конкуренция за ресурсы
Катастрофы
НА

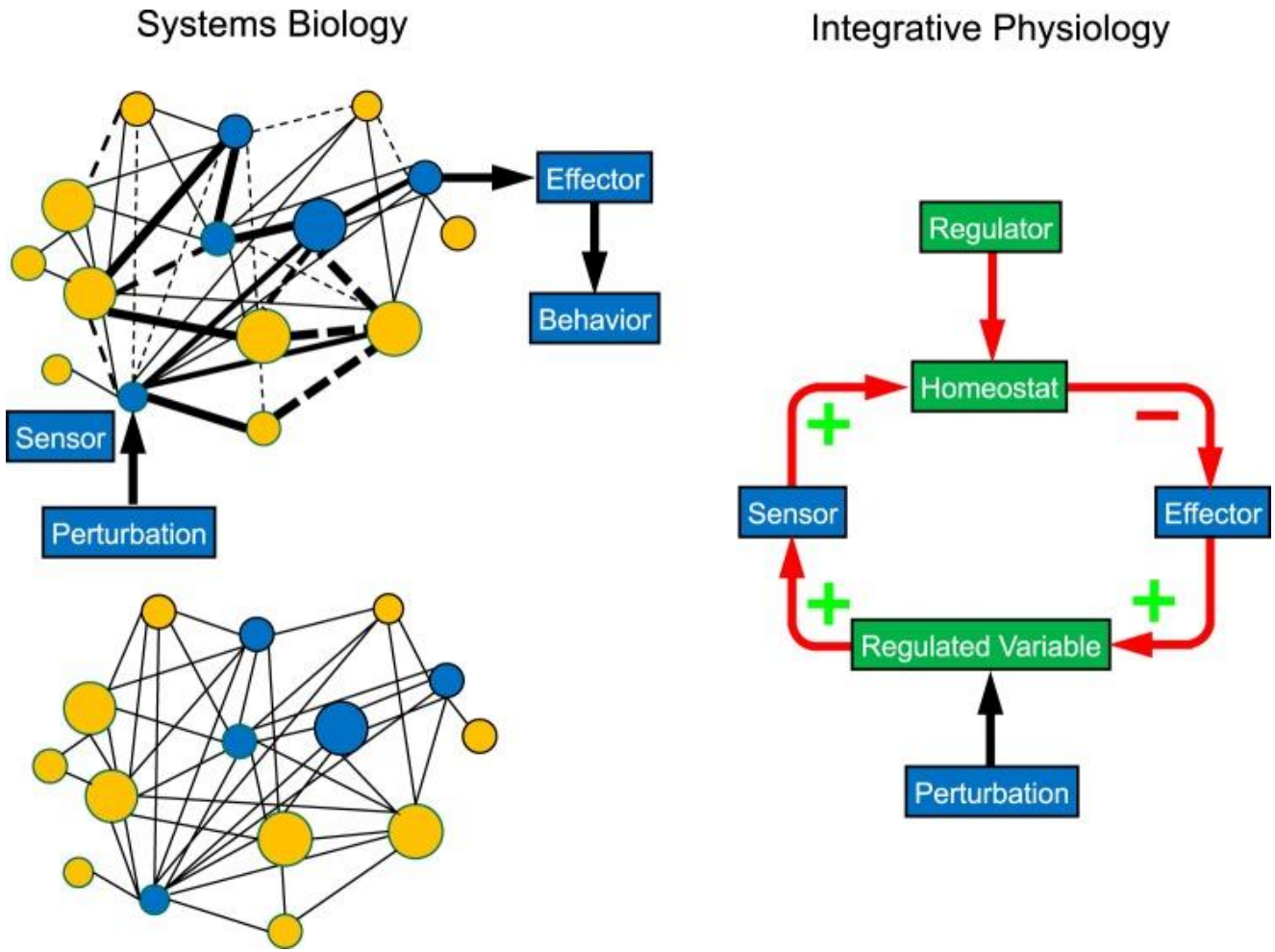
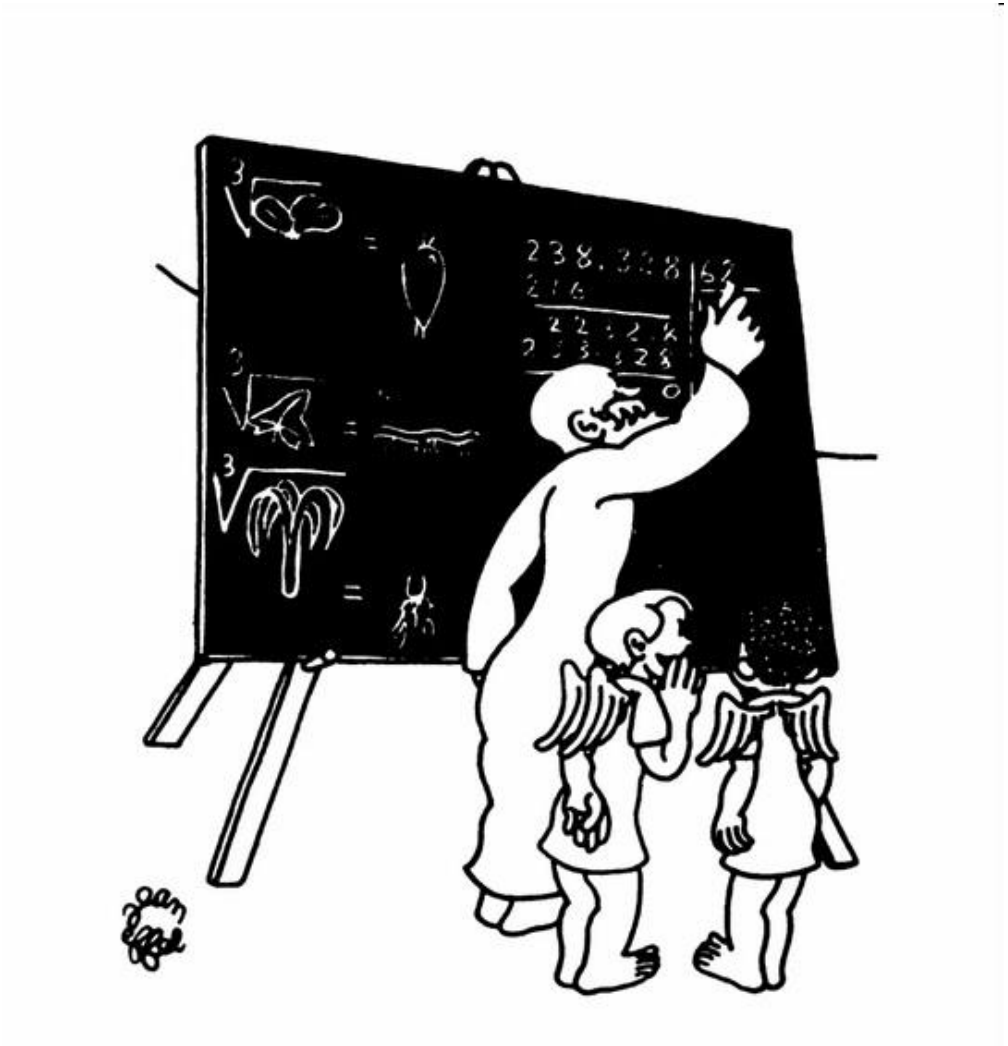
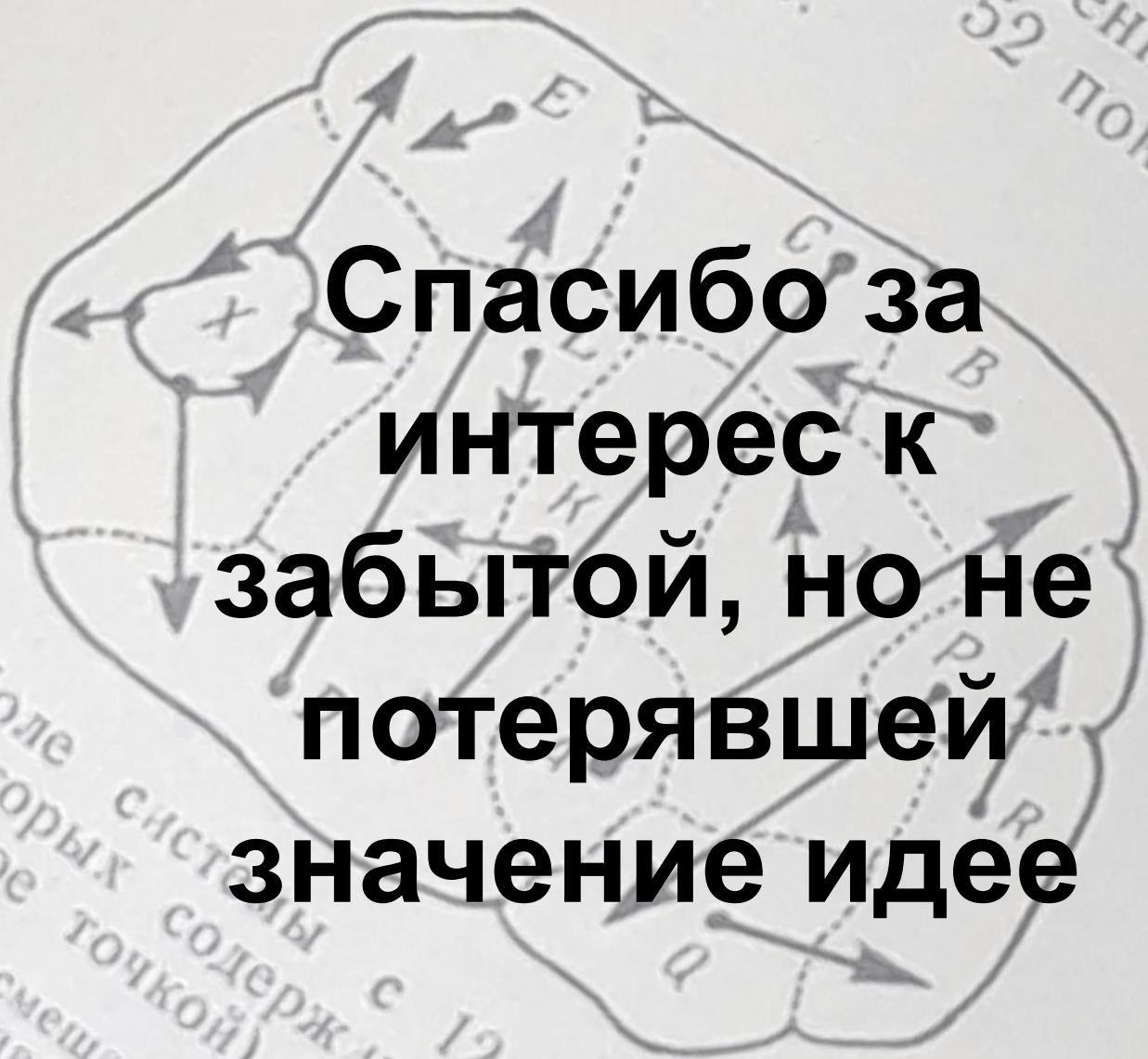


Рисунок из статьи David S Goldstein **Am.J.Physiol.(apr.2019) How does homeostasis happen?...**



Вычислительные методы в *Сотворении мира* глазами Жана Эффеля

«…Он вычисляет корни»



Спасибо за интерес к забытой, но не потерявшей значение идее