

potentialities, giving the impression that these techniques were indeed produced mechanically' (Norbert Wiener, *Cybernetics and Society*).

Progress in science and technology imposes serious problems on mankind, in particular on scientists themselves. But we cannot hold back science on that account, since it is a product of man's natural curiosity.

If there had been sceptics with a lot of foresight, they would have said that the invention of a stone axe has provided a very dangerous toy which ultimately would lead to the invention of missiles with atomic warheads. It is, however, clear that the possibility of using the fruits of man's genius for evil does not mean that these should not be generated; it only evidences the necessity of fighting for these achievements to be used for good and not for evil. History shows that despite the danger of fire, gunpowder, electricity, atomic energy and many other 'dangerous' inventions, progressive forces of society have managed to control these elements.

The correct conclusion to be drawn from all that has been said above, is that in our time nobody — and in particular not the intellectuals — can shelve responsibility from scientific analysis of the development of society, from influencing actively and purposefully this process; they cannot transfer to other people the responsibility for the social consequences of their activities and for the entire course of modern development of society.

It is incorrect to conclude that society should not use computers for development and realisation of a programme of controlling its own development. The long-term freedom consists of recognising and utilising objective relationships, which is impossible without machines, in view of the enormous quantity of information which has to be processed rapidly and in a complex manner for the purpose of revealing the main tendencies, finding optimal solutions, etc. Control by means of machines will be more perfect than control without machines; ignorance or lack of skill has never provided an advantage in any type of work. It is only necessary to realise that the solutions suggested by the machines may harbour unexpected and fateful consequences similar to the magic talisman from the story of Jacob *The Monkey's Paw*, which fulfils the desires of its master in a ruinous manner. Therefore there is nothing to free man from his responsibility to make choices if he does not want to achieve a society whose stability is maintained by 'circumspect and conscious injustice'.

All this means that we cannot entirely and blindly accept solutions which were adopted on the basis of a criterion which differs from our ideals, our concepts of a desirable organisation of society, on human relations and man itself regardless of who made the decision, whether it is an electronic brain or a bureaucratic machine. The guarantee of progress of human society is in active, free and independent efforts of all thinking and progressive people.

The future depends on our present efforts, on the depth of our understanding of the objective development of society, on our courage, willpower and ability to act. We want to see in the future a really happy society of free and good and noble descendants. Then we will be their worthy ancestors!

# Bibliography

## Chapter 1

1. Berg, A. I. *Cybernetics — The Science of Optimal Control. Energiya*, 1964.
2. Wiener, N. *Cybernetics or Control and Communication in the Animal and the Machine*. MIT Press and Wiley, 1948 and 1961.
3. Lyapunov, A. A. On some general problems of Cybernetics. Coll. *Problems of Cybernetics*. No. 1. Fizmatgiz, 1959.
4. Poletayev, I. A. The Signal. *Sov. radio*, 1958.
5. Encyclopaedia *Automation of Production and Industrial Electronics. Sovetskaya entsiklopediya*, 1962-1965.
6. Ashby, W. R. *An Introduction to Cybernetics*. Chapman and Hall, 1965.

## Chapter 2

1. Landau, L. D., Lifshits, E. M. *Mechanics*. Translated from Russian. Pergamon.
2. Peierls, R. E. *The Laws of Nature*, 1955.
3. Engels, F. *Dialectics of Nature*.
4. Yablonskiy, S. V. Fundamental notions of Cybernetics. Coll. *Problems of Cybernetics*. No. 2. Fizmatgiz, 1959.

## Chapter 3

1. Beer, S. *Cybernetics and Management*. English Universities Press, 1959.
2. Kogan, B. Ya. *Electronic Modelling Devices and their Application to the Study of Automatic Control Systems*. 2nd ed. Fizmatgiz, 1963.
3. Moore, E. F. Speculative experiments with sequential machines. Translated from English. Coll. *Automata*, IL, 1956.
4. Mikheyev, M. A., Kolpakov, P. K. (eds.) *The Theory of Similarity and Modelling*. Izd-vo AN SSSR, 1951.

## Chapter 4

1. Andronov, A. A., Vitt, A. A., Khaykin, S. E. *The Theory of Oscillations*. 2nd ed. Fizmatgiz, 1959.
2. Landau, L. D., Lifshits, E. M. *Mechanics*. Translated from Russian. Pergamon.
3. Nemytskiy, V. V., Stepanov, V. V. The qualitative theory of differential equations. Ch. 5 of *General Theory of Dynamic Systems*. Gostekhizdat, 1947.



**Chapter 5**

1. Brillouin, L. *Science and Information Theory*. Academic Press, 1967.
2. Fano, R. M. *Transmission of Information: a Statistical Theory of Communication*. MIT Press, 1961.
3. Kharkevich, A. A. *Outline of the General Theory of Communication*. Gostekhizdat, 1955.
4. Shannon, C. E., Weaver, W. *Mathematical Theory of Communication*. Univ. of Illinois Press, 1949.
5. Yaglom, A. M., Yaglom, I. M. *Probability and Information*. Fizmatgiz, 1960.

**Chapter 6**

1. Lerner, A. Ya. *Introduction to the Theory of Automatic Control*. Mashgiz, 1958.
2. Fel'dbaum, A. A., Dudykin, A. D., Manovtsev, A. P., Mirolyubov. *Basic Theory of Communication and Control*. Fizmatgiz, 1963.

**Chapter 7**

1. Lerner, A. Ya. *Introduction to the Theory of Automatic Control*. Mashgiz, 1958.
2. Pugachev, V. S. (ed.) *Fundamentals of Automatic Control*. Fizmatgiz, 1963.
3. Hammond, P. *The Theory of Feedback and its Applications*.

**Chapter 8**

1. Bellman, R. *Dynamic Programming*. Princeton University Press, 1957.
2. Ventsel', E. S. *Elements of Dynamic Programming*. "Nauka", 1964.
3. Lerner, A. Ya. *Principles of the Construction of Fast-Response Servosystems and Regulators*. Energoizdat, 1961.
4. Pontryagin, L. S., Boltyanskiy, V. G., Gamkrelidze, R. V., Mishchenko, E. F. *The Mathematical Theory of Optimal Processes*. Fizmatgiz, 1961.
5. Fel'dbaum, A. A. *Fundamentals of the Theory of Optimal Systems*. Fizmatgiz, 1963.

**Chapter 9**

1. Shannon, C. E., McCarthy, J. (eds.) *Automata Studies*. Princeton University Press, 1956.
2. Gaaze-Rapoport, M. G. *Automata and Living Organisms*. Fizmatgiz, 1961.
3. Kobrinskiy, N. E., Trakhtenbrot, B. A. *Introduction to the Theory of Finite Automata*. Fizmatgiz, 1962.
4. Murray, F. J. *Mechanisms and Automata*. Translated from English. *Kiberneticheskiy sbornik*, No. 1, IL, 1960.
5. Gavrilov, M. A. (ed.) *Structural Theory of Relay Devices*. Collection of articles. Izd. AN SSSR, 1963.
6. Trakhtenbrot, B. A. *Algorithms and Solution of Problems by Machine*. Gostekhizdat., 1957.

**Chapter 10**

1. Kitov, A. I. *Electronic Digital Computers*. Sov. radio, 1956.
2. Kitov, A. I., Krinitskiy, N. A. *Electronic Digital Computers and Programming*. 2nd. ed. Fizmatgiz, 1961.
3. Murphy, G. J. *Electronic Digital Computers*. Van Nostrand, 1959.
4. Turing, A. M. *Computing Machinery and Intelligence*. *Mind*, 1950, 59, 433-460.

**Chapter 11**

1. Bellman, R. *Adaptive Control Processes: A Guided Tour*. Princeton University Press, 1961.
2. Tsien, H. S. *Engineering Cybernetics*. McGraw-Hill, 1954.
3. Ashby, W. R. *Design for a Brain*. 2nd ed. Chapman and Hall, 1960.

**Chapter 12**

1. Williams, J. D. *The Complete Strategist*. McGraw-Hill, 1954.
2. Ventsel', E. S. *Elements of the Theory of Games*. Fizmatgiz, 1959.
3. Luce, R. D., Raiffa, H. *Games and Decisions*. Wiley, 1957.
4. McKinsey, J. C. C. *Introduction to the Theory of Games*. McGraw-Hill, 1952.
5. Shannon, C. E. *Game-Playing Machines*. Transl. from English. *Kiberneticheskiy sbornik*, No. 1, IL, 1960.
6. Shannon, C. E. *A Chess-Playing Machine*. Transl. from English. Coll. *Papers on Cybernetics and Information Theory*. IL, 1963.

**Chapter 13**

1. Bush, R. R., Mosteller, F. *Stochastic Models for Learning*. Wiley, 1955.
2. Vannik, V. N., Lerner, A. Ya., Chervonenkis, A. Ya. *Systems of learning pattern recognition by means of generalised portraits*. *Tekhnicheskaya kibernetika*, 1965, No. 1.
3. Tseytlin, M. L. *Teaching Stochastic Automata*. *Avtomatika i telemekhanika*, 1961, No. 10.
4. Shannon, C. E. *Presentation of a Maze-Solving Machine*. *Trans. of the Eighth Cybernetics Conference*, Josiah Macy Found, 1952, pp. 173-180.

**Chapter 14**

1. Beer, S. *Cybernetics and Management*. English Universities Press, 1959.
2. Buslenko, N. P. *Mathematical Models of Production Processes*. Nauka, 1964.
3. Goode, H. H., Machol, R. E. *System Engineering*. McGraw-Hill, 1957.

**Chapter 15**

1. Zukhovitskiy, S. I., Radchik, A. I. *Mathematical Methods of Network Planning*. Nauka, 1965.
2. Burkov, V. N. et al. *Network Models and Control Problems*. Sov. radio, 1967.
3. Rivett, B. H. P., Ackoff, R. L. *A Manager's Guide to Operational Research*. Wiley, 1963.
4. Tsyppin, Ya. Z. *Adaptation, Teaching and Self-Teaching in Automatic Systems*. *Avtomatika i telemekhanika*, 1966, No. 1.

**Chapter 16**

1. Bernshteyn, N. A. *Ways of Developing Physiology and Problems of Cybernetics Connected with Them*.
2. Braynes, S. N., Napalkov, A. V., Svechinskiy, V. B. *Scientific Reports (on Neurocybernetics)*. Izd-vo Mosk. un-ta, 1959.
3. George, F. H. *The Brain as a Computer*. Pergamon Press, 1961.
4. *Cybernetics and the Living Organism*. Translated from the English. *Naukova dumka*, 1964.
5. Kleene, S. C. *Representation of events in neural networks and finite automata*. Coll. *Automata*. Translated from English. IL, 1956.
6. Kolmogorov, A. N. *Life and thought from the viewpoint of Cybernetics*. In the book: Oparin A. I. *Life and Its Relationships with Other Forms of Movement of Matter*. AN SSSR, 1962.



7. Neuman, John von. *The Computer and the Brain*. Yale University Press, New Haven, 1958.
8. Rosenblatt, F. *Principles of Neurodynamics*. Spartan Books, Washington, 1962.
9. Ashby, W. R. *Design for a Brain*. 2nd ed. Chapman and Hall, 1960.

#### Chapter 17

1. Brillouin, L. *Science and Information Theory*. Academic Press, 1967.
2. Foerster, H. von, Zopf, G. W. (eds.) *Principles of Self-organization*. Pergamon Press, New York, 1962.
3. Fel'dbaum, A. A. (ed.) *Self-learning Automata*. Nauka, 1966.
4. Yovits, M. C. (ed.) *Self-organizing Systems*. Proc. of an Interdisciplinary Conference, May 1959. Pergamon Press, New York, 1960.
5. Schroedinger, E. *What is Life? The Physical Aspect of the Living Cell*. 1944.
6. Ashby, W. R. Design for an Intelligence-Amplifier. In *Automata Studies*, Princeton, 1956, 215–234.
7. Ashby, W. R. *Design for a Brain*. 2nd edition. Chapman and Hall, 1960.
8. Gel'fand, I. M. et al. Models of the Structural-Functional Organization of Some Biological Systems. *Nauka*, 1966.

#### Chapter 18

1. Engineering Psychology. Translated from English. *Progress*, 1964.
2. Lilly. *Automation and Social Progress*. Translated from English. IL, 1958.
3. Lomov, B. F. *Man and Engineering*. Izd-vo LGU, 1963.
4. Gaaze-Rapoport, M. G., Lerner, A. Ya, Oshanin, D. A. (eds.) The System 'Man – Automaton'. *Nauka*, 1965.

#### Chapter 19

1. Wiener, N. *Cybernetics or Control and Communication in the Animal and the Machine*. Wiley, 1961.
2. Wiener, N. *Cybernetics and Society*. Houghton Mifflin, Boston, 1954.
3. Wiener, N. New Chapters of Cybernetics. Translated from English. *Sov. radio*, 1963.
4. Berg, A. I. (ed.) *Cybernetics, Thinking, Life*. Collection of articles. *Mysl'*, 1964.
5. Thomson, G. *The Foreseeable Future*. 1955.
6. Il'yin, V. A. et al. (eds.) *The Philosophical Problems of Cybernetics*. Sotsekgiz, 1961.
7. Shklovskiy, I. S. *The Universe, Life, Intelligence*. 2nd edition. *Nauka*, 1965.
8. Engels, F. *Anti-Dühring*.
9. Encyclopaedia *Automation of Production and Industrial Electronics*. *Sovetskaya entsiklopediya*, 1962–1965.

## Index

Bold numbers indicate the page where the definition of the respective term is given.

- Accumulator, 251
- Action, input, 7
- output, 7
- Adaptation, 169ff
- Adder, 148
  - one-digit, 149
  - multi-digit, 149
- Addition, logical, 130
- Address, 148
- Algebra, boolean, 129
  - of logic, 129
- Algorithm, 137
  - control, 77
- Alphabet, 59, 128ff
- Amount of information, 60ff, 65ff, 84ff, 257
- Amplifier, 93
- Anticipation, 225
- Area, isochronous, 119
  - of permissible states, 15
- Automaton, 128ff
  - adaptive, 176ff
  - deterministic, 141ff
  - discrete, 128
  - logical, 129ff
  - probabilistic, 141ff
  - reference, 198
  - with finite memory, 129 134ff
  - with infinite memory, 138ff
  - without memory, 128
- Axon, 240
- Behaviour, learning, 199ff
  - system, 25, 209
- Bit, 60
- Black box, 26, 142
- Boolean algebra, 129
- Brain, 238ff, 241
- Cerebellum, 241
- Cerebrum, 241
- Characteristics, frequency, 106
  - amplitude-frequency, 106
  - phase-frequency, 106
- Code, 58
  - basis, 59
- Coding, 56, 58
- Coefficient, transmission, 90, 92
- Collateral, 240
- Communication channel, 57, 63
- Computer, 146ff
  - analogue, 164ff
  - digital, 147ff
- Conditional instructions, 148
- Conjunction, 130
- Contact, synaptic, 240
- Control, 18, 75ff, 77ff, 89ff
  - automatic, 89ff
  - bio-electric, 274ff
  - centralised, 213
  - device, 77
  - of large systems, 210ff
  - operational, 224



- operative, 233
- optimal, 112ff
- programmed, 102ff, 157ff
- resource, 210
- signal, 77
- system, 78ff
- Controlled object, 75
- Converter, analogue-digital, 154
- digital-analogue, 154
- Coordinates of system, 15, 170, 175
- phase, 43
- Cord, spinal, 241
- Corpus striatum, 241
- Cortex, cerebral, 241
- Criterion, effectiveness, 112ff, 211
- Cybernetics, 1, 238
- Cycle, 48, 134ff
  - stable limit, 50
  - unstable limit, 50
- Cytoplasm of cell, 239
- Degree of freedom, 15
  - of order, 255
- Definiteness, 137
- Dendrite, 240
- Device, control, 77
  - stabilising, 101
  - storage, 251
- Direct link, 82
- Disjunction, 130
- Disturbance, 18
- Domination, 186ff
- Edge of graph, 225
- Effectiveness, 163
  - criterion, 112f, 211
- Element, actuating, 90
  - control, 90
  - correction, 107
  - delay, 135
  - measuring, 90
- Entropy, 62ff 264
- conditional, 65
- Equilibrium, 40, 46, 48
- Event, beginning, 225
  - final, 225
- Feedback, 2, 80, 82
  - negative, 82
  - positive, 82
- Flip-flop, 135ff
- Frequency characteristics, 106
- Fulfillment of programme, 79, 102
- Function, estimation, 190
  - logical, 129ff
- Game, 183, 184ff
  - against nature, 184
  - coalition, 184
  - finite, 184
  - infinite, 189
  - machine, 189ff
  - matrix, 184
  - mixed, 186
- Game, pair, 184
  - payoff, 184
  - theory, 184
  - two-person, 184
  - value, 186
  - zero-sum, 184
- Generality, 137
- Graph, 34, 225
  - finite, 225
  - finite directed, 225
- Homeostasis, 170, 238
- Homeostat, 178ff
- Homomorph, 29
- Hyperspace, 14
- Information, 56, 58ff
  - content, 56
- Input, 17, 147
  - signal, 17
  - value, 17
- Instruction, 148
  - conditional, 148
- Isochrones, 119ff
- Iso-surface, 118ff
- Large system, 209ff
- Learning, 195ff
  - behaviour, 199
- Letter of alphabet, 59
- Line, switching, 121
- Link, direct, 82
  - open, 80
- Logical addition, 130
  - depth, 165
  - multiplication, 130
  - negation, 130
- Machine, teaching, 202
- Manipulator, 275ff
- Matrix, payoff, 184
- Maxwell's demon, 256

- Medium, 7
- Medulla oblongata, 241
- Membrane, cell, 239
- Memory, 66ff, 147
  - cell, 148ff
- Message, discrete, 59
- Method, Gauss-Seidel, 175
  - heuristic, 217ff
  - Monte Carlo, 218ff
  - phase-space, 9
  - scanning, 174
  - search, 174
  - static modelling, 218ff
- Midbrain, 241
- Mixer, 246
- Model, 23ff
  - adaptive, 261
  - dynamic, 235
  - homomorphous, 29, 260
  - mathematical, 33ff
  - network, 224
  - simplified, 29
- Movement, 11ff
- Multiplication, logical, 130
- Negation, logical, 130
- Negentropy, 255, 264
- Network, 225ff
  - analysis, 227
  - nerve, 242ff
- Neuron, 240
  - association, 240
  - external, 242
  - input, 242
  - motor, 240
  - output, 242
  - sensory, 240
- Nucleus, cell, 239
- Object, 24, 90
- Open link, 82
- Operand, 20
- Operator, 19
- Operation, 224
- Order of system, 43
- Ordering, 253
- Original, 23
- Oscillations, forced, 50
  - free, 50
  - stable, 50
- Output, 17, 147
  - signal, 17
  - value, 17
- Part of system, controlled, 7
  - controlling, 7
- Pass-band, 107
- Path, 225
  - critical, 228
  - longest, 227
  - optimal, 119
- Pattern, 196
  - recognition, 196ff
- Perceptron, 247ff
- Period, training, 201
  - latent, 269
- Phase coordinates, 43
  - portrait, 43ff, 101ff
  - space, 42, 43
  - space method, 7
- Planning, operational, 229
- Point of equilibrium, 40
  - representative, 15
  - saddle, 186
- Poisson distribution, 221
- Pole, 119
- Probability, 63
  - conditional, 63ff
  - joint, 64
- Problem of functional control, 210
  - of operational control, 210
- Process, multi-stage, 116
  - optimal, 113
  - transient, 30
- Programme, 148, 235
- Programming, 272
- Punishment (penalty), 177, 201
- Queuing, 220ff
- Receptor, 241
  - field, 248
- Recognition, pattern, 196
- Redundancy, 255
- Reflex, conditioned, 250
  - unconditioned, 250
- Regime, equilibrium, 40
  - periodic, 40, 41
  - steady state, 40, 41ff
  - transient, 40, 41
- Register, shift, 150
- Reliability, 214
- Representation, 198ff
- Reward, 201
- Resultativeness, 137
- Rigidity, 214



- Saddle point, 186
- Scanning method, 174ff
- Search, 180
- Set of possible (control) forces, 77
  - of states, 57
- Signal, 56ff
  - bio-electric, 275
  - input, 17
  - output, 17
  - stimulation, 271ff
  - transmission, 63ff
- Similarity, 24ff
  - in behaviour, 25
  - in shape, 25
  - in structure, 25
- Situation, conflicting, 183
- Space, multi-dimensional, 14
  - of control forces, 76
  - of operating conditions, 171
  - phase, 43
- Stabilisation, 79
- Stability, 4, 46ff
- Stable limit cycle, 50
- Stage, operation, 224
- State, equilibrium, 40, 46, 48
  - internal, 196
  - space, 12, 15ff
    - continuous, 15
- Stimulus, 269
- Strategy, 184
  - minimax, 185
  - mixed, 187
  - optimal, 116ff, 186
  - pure, 186
- Structure, hierarchical, 215
- Synapse, 240
- System, abstract cybernetic, 6
  - analogue, 29, 30
  - astatic, 98
  - automatic control, 90, 95
  - bio-electric control, 276
  - centralised control, 213
  - control, 5, 78
  - controlled, 8
  - closed-loop, 82ff, 102, 235
  - combined control, 83
  - cybernetic, 6ff
  - dynamic, 30
  - feedback, 82
  - hierarchical, 215
  - hormone, 238
  - isomorphous, 27
  - large, 209
  - linear, 106
  - machine, 260
  - nervous, 239, 241
  - open-loop, 81ff, 102
  - optimal control, 121
  - organised, 8, 255
  - self-organising, 256, 263ff
  - servo, 92, 104ff
  - static, 97
  - tracking servo, 104
- Teacher, 198
- Teaching machine, 202ff
  - self-adapting, 203
- Threshold, 240
  - neuron, 242
  - obsolete, 272
- Tracking, 79
- Trainer, 203
- Transform, 20
- Transformation, 19
  - functional, 90
  - linear, 90
- Truth tables, 130
- Turing machine, 137ff
- Uncertainty, 67ff
- Unit, actuating, 78
  - arithmetic, 147
  - astatic, 92ff
  - control, 147
  - dynamic, 92
  - input, 147
  - memory, 147
  - output, 147
  - static, 92ff
- Value, input, 17
  - output, 17
  - representative, 31
- Variable, random, 61
  - independent, 65
- Vertex of graph, 225
- Word, 59
- Work, 225
  - fictitious, 225