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The Importance of Automatic Control

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The Importance of Automatic Control

I have the honour and privilege to present the opening address to this illustrious gathering of scientists and engineers assembled at the First Plenary Session of the Fourth Congress of IFAC. This Congress is also the first large International Meeting on Automatic Control in my country.

I start first with some figures. We shall have at the present Congress 11 plenary meetings, 50 technical sessions, 10 round table conferences and 10 survey papers.
As far as the technical reports are concerned, we have 303 reports, of which 162 reports deal with theory, 37 with components and 104 with applications and systems problems respectively. In London at the Third Congress of Automatic Control we had 49 sessions of technical papers, in which 271 technical reports were presented besides 10 survey papers presented separately.

We tried very hard at the International Selection Committee meetings in November 1968 under the Chairmanship of Prof. R. Kulikowski to admit as many papers as possible in the domains of components and applications and we had to cut quite a good number of papers dealing with various aspects of theory.
The fact, that theory-papers are again prevailing however is not a dangerous one, as many theoretical papers deal with practical problems - if not those of to-day then of to-morrow. On the other hand, an increasing number of symposia is dealing with problems of components, applications, systems engineering and space problems, so that one can say, that the practical engineer, who is associated with IFAC, is getting his due share of professional importance in the papers presented. In the 3 years - when I had the honour to be in office as President of IFAC we had quite a number of Symposia organized by the various IFAC Committees with the help of various Member-countries, all of which have been a success. May I also add, that besides the Bulletin of IFAC, which is nowadays more or less a press-release, IFAC has its own scientific and technical periodical „Automatica", the first number of which appeared on the first of January 1969. In addition we issued a six-language version of a Multilinguar Dictionary of Automatic Control Terminology, published by the Instrument Society of America.

We have now 33 member-countries in IFAC, but IFAC admits at its Congresses and Symposia papers from any country without discrimination.

At the present Congress authors from 26 countries are presenting their papers. We are an International Professional Brotherhood, what is also underlined by the fact, that some papers are written by coauthors from different countries.

As at the III IFAC Congress, the President of IFAC has to deliver the opening address, may I therefore begin my short survey.

I start with definitions, although Samuel Butler once said: „To define something means to draw a wall of words around some space deprived of ideas".
The word „mechanization" means the execution of all processes in which an external energy replaces the energy of human or animal muscles. In mechanization processes the human operator is still present, but his work is limited to guide and control materials and machines. Every technology, the aim of which is to supply man with a given product, has in the past started with a tool, then progressed in instruments, later in mechanisms and still later in machines. Mechanization involves not only machines but also the transport of raw materials, partly and totally finished products.
Mechanization is limited to the fact that the machine executes blindfoldedly a predetermined program in a rigid way.

The word „Automatization" or „Automatic Control" means the replacement of the human operator by a feed-back system and error-detectors. Crudely said, an Automatic Control system has to keep one or more physical parameters within certain limits or at certain values in comparing the values of the output parameters with the "desired" values of these parameters.

In order to achieve these output values, one has to "feed" them back and compare them with the desired values in error-detectors, amplify the errors and utilize actuators, like servomotors etc to correct the output values so, that they may possess the least error compared with the desired values.

Of course an automatic control system consists of quite a number of parts or components not to speak about the regulated object itself, it requires detectors and transducers, which measure the regulated parameters and transform them into signals of a proper physical parameter most adequate to the designed system, error-detectors, amplifiers and other components.

In 1952 D.S. Harder, Vice-President of the Ford Motor Company utilized for the first time the americanism „automation", this term consisting of the junction of two words „automatic" and „organization" - was at the same time defined by John Diebold as a method, which „analyzes, organizes and controls our means of production in order to realize the optimal utilization of all our productive, mechanical material and human resources". This definition incorporates any technical innovation - including automatic control systems - which consists in analyzing, organizing and - or controlling a production process in order to achieve a maximal productivity. Automation thus is a polyvalent operation by the means used in fulfilling its objective as well as by the economic, psychological and social consequences resulting from its application.

The ultimate objective of automation is the sparing of man's efforts, whether muscular or cerebral. In the definition of automation the word „ productivity" has been used.

Productivity may be defined as the ratio of output /in money value or specified product/ to manhours required to create this output.

There is a domain related to and being increasingly utilized in automation, which may be called „Information Processing" or in French „l'informatique". One may call this science the production, amplification, transmission reception, coding and decoding, transformation and storing of information of any kind. Any information demands its own language. A computer has its language expressed in the program submitted similarly to the language of a child, which sometimes only its mother understands.

Mechanization, Automation and Information Processing have given us a new technical revolution, the witnesses of which we are at present and whose implementations we cannot foresee, as the time of existence of the progresses made is too short and the development too vivid.

There is a word which I particularly do not like, that is „cybernetics". Norbert Wiener, the inventor of this word says, that „cybernetics is a Design Theory of Control and Communication", in fact it means the theory and design of all self-regulating and self adapting control mechanisms including biological organisms. According to Donald Mac Kay cybernetics means „control under the guidance of information". The only merit of coining this word may be, that it embraces all domains of automatic control and information processing, albeit industry, biology, sociology or administration.

Although automation is a new word, its application is very old. Intelligence and imagination of man are as old as our history and automation probably started when our ancestors stopped climbing trees. Any technology did not start at once and the first digital computers were human fingers. Already in the time of the Pharaons there existed in Egypt an automatic irrigation system utilizing the water of the Nile.
In the 4th century before our era Archytas of Tarentum was already flying a self-propelled wooden pigeon and a Greek beggar invented the first slot-machine, from which - by putting in 5 drachmae - a given amount of water was ejected.
Heron of Alexandria in the third century of our era created already the first automatic installations utilizing gravity, waterfalls and steam. At the time the first wind-mills with variable pitch were imported from the Near East to Europe.
A few centuries later church-organs with hot air were already in use. In the XIIIth century we had already the first hydraulic motors for spinning silk, in the XVth century Leonardo da Vinci and Salomon de Caus knew already how to utilize steam, long before Boyle, Papin and Newton. There were many androids-robots imitating human beings - which gave through the ages sensational performances at royal courts.
A life-sized flute player, built by Jacques de Vaucanson in 1738, was quite a mechanical wonder comparable with the moving and singing menagerie of Pierre Droz, a Swiss watchmaker.

The age of mechanization, called the First Industrial Revolution started in 1698, when Thomas Savery devised a steam-pumping engine to remove water from coal mines.

The water was previously removed by men carrying pots or buckets on their own shoulders. Fifteen years later Thomas Newcomen invented an atmospheric engine, of which about a hundred was already in use 50 years later. In 1712 Andrej Konstantinowitch Nartov a mechanic employed by Peter the Great in Russia installed the first automatic lathe. The first double-acting steam engine of James Watt was patented in 1782, and shortly afterwards his automated governor controlled his engines. By 1800 more than 500 steam engines were in use, mostly in textile factories. Papin in Germany, the Marquis de Jouffroy in France and Fulton in America built shortly the first river ships driven by steam engines.

The first industry which was mechanized was the textile industry. In 1733 John Kay invented in Lancashire the fly - shuttle and thus immediately doubled production. Production increased still further, when in 1764 John Hargreaves invented a simple machine called the spinning-jenny, spinning 7 threads simmultaneously. A few years later already 120 threads could be spun at one time. By 1780 already 20.000 machines of this type were in use. Richard Arkwright patented in 1769 a spinning frame of large dimensions, powered by horses or water, whereas in 1785 Edmund Cartwright developed a power loom, by 1820 with the use of the steam engine more than 12.000 looms were installed in England alone.

Normally the XIXth century is considered as the age of the first industrial revolution. In 1802 Jacquard patented his machine, in which we have already a design on the cloth programmed aforehead on punched cards, used also to-day in the textile industry as well as in mechanical pianos and music boxes. Round 1815 there were about 11.000 automatic weaving looms in France alone. In 1802 in the USA Eli Whitney made ten thousand rifles at a new factory, all of them had identical interchangeable parts - more than a hundred years before Henry Ford recognized the benefits of mass production. The second factory based on mass production was built by Colt, the inventor of the revolver. In 1860 Kosma Dmitrievitch Frolov in Russia started a factory for recovering gold from minerals, the whole process was mechanized and automatically controlled. A water-wheel system provided the power for grinding, milling, washing, gold recovery and transport. In 1870 Brown and Sharp put on sale the first automatic lathe with a revolving head and an automatic program for the various operations. The second half of the nineteenth century was marked by many inventions: the steam-turbine, electric generators and motors, the Bessemer converter, the first plastic celluloid, typewriters, adding machines, rayon. In 1889 the automatic telephone was invented, however only in 1908 were the first lines met at the public disposal. At the time one had still the patience to wait.

The first half, or let us say - untill 1945 - of the Twentieth Century was already marked by an increased process of instrumentation and automatic control and further steps in mechanisation. New instruments like pyrometers, volta - meters and many registring instruments were installed. In 1900 the American steel industry introduces continuous rolling mills.

In 1912 Henry Ford applies the principle of mass production and utilizes assembly lines in order to produce 1000 motor-cars per day - this all at a time, when a car in Europe was still considered as a luxury.

Repetetive methods and chain production came later also to Europe, which was at that time involved in the struggle of the First World War. The first automatic firing directors for anti-aircraft guns were introduced at that time. Industry in Europe is getting automatic control and starts with continuous production. The output per worker in the automobile industry was three times as much in 1925 as in 1914, the output in the iron and steel industry doubled in the same period, it trebled in the petroleum industry and it increased 34 per cent in the paper and pulp industry.
In 1924 the Morris factory at Coventry introduced the first transfer machine, which could do its own loading, positioning and unloading. Although production was increased, it was not until 20 years later that the Ford Motor Company installed and operated fully automatic transfer machines. In nearly all branches of industries mechanization and automatic control increases and the use of electricity has a big share in this development.

Since Lee de Forest invented the triode electronics is slowly coming off age, but it was chiefly restricted to the development of wired and wireless communication.

The Second World War brought among other developments a revolution in electronics, chiefly due to radar and other navigational aids.

After the war and after lifting the veil of secrecy electronic automatic control is gaining momentum in industry, not only in repetetive or batch production, but also in continuous processes. Already in 1942 machines with digital control were utilized in the United States in the aircraft - and weapons industry. In 1946 the Renault factory produces its 4 CV car with transfer machines equipped with electro-mechanical heads.

In the meantime John Sargrove invented a machine for automatically producing radio circuits. This development led to the printed circuits.

The discovery of the transistor in 1948 gave a new impulse to semiconductor devices. The transistor replaced the large and fragile vacuum tube and paved the way for better instruments, electronic equipment and contributed to a new generation of computers.

Since 1960 the digital computer enters into the field of automatic control and of automatic data processing. With the ascendance of automatic control systems and an always increasing amount of administrative work, automatic control and information processing are forced to employ computers.

Computation has its history as well as the progress of mechanisation and automatic control. It started first with digits and the abacus was the first digital computer, which by the way is still in use in some countries. The first arithmetical machine was designed in 1642 by Blaise Pascal, it effected already additions with the help of retainers. The first machine multiplication was carried out by Leibnitz half a century later. Pascal's machine - forgotten for 2 cen-

turies, was redesigned in 1820 by Charles-Xavier Thomas from Colmar and produced in several hundred copies.
In 1770 the German Hahn utilized the idea of Leibnitz of a cylindric wheel equipped with teeth and produced a machine which could carry out all four basic arithmetical operations.
In 1822 Charles Babbage, professor of Mathematics at Cambridge coupled the two ideas of automatic carry-over and the perforated card and conceived his „analytical apparatus", the first mechanical computer which carried out several successive operations without human intervention.
The Babbage computer had already a program registered on perforated cards, a memory and a registered output.
In 1885 Hermann Hollerith patented the coding of information on punched cards and built an electromechanical computer.
He founded in 1895 an industrial society, which become in 1911 the International Business Machine Company. In Europe the Norwegian Bull patented a machine working with punched cards, in France the Compagnie de machines Bull started the production of computers based on Bull's patents.
In 1925 one can note the development of various counting machines, first mechanic, later electromechanic and electromagnetic, which started at the beginning with one operation per second. Already in 1940 the Bell Laboratories had an electric computer which could fulfill several million operations per second according to a predetermined program.
However for every new program a new plug-board had to be supplied. During the war a number of electromagnetic relay computers for ballistic purposes was in operation.

Electric relay computers however were short-lived, the electronic computer was the base of the first generation of computers utilizing electronic valves. In 1942 Zuse in Berlin built the first valve computer „Z4" with 1500 valves. In 1944 Aiken designed the Harvard Mark I, an office computer with several thousand valves, one addition lasted one third of a second, one multiplication four and one division eleven seconds respectively, the cost was 400.000 dollars.
In 1946 the „ENIAC" /The Electronic Numerical Intergrator and Automatic Calculator/ was designed at the University of Pennsylvania, its weight was 30 tons, it had 18.000 valves and 50.000 commutators. The ENIAC could already perform 300 different operations per second or 5000 additions.

Between 1945 and 1955 much progress has been made in computer-development, to mention only logic circuits, memories and programming.

Since 1950 computers were no longer cabled, they had already printed circuits. Before 1951 the computer was used for military and scientific purposes, since that date however it starts its carrier in the commercial field especially for administrative purposes. Magnetic drums, ferrite memories, semiconductor diodes and transistors are starting the second computer generation. The transistor, existing since 1948 revolutionized 10 years later all electronic equipment including analog and digital computers.
IBM produced in 1960 the 1401 series, which was shortly followed by the 360 series, in addition magnetic tape memories, like the „Dispac" of IBM could contain already 3 million bits.

The amount of the second generation of electronic computers can be evaluated as 50.000 between 1958 and 1966.
One can consider the year 1964 as the start of the third generation of computers, which use micromodules and integrated circuits produced automatically. Evaporated films, epitaxial layers, metal oxide semiconductor transistors /MOS/, field effect transistors /FET/, thin film transistors /TFT/, thin film memory tapes and so on are new components of this generation of computers, which contain several hundred thousand elements with some 40.000 transistors.

One microcircuit fulfills nowadays the function of a whole unit of a classical electronic circuit which contained some 20 transistors, diodes, condensors and resistors. The access speed of these computers is of the order of one billionth of a second.

To-day the total information /sound and vision/ of a television transmission of several hours duration can be stored in several cubic cm. Along with volume compression in control and computer components greater viability and reliability were achieved.

The progress in hardware was accompanied by the progress of software. Quality of control and speed of operation are increasing at a steady path. Despite the increase of memory devices in computers, the response time is shorter.

Research is supplying us with new devices like thin films, cryotrons working in the vicinity of the absolute zero of temperature and lasers. Although it needed tens of years to double the speed of railways it takes nowadays only up to six months to increase by a factor of thousand the speed of a modern computer. In 1967 the signal response in computers could already profit from the nanosecond technique. The cost of computers is also dropping considerably, one can estimate, that within 10 years' time, the operational cost in data transmission will drop by 50 %, the registration on magnetic tapes by 90 %. Every technological process whether continuous or repetitive can be automatically controlled.

The computer is slowly entering the field of automatic control, because managers and operators are still showing a certain amount of misbelief that a computer - expensive as it is - is not too reliable, in some automatic control systems computers are installed in parallel to „classical" control equipment and are working as guiding operators.

Because computers are still expensive for smaller factories and enterprises, they can work on a base of time-sharing, they can be utilized collectively.

The computer has then as many programs as there are partners to it. In Edinburgh about one hundred Research Laboratories are utilizing one computer. In London an "IBM 360" computer will shortly link up directly with Paris, Lille, Madrid and Stuttgart.

At the International Atomic Energy Agency in Vienna the INIS - system /International Nuclear Information System/ will come into being in 1970 and supply information on nuclear literature by means of a central computer to 100 Member States of the Agency. Thus besides Automatic Control Remote Data Processing will become of increasing importance. Without remote control the great achievements of our era - starting with Jurij Gagarins space flight on the 12th April 1961, the sputniks and Apollo-space vehicles including the landing of man on the moon by means of the Lunar Module vehicle, were not possible.

Communication satelites are enabling us new pleasures in television and facilitating all other means of communication. The progress in computer technology contributes much to the advancement of digital control in automatic control systems. The "start and stop" push button technique is receding before instructions given to the machine by magnetic tapes and punched tapes.

The best way of course is to combine information processing with automatic control, i.e. to incorporate digital computers into control systems.

In a few years' time digital control systems will claim about half of the total of computers produced.

Computers are being built with the aid of other computers executing the digital control of manufacturing micromodules and other computer components. Computers are increasingly used for operational research, whose aim is the systematic study of problems translated in apropriate mathematical equations. Operational research gives us technical and economic strategies and presents us with solutions for logistic problems, it permits to simulate events in advance and to choose optimal solutions. One can e.g. simulate the operation of a high furnace in a steelwork by means of 30 seconds of computer operation, these 30 seconds replace 30 hours of real operation of the furnace. One of the big chemical enterprises had to build a 150 million pound acrylonitrile plant in England, the project economics were before simulated in a model having about 120 variables, including location, taxes, labour costs, tariffs and transport. Over 100 simulations were run before the final decision was made. Even such items as a dynamic appraisal over the expected life of the plant in relation to its economics was made for the entire period.

The computer has found its increasing application in management and administration. In 1968 there were about sixty five thousand digital computers in operation all over the world, 42.000 computers alone were placed in the United States.

Although the digital computer has shown such rapid development and had its impact on automatic control, there was a lot of other new developments in the theory and technology of automatic control systems. As I already mentioned we witnessed great achievements in space technology in the last few years like the soft landing of an unmanned Soviet lunar vehicle Luna 9 on the moon, the manned flight of Apollo 8 around the moon, the decoupling and coupling of command modules and lunar modules of Apollo 9 and the first flight around the moon and safe return at a predetermined point on earth by the spacecraft Sond 5 in September 1968. At present Soviet and American rockets have lifted into space more than 900 manned and unmanned space-vehicles and satellites. Increased application of methods of automatic control and information processing is to be noted for the benefit of economic systems of planning and operational research. The behaviour of economic systems has however still be studied.

In automatic control systems the controlled system still needs more theoretical and experimental investigation and identification.

The theory of continuous systems was enriched by the study of complex, multilevel and multivariable systems, utilizing the idea of decomposing complex systems into simpler units and defining Liapunov's vector function. The problem of stability and quality of regulating complex systems demands further investigation.

The theory of optimal systems has made further progress in evaluating control functions and phase vectors as well as the limitations on phase coordinates of optimal systems. Good results were achieved in finding methods for the synthesis of optimal regulators. Such a synthesis can be carried for many determined systems of any complexity.

In the theory of discrete systems new methods of optimizing pulsed systems with any initial values and limitations have been found. Further improvements were made in the methods investigating self-optimizing relay-systems and digital automatic control systems. New results were obtained in adaptive and multivariable systems, in identification problems and in applying stochastic methods.

In the last few years considerable progress has to be noticed in the field of pattern recognition and learning machines. The evaluated algorithms were of considerable for technical and medical diagnostic purposes, for the interpretation of geological and geophysical data and in scientific research.

Automatic reading machines went into serial production.

The theory of statistical approximation was further developed and applied to automatic control systems, it permitted to unify the algorithms of learning devices, pattern recognition and object identification.

Useful results were obtained in designing stochastic models of complex controlled systems with distributed parameters, as well as investigating controlled systems by means of stochastic methods and thus achieving better adaptive automatic control systems.

As already stated great progress has been made in utilizing digital and hybrid computers in automatic control systems for their use standard algorithms for solving the partial problems of process control have been established and the flow of information in the various parts of the system evaluated. Automatic Data Processing and Information Processing has been applied to many branches of industry and administration. The problems of reliability and redundancy found more fields of interest than ever before, one can say, a new branch of control developed, which may be called automatic diagnostics with automatic alarming and automatic replacement of redundant components.

As any automatic control system has to relay upon informations presented by sensors, more research and development has been also achieved in the field of components. Practically all new physical phenomena have been converted into practical use, to mention only a few like: integral and selective radiation alpha, beta, gamma rays, neutrons, infrased, visible and ultra-violet light, lasers, the Faraday-, Gauss-, Hall-, Mössbauer effect, X-rays, mass - spectroscopy- electron- and nuclear magnetic resonance, acoustic and ultrasonic devices, electromagnetic waves of very long and very short wave length. Besides the aforementioned developments in transistor and integrated circuits technology, pneumatic and hydraulic components, especially those for logic circuits can also register further progress and found new applications, especially in mining and in the chemical industry. In mines the introduction of metallic supports and hydraulic props facilitated the mechanization of working faces in pits, in fact there were in 1967 already about 1300 fully mechanized support faces installed at collieries, equiped cutter-loaders, feeding coal onto conveyors or releasing coal into self-propelled cars.

Despite the tremendous progress which the theory and application of automatic control systems has shown, there is still a lot of problems to be solved or further elaborated. May I enumerate some of them:

- More knowledge of Systems Engineering in attacking the problems of complex automatic control systems /CACS/, the study of adaptive systems and the decomposition of complex systems,
- further studies of making useful algorithms available for a larger class of tasks, of programming and computer languages for CACS,
- simulation of larger systems, their identification and optimization,

- more studies of economic and social problems with methods already known in control engineering,
- further research in bionics and the application of automatic control knowledge in medicine, like transplant-technology, artificial limbs, mechanical and optical aids for the blinds,
- further applications of CACS-technics in administration,
- further development in learning and self-learning machines.

I gave only a few examples, being aware, that they do not contain a full list neither of our needs nor desires. A number of new theories components and applications will be presented by eminent authors during this Congress.

So far I did not touch the problem of employment, but I would like to make a few comments regarding this problem. Technological changes and the introduction of automatic control and automatic information processing has undoubtedly a marked influence on employment, on displacement of labour forces, of the ratio of white- to blue-collar workers and on education.

Any rise in productivity, defined as output per manhour of work used to produce this output has of course a direct influence on employment in the given industry or enterprise concerned. Let us face facts and state, that an increase of productivity of 2 % results in a doubling time of 36 years, an increase of 3 % results already in a doubling time of 24 years, which means, after the period, defined as doubling time, either on receives a double production rate per year with the same number of workers, or the same production with half the number of workers. Between 1915 and 1945 the average increase of productivity was about 2 %, whereas from 1945 until 1965 it was 3,2 % /including the growth of productivity in agriculture/.

Technological innovations need of course a certain time interval between the birth of a new idea and its commercial application.

This time interval fell from about 30 years before the First World War to sixteen years between 1918 and 1939 and on the average to nine years after 1945. The fact is, that technological advances eliminate jobs but not work. Economic policy has an obligation to match increased production with increased purchasing power and demand.

One of the consequences of increased productivity is the shortening of working hours, the other - increased salaries for those who work. As the world's population is still increasing, there will be an aboundance of labour force, thus we shall have to face to factors, namely longer years of education and an earlier age of retirement. There will still remain the problem of employing the unemployed.

Increasing employment will be demanded in such domains like transport, housing and above all in new branches of industry, especially those which produce the tools of automation. There is also a new branch of employment to be envisaged, that is Environmental Engineering. Modern technology has its side - effects, especially increased waste. As there are more and more newspapers, food-waste, perishable containers and envelopes, the garbage in some cities is reaching the rate of several kg/per person a day. Healthy drinking water is getting more and more scarce and more and more polluted by floods of liquid and toxic waste from industry. We have also to face the problem of thermal pollution due to the temperature rise in surface waters used for cooling purposes of both fossil-fueled and nuclear power plants.

Thermal pollution results in a decrease of dissolved oxygen in water, which influences the aquatic life of the water body, its waste assimilation capacity and the quality of water for municipal, industrial and recreational uses. Increased demand of fresh water will result in building conventional and nuclear desalination plants of ever increasing capacities.

Everyone of us is aware of the problem of air pollution due to carbon monoxide, carbon dioxide, the sulphur oxides, the oxides of nitrogen and hydrocarbons. The present concentration of carbon dioxide in air is 300 ppm. There is the problem of increased absorption of radiant heat from the earth which will be trapped by carbon dioxide in the atmosphere surrounding us, the doubling of this concentration in the atmosphere would cause a rise of several centigrades, which may have in the year 2000 severe meteorological effects.

Air pollution is particularly evident in large cities, and motorcars have to be equipped with devices lowering air contamination, to-day there exist already computers in cars for optimal control of the air to fuel ratio. In the future the liquid fuel motorcar will probably disappear from cities,

rendering its place to electric cars and automatic escalators and transport bands for pedestrians.
Garbage plants will be built in increasing numbers.
Increased spending for research and development has to be made for medical and health engineering.

One of the principal problems which shall face us in the coming years is the problem od education. Let us be frank about the labour problem and face facts: as years will go by, the unskilled labourer will be less and less needed.

Somebody said, that in 1975, anybody in industry should have an education at a level of a finished high school, in 1985 - at the level of to-day's B.Sc. and in the year 2000 - at the level of to-day's Ph. D. or D. Sc. There is however no doubt about it, that education will last longer, because the amount of information to be pumped into pupils will steadily increase, in addition the pupil has to learn early to think on his own and develop more brainpower. For those, who are still young to-day and will be alive in the year 2000, reeducation and constant self-studies are of primary importance. In addition managers - which means decision making people - have also steadily to learn and requalify.

Although there will be still many new technological advances, still more automatic control systems and still more computers, but there will be also some domains where automation will have a closed door. Man will have - thanks to technological progress and automation - more time for leisure, he will be healthier and live longer.

He may devote himself more than to-day to the human science, to literature and the fine-arts, to sport and recreation. Scientists will have more financial resources and more time to devote themselves to basic research and try to unveil new mysteries dwelling in the bosom of nature.

Let us believe in the human genius and the ability of man to create a better world free from want and poverty.

P.J.Nowacki

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