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FOREWORD

The ICTP Physics and Development Programme resulted from the recognition that the scientific, technical, economic and social progress of the developing nations are strongly interrelated and from the recognition that physical and mathematical sciences play an exceedingly important role in providing satisfactory solutions to problems of development in general.

Within the framework of this programme, renowned experts are usually invited to give lectures on science and technology, economics and planning, with particular reference to the needs of developing countries. The purpose is to improve the awareness of scientists visiting the Centre, of the current technical, economic and social aspects of development, thereby assisting them in better utilizing their talent in the development programme of their countries.

H.R. Dalafi

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PHYSICS AND THE EXCELLENCES OF THE LIFE IT BRINGS

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The title of my talk tonight is taken from Robert Oppenheimer. He had three types of excellences in mind. First, for the theoretician, the excellence of new ideas while he attempts to read Allah's design; for the experimenter, the excellence of new discoveries, of the pleasure of the search, of sheerly carrying an experimental technique to its limits and beyond; and finally, of the desire to spite the theorist. Oppenheimer had these excellences in mind - but also much more; he emphasised the opportunity Physics afforded to come to know internationally a class of great human

beings whom one respected not only for their intellectual eminence but also for their personal human qualities - a true reflection of their greatness in Physics. And, in addition, he had in mind the opportunities which Physics uniquely affords for involvement with mankind - in the parlance of today, in engaging in problems of development and of enhancing the human ideal.

Tonight I wish to speak on some aspects of Oppenheimer's thoughts from a personal point of view. I shall illustrate these by recalling my induction into research, on renormalization of meson theories, and the excellent men I was privileged to meet while pursuing it. I also wish to speak, as Max Dresden wanted me to, on excellence through world development. Max Dresden wanted me to speak on the International Centre for Theoretical Physics, whose creation, under the auspices of the United Nations, I was privileged to suggest in September 1960. The Centre came into being only in October 1964 - beyond the cut-off date of this Conference's coverage. However, the ideas that went into the Centre's creation and the political battles that had to be won, as well as the Physics milieu of the early sixties - with its desire to keep alive the internationalism of the subject, with its emphasis on Science rather than technology, and with its perception of brain drain of high level talent, particularly to the US - do fall within the period covered.

The notion of a Centre that should cater particularly to the needs of physicists from developing countries had lived with me from 1954, when I was forced to leave my own country because I realised that if I stayed there much longer, I would have to leave Physics, through sheer isolation. At the September 1960 Rochester Conference, in his banquet speech, Mr. John McCone, the then Chairman of the US Atomic Energy Commission, made a reference to the desirability of creating international centres in Physics. He had principally in mind accelerator establishments, which might be created under joint US/USSR/European auspices. After the banquet, over coffee, I remember a conversation with Hans Bethe, Robert Sachs and Nicholas Kemmer in the beautiful hall of the women's residence at Rochester University. We discussed

the practical possibility of such centres being created and came to the conclusion that the simplest would be to think in terms of an international theoretical centre.

The same month I had the privilege of being able to voice, on behalf of the Government of Pakistan, this visionary ideal, in the form of a resolution at the annual conference of the International Atomic Energy Agency (IAEA) at Vienna. We were fortunate to receive co-sponsorship of the resolution from the governments of Afghanistan, the Federal Republic of Germany, Iran, Iraq, Japan, Philippines, Portugal, Thailand, and Turkey. As the list of sponsors indicates, the setting up of such a centre was of interest not only to the less privileged countries but also to some of the developed ones. The hope was that a centre of this type, besides providing a venue for collaborative international research for the East and the West, might also help in resolving one of the most frustrating problems that active scientists in poorer countries face - the problem of isolation. Such men, supported by international funds, would come fairly frequently to the Centre to renew their contacts and engage in active research in their fields.

Right from the beginning we received enthusiastic support from the world physics community. Niels Bohr, before his death, expressed his wholehearted support; scientific panels, convened in 1961 and again in 1963 by the Agency's physicist Director General, Dr. Sigvard Eklund, forcefully recommended its creation. Members of the 1961 panel were Aage Bohr, Paolo Budinich, Bernard Feld, Leopold Infeld, Maurice Levy, Walter Thirring; of the 1963 "Three Wise Men Panel", the members were Robert Marshak, Leon Van Hove and Jayme Tiomno.

Unfortunately, there was not the same unanimous response from the atomic energy commissions around the world. At the 1962 annual conference of the IAEA (where these commissions represent their governments), even though the creation of a centre was accepted in principle after a divided vote - by and large the industrialised countries voted against, and the developing, for the Centre - the IAEA's Board of Governors voted the princely sum of $55.000 to

set up an International Centre for Theoretical Physics. The United Nations Educational and Scientific Organization (UNESCO) voted $27.000. Thus, additional offers of financial assistance from interested member states had to be solicited; of the five received (from the Government of Italy for a centre to be located in Trieste, from Austria for Vienna, from Denmark for Copenhagen, from Pakistan for Lahore, and from Turkey for Ankara), the most generous was the Italian Government's offer of around $300.000 plus a prestigious building, with Paolo Budinich, Professor of Physics at the University of Trieste, as the moving spirit behind it. This was accepted in June 1963 and the Centre started functioning on 1 October 1964, with a charter for four years. Oppenheimer served on the first Scientific Council of the Centre. In spite of his terminal illness, he came to Trieste, where he helped draft the Centre's Charter. One admired him and his felicity of phrase - even in such legal drafting. Other members of the first Scientific Council were: Aage Bohr, A. Matveyev, V.G. Soloviev, Sandoval Vallarta and Victor

Weisskopf. Dr. Alexander Sanielevici, from Romania, was one of the Scientific Secretaries.

Of the Centre and its functioning, I shall speak little tonight, for surely this will be one of the subjects covered by the future conferences in this series. In 1964, when we assembled in Trieste in a rented building, the whole enterprise seemed like a dream. Once again the world's theoretical community rallied around us - Plasma Physicists as well as Particle Physicists. We cared not for frills, only for Physics. Our goal was to acquire scientific visibility. In this we succeeded. Thus, one year after the Centre's inception, Oppenheimer could comment at the Centre's Council: "It seems to me that the Centre has been successful in these eight or nine months of operation in three important ways. It has cultivated and produced admirable theoretical physics, making it one of the great foci for the development of fundamental understanding of the nature of matter. The Centre has obviously encouraged, stimulated and helped talented visitors from

developing countries who, after rather long periods of silence, have begun to write and publish during their visit to the Centre in Trieste. This is true of physicists whom I know from Latin America, from the Middle East, from Eastern Europe and from Asia. It is doubtless true of others. The Centre has become a focus for the most fruitful and serious collaboration between experts from the United States and those from the Soviet Union on the fundamental problems of the instability of plasmas, and of means for controlling it. Without the Centre in Trieste, it seems to me doubtful that this collaboration would have been initiated or continued. In all the work at the Centre of which I know, very high standards prevail. In less than a year it has become one of the leading institutions in an important, difficult and fundamental field".

To continue the story briefly, in the twenty years of its existence, the Centre has flourished, with Physicists from 100 countries, East and West, North and South, ranging over all disciplines of Physics - from fundamental

Physics to Physics on the interface of technology, environment, energy, the living state and applicable mathematics. The Centre welcomes around 1.000 physicists from industrialised and 1.000 physicists from developing countries every year for research courses, workshops and meetings and for conducting research, for periods ranging from a few months to a few years. In addition, from a generous grant from the Italian Government, we provide 100 fellowships in experimental physics, tenable at Italian Laboratories. We are federated with approximately 100 institutes, mostly in developing countries. In addition, our Scientific Council selects 200 physicists (whom we call Associates of the Centre) - these men and women are accorded the privilege of coming to the Centre three times in six years for periods up to three months per visit, at times of their own choosing, provided they are living and working in developing countries. The Centre's current budget is of the order of 5 million dollars - three millions come from the Government of Italy, one from IAEA, half a million from UNESCO, and the rest from other Government Agencies. The US Department of Energy gives us a special grant of $50.000 for US physicists.

Although in the founding and running of the Centre we have depended on the volunteer help of the world's leading physicists, it remains a sad fact that the physics communities of the developed countries have, by and large, rendered little assistance in an organised form to the cause of physics in developing countries, including the Centre. I wish to stress the word organised, lest I should be failing to pay a heartfelt tribute to the continued work of great individuals - men like Robert Marshak - who have made real sacrifices in this cause.

There is no question but that the real amelioration of the worsening situation for Physics Research in developing countries lies within the countries themselves and the role of the Centre and any other outside agency can only be to help generate self-reliant communities. But outside help - particularly if it is organised help - can make a crucial difference. This could take various forms: for example, the physical societies could help by donating 200-300 copies of their journals to the deserving institutions and individuals and by waiving publication charges. The American Physical Society in fact does provide its publications at half cost to 31 physicists from 13 least developed countries. IUPAP has been helping the Centre defray postage costs for distribution of old runs of journals donated by generous individuals. These schemes should, however, be extended by other societies and laboratories also to cover equipment, and in fact CERN has recently signified its willingness to donate some of its used equipment to laboratories in developing countries. Most important, the research laboratories and the university departments in developed countries could finance visits of their staffs to the institutions in developing countries in an organised manner and reciprocally by creating schemes like the three month Associateship scheme we run at the Centre - at the least for their ex-alumni now working at the developing country Universities. Leon Lederman has initiated a scheme at Fermilab whereby a number of Latin American experimental physicists are regularly brought over to train them in techniques of particle physics and ancillary disciplines. And then there are the excellent cooperative schemes

of training like the one which T.D. Lee runs for China. These could perhaps be extended to other developing countries.

May I be forgiven for thinking in the following terms: that the physics institutions in developed countries may consider contributing in their own ways, according to the norms of the well-known United Nations formula, whereby most developed countries have pledged to spend 1% of their (GNP) resources for world development. In the end, it is a moral issue whether the better-off segments of the physics community are willing to look after their own deserving but deprived colleagues, helping them not only materially to remain good physicists, but also joining them in their battle to obtain recognition within their own communities, as valid professionals who are important to the development of both their countries and of the world.

So much for the excellences of a life of Physics for realising the ideals of development. Now, I would like to turn to the second aspect of Oppenheimer's thought; some of the excellent and humanly great physicists I came to know internationally in the early part of my research.

During the period covered by this Conference (1950-1964), it appears to me that there have been five major developments in Theory. First, the rise and the fall of Yukawa's standard model; of pions and nucleons. Connected with this was the rise (and the later fall) of the S-matrix theory. The second major development was the understanding of the role of flavour symmetries, in particular, of flavour SU(3). The third development concerned the emergence of chirality; the fourth, the Nambu-Goldstone spontaneous symmetry breaking phenomena; and the fifth the Yang-Mills-Shaw gauge theory and its application to electroweak unification.

I have told the story - at least of my humble part in it - in respect of the last three developments - the rise of chiral symmetry, of spontaneous symmetry breaking and of the electroweak unification - in the Stockholm Lecture of 1979 - including the story of interactions with Pauli, Peierls, Ward, Weinberg, Glashow and others. I shall not repeat this, except to say that I can take legitimate pride in that the Yang-Mills theory and the

flavour eightfold way were independently invented by two of my illustrious pupils within the ethos of my research groups at Cambridge and London.

For tonight, I shall concentrate mainly on the story of the short-lived rise of the pion-nucleon theory as the standard model of 1950-51, in consequence of the proof that this was the only theory which could be renormalized then. The people concerned with my story were P.A.M. Dirac, Nicholas Kemmer and Paul Matthews at Cambridge, besides Freeman, Dyson, who was visiting Birmingham, and John Ward at Oxford.

The immediate post-war generation - our generation - was brought up to believe implicitly in the Yukawa model of the nuclear forces. The only open question at that time concerned the spin of the meson and the precise form of the nucleon-meson interaction. After Yukawa, Nicholas Kemmer - at least outside Japan - had made the most crucial contributions towards defining this problem. In a classic paper written at Imperial College, London, in 1938, he had classified the Yukawa interactions according to meson spins and parities, and whether they were direct or derivative couplings. When I started research in October 1949, Kemmer was at Cambridge. Surprising though it may seem, I had started life as an experimental research student in the Cavendish, with a remit to scatter tritium against deuterium for Sam Devons, now Professor at Columbia. My finding myself as an experimenter was in accordance with the holy Cambridge tradition - handed down from Rutherford's days: those who fared well in the Physics Tripos became experimentalists; those who got third classes were consigned to theoretical research. Soon after starting, I knew the craft of experimental physics was beyond me - it was the sublime quality of patience particularly patience with the recalcitrant equipment of the Cavendish - which I sadly lacked. Reluctantly, I turned my papers in, and started instead on quantum field theory, with Nicholas Kemmer, in the exciting department of P.A.M. Dirac.

I said I started on theory research, but it was not that easy. Those were the great days of renormalization theory with the papers of Tomonaga, Schwinger, Feynman and Dyson providing feverish excitement. At Cambridge, Nicholas Kemmer was the only senior person interested in these developments. He had behind him not only the kudos of having tabulated all possible meson interactions, but also the reputation of being a prince among men - of generousness to a fault, to his students. So I went to Kemmer and requested him to accept me for research. He said he had eight research students already and could not take any more. He suggested I go to Birmingham to work with Peierls. But I could not bear to leave Cambridge - principally because of the beauty of the rose gardens at the Backs of my College - St. John's. (Incidentally, Dirac was at St. John's College also.) I asked Kemmer, "Would you mind if I worked with you peripherally for the time being?" He graciously assented. In my first interview with Kemmer, he said, "All theoretical problems in Quantum Electrodynamics have already been solved by Schwinger, Feynman and Dyson. Paul Matthews has applied their methods to renormalize meson theories. He is finishing his Ph.D. this year. Ask him if he has any problem left."

This was early 1950. So I went to Matthews and asked him what he was working on and if he had any crumbs left. The first piece of advice Matthews gave me was to forget the papers of Schwinger and Feynman and to concentrate on Dyson's two classic papers - particularly his most recent in 1949 where he had shown that quantum electrodynamics was renormalizable to all orders in α. He told me he had spent one and a half years already, trying to renormalize meson theories. He had found that only spin zero may work. He was writing up his one-loop calculations for his Ph.D. and had shown that the theory of spin zero mesons was indeed renormalizable up to the second order.

Matthews had at that time already tabulated which theories may possibly be renormalizable with the techniques then known. He had come to the conclusion that no derivative coupling meson theory could be renormalized at all, and

that among the direct coupling theories with nucleons, the only hopefuls were either spin-zero, or the neutral vector meson theories with conserved currents for nucleons. No charged vector theory (with massive mesons) could be renormalizable. He had also shown that the neutral vector meson theory with mass was a replica of electrodynamics and one could take over the work of Dyson more or less intact and show its renormalizability. Regarding the spin-zero theories, he had shown that one would, at the least, need an additional $\lambda \phi^4$ term where ϕ is the meson field. The corresponding term for electrodynamics ($e^4 A^4$) was gauge variant, as had been remarked on by Dyson - with John Ward actually proving that the corresponding infinity did not exist.

The ϕ^4 term for spin-zero mesons would however be a new fundamental interaction term with a new fundamental constant λ. A new fundamental constant appeared just too radical those days, and we agonised over this. But the real question was: could one be sure that even with this new interaction term, all the infinities could be asssimilated to a renormalization of the meson-nucleon coupling constant, the new constant λ, the masses of the mesons and the nucleons, plus a renormalization of their wave functions. Matthews had worked with one-loop diagrams and shown that renormalizability appeared possible. He could not go beyond one-loop because overlapping infinities started to come in for higher loops and one had to solve this basic problem, before progress could be made. This was the situation around March 1950.

Matthews had his Ph.D. viva shortly afterwards. His external examiner was Dyson who was visiting Birmingham at that time. Dyson used to spend a few months at Birmingham and the rest of year in the US. In the viva, Dyson had asked Matthews about overlapping loop infinities. Dyson had asked him, "Have you come across these infinities? And if so, how do you resolve the problems posed by these?" And Matthews had replied, "You have claimed in your paper on Quantum Electrodynamics (QED) that these infinities - which occur in the self-energy graphs - can be properly taken care of. I am simply following

you". No further question on these infinities was asked; both Dyson and Matthews kept silent after this brief exchange.

Now overlapping infinities had indeed appeared in QED where a general self-energy graph can be viewed as an insertion of a modified vertex at either end of the lowest order self-energy graph. Insertions of modified vertices at both ends would be tantamount to double-counting. But Dyson, in his paper, while discussing these, had recommended precisely this - that one should substract the vertex-part sub-infinities twice before subtracting the final overall self-energy infinity. Dyson must be right; but why? And what made life awkward was that whereas this troublesome overlap occurred only for self-energies in QED, for meson theories, the overlaps of the infinities were everywhere.

With characteristic generosity of which I became a life-long recipient, Matthews said to me, "My viva is over. After my degree, I'm going off, to take a few months holiday. And then I'll go to Princeton. You can have this problem of renormalizing meson theories till I get back to work in the Fall. And if you don't solve it by then, I'll take it back".

That was the sort of gentleman's agreement we parted on. So I had to get to the bottom of the overlapping infinity problem. I thought that the best thing for me would be to ask Dyson's direct help. So I rang him. I said: "I am a beginning research student; I would like to talk with you. I am trying to renormalize meson theories, and there is this problem of overlapping divergences which you have solved. Could you give me some time?" He said, "I am afraid I am leaving tomorrow for the US. If you wish to talk, you must come tonight to Birmingham". So I travelled from Cambridge to Birmingham that evening. Dalitz and his gracious wife put me up for the night.

Next morning, Dyson came to the Department - this was the first time I had met him. I said, "What is your solution to the overlapping infinity problem?" Dyson said, "But, I have no solution. I only made a conjecture". For a young student who had just started on research, this was a terrible shock. Dyson was our hero. His papers were classics. For him to say that he

had only made a conjecture made me feel that my support of certainty in the subject was slipping away. But he was being characteristically modest about his own work. He explained to me what the basis of his conjecture was. What he told me was enough to build on and show that he was absolutely right. I travelled with him to London that afternoon. He was due to catch his boat from Southampton later that day. I think it was during that train journey, in conversation with Dyson, that I appreciated for the first time how weak the weak forces really were.

At Cambridge, amid the summer roses at the Backs of the Colleges, I went back to the overlapping infinity problem, to keep the tryst with Matthew's date-line. Using a generalisation of Dyson's remarks, I was able to show that the spin-zero meson theories were indeed renormalizable to all orders. At that time transatlantic phone-calls for physics research had not been invented. So I had a vigorous correspondence with Dyson, with the fullest participation of Kemmer, my supervisor. Exciting days indeed!

The subtraction procedure that I designed worked in momentum space. A crucial element of the proof was to associate with a given graph a set of integration variables in momentum space such that for the entire graph or for any of the sub-graphs contained in it, every possible infinity could be associated - on a one to one basis - with a single sub-integration. Assuming that this was possible, the substraction procedure left behind an absolutely convergent remainder - absolutely convergent in the mathematical sense. To prove this one to one relationship, one had to consider the topology of the graphs. I could show, with Res Jost's help, that this result certainly holds for the so-called renormalizable theories. I have always felt very proud of this particular part of the proof (Phys. Rev., 84, 426 (1951)), but to my knowledge, the paper embodying this has never been referred to by anybody ever. I can only assume that the result has been taken on trust and that no one has ever re-checked it.

Contemporaneous with mine was the work of John Ward at Oxford, who devised

a most ingenious scheme of regularization. This depended on differentiation with respect to external momenta and this was the technique used later by Gell-Mann and Low in their beautiful work on the renormalization group. Later still, other regularization schemes were devised in X-space, notably by Hepp, Speer, Bogoliubov and Parasiuk. My procedure, however, was a straightforward subtraction in momentum space; the use of the technique I had devised would make the final integrals absolutely convergent. And it would also permit a count of the wave function renormalization (Z) factors correctly in all conceivable situations. (P.T. Matthews and Abdus Salam, Phys. Rev. 94, 185 (1954)). Matthews and I wrote a brief review of these developments for The Reviews of Modern Physics of October 1951 in which we stated the following criterion for acceptability of a proof in this subject: "The difficulty ... is to find a notation which is both concise and intelligible to at least two people, of whom one may be the author". We left it unsaid that "the other person may be the co-author".

I can here tell a story about this work being considered deep and believed in, but seldom read. I was invited to the Institute for Advanced Study at Princeton in January 1951. I had by then applied my technique to renormalize spin-zero electrodynamics. I took a manuscript copy of the new paper to Robert Oppenheimer to read and, if he approved, to send to the Physical Review. I then realised that I had given him a copy with no diagrams in it. So I went to his office to retrieve the manuscript. I had to wait for some while because he had visitors, but then he came out of his inner office, saw me and said, "I enjoyed reading your paper. It is a fine paper". I should have kept quiet but like a fool, I said, "I am sorry, I gave you a copy in which there were no diagrams. I don't think you could have understood it". Oppenheimer visibly changed colour. But he only said, "The results are surely true and also intelligible even without diagrams".

This proof of the renormalizability of spin-zero meson-nucleon direct-coupling theory had come at an opportune time. With the discovery by Cecil

Powell of the pion and the subsequent determination of its spin as zero, theory and experiment seemed to converge to a definitive standard model of nucleons and pseudo-scalar pions, with a direct Yukawa plus the Matthews interaction. Our elation, however, was short-lived. The Yukawa coupling which nature seemed to favour was not the direct renormalizable pseudo-scalar coupling but the unrenormalizable pseudo-vector coupling. The two couplings were, of course, equivalent in the lowest order - but with the large coupling parameter $g^2/4\pi \approx 14$ - was order by order perturbation of any practical significance?

Then came the discovery of the Δ (3/2, 3/2) resonance, plus the discovery of the form factor for the nucleon by Hofstatder. These coups de grace finally killed the model. Influential in our thinking was also the paper of Fermi and Yang, which questioned heretically whether the pion was a fundamental entity or merely a nucleon - anti-nucleon composite.

For me personally, the disenchantment with the pion-nucleon theory had started much earlier. One of the post-war texts on Nuclear Physics was L. Rosenfeld's, which I believe he wrote in a war-cellar during 1944-45 in Belgium. This was a 600-page book which then cost £6 - the equivalent of something like $80 today. As a research student, I had invested in the book, with great reluctance; it had burnt a hole in my meagre pocket. The book consisted of the theory of the deuteron, a complete analysis of meson-theoretic nuclear forces, with Moller-Rosenfeld mixtures and the like; and a description of pion-nucleon scattering phase-shifts analyses below 1 Mev. Then Hans Bethe came to lecture at the Cavendish; during this lecture he made the categorical statement that all known deuteron parameters as well as any phase shift analyses below 1 Mev, could determine no more than two parameters of the nuclear potential; the scattering length and the effective range. While listening to the lecture I kept thinking, "Surely this result Bethe has announced makes a book like that of Rosenfeld irrelevant?" The

thought crossed my mind that just after the lecture finishes, everyone who has acquired a copy of the book will be trying to dispose of it. So, immediately after Bethe finished, I rushed to my lodgings at St. John's College, retrieved my copy and made a sprint to the Heffers Bookshop from which I had purchased the book. The sharks at Heffers offered me £3 to buy the book back even though it was in a mint condition. I accepted, but of course now I feel very sorry that I sold it, because the book contained marvellous tables on harmonic functions.

I started my remarks with Dirac, who did not believe in the renormalization ideas which we were pursuing in 1950-51. He listened to us, but always maintained the hope for a finite theory. He has now recently been proved right by the rise of supersymmetry theories, some of which are completely finite - among them the N=2 and N=4 supersymmetry theories. In three decisive years, 1925, 1926 and 1927, with three papers, Dirac laid, firstly, the foundations of quantum physics as we know it; secondly, he laid the foundation of quantum theory of fields; and thirdly, that of the theory of elementary particles, with his famous equation of the electron. No man except Einstein has had such a decisive influence in such a short time on the course of physics in this century. But additionally for me, Dirac, whom I later came to know better, at the Trieste Centre, represented the highest reaches of personal integrity of any human being I have ever met. Knowing him has been one of the excellences of my life of Physics.

I will conclude with a story of Dirac and Feynman that perhaps will convey to you, in Feynman's words, what we all thought of Dirac. I was a witness of it at the 1961 Solvay Conference. Those of you who have attended the old Solvay Conferences will know that at least then, one sat at long tables that were arranged as if one was sitting to pray. Like a Quaker gathering, there was no fixed Agenda; the expectation - seldom belied - was that some one would be moved to start off the discussion spontaneously.

At the 1961 Conference, I was sitting at one of these long tables next to Dirac, waiting for the session to start, when Feynman came and sat down

opposite. Feynman extended his hand towards Dirac and said: "I am Feynman". It was clear from his tone that it was the first time they were meeting. Dirac extended his hand and said: "I am Dirac." There was silence, which from Feynman was rather remarkable. Then Feynman, like a schoolboy in the presence of a Master, said to Dirac: "It must have felt good to have invented that equation". And Dirac said: "But that was a long time ago." Silence again. To break this, Dirac asked Feynman, "What are you yourself working on?" Feynman said: "Meson theories" and Dirac said: "Are you trying to invent a similar equation?" Feynman said: "That would be very difficult". And Dirac, in an anxious voice, said: "But one must try." At that point the conversation finished because the meeting had started.

SYNERGETICS - FROM PHYSICS TO BIOLOGY

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1. The developing world of physics

This heading is not meant in a political sense but in the following one:

Let us consider what one might call the industrialized world of physics. It deals with high energy or high power physics. Here we are thinking of the huge machines to create new elementary particles or the powerful stellarators, tokomaks a.s.o. to generate plasmas at very high temperatures in order to eventually produce fusion.

It is a fascinating world but in order to do experiments enormous sums of money are required.
To this world there belongs also the world of astrophysics with its telescopes, its rockets and satellites.
But then there is the world of our dimensions, so small as the dimensions of molecules. It is here where the greatest mystery of nature is buried, namely the mystery of life.

Here, in general, only modest amounts of money are required, but the complexity of the problems represents a fascinating challenge to the human mind. In particular I believe, that physicists with their experience in statistical physics, many body theory a.s.o. can make fundamental contribution to this "developing world".

In my talk I shall be slightly concerned with the question:

What can physics contribute to the understanding of life?
Indeed all living beings are composed of atoms and molecules which quite clearly obey the laws of physics. Therefore it has always been quite a legitimate question for a biologist to ask a physicist whether he can explain, at least in principle, the formation of ordered structures and eventually the structures of life.

The discipline of physics which is quite generally concerned with order and disorder is thermodynamics including irreversible thermodynamics. But it is interesting to note that this simple question has embarrassed physicists for quite a long time. Indeed, there are experiments in physics belonging to our daily experience which seem to contradict the formation of structures. We know that in closed systems the second law of thermodynamics holds according to which entropy increases which implies that disorder increases, or in other words that in such a system structures disappear.

Boltzmann, the founder of statistical mechanics, was entirely aware of this difficulty but his statistical mechanics allowed him to make an interesting suggestion, he said: "Life is a giant fluctuation" which is indeed still possible in statistical mechanics and does not violate fundamental laws of physics. But there are two objections. First of all such a giant fluctuation is extremely improbable and in fact we must admit that its probability is practically vanishing.

And there is a second point. If life is just a giant fluctuation, why does complexity, at least in general, increase? In fact we find in evolution that we have an ever increasing complexity and there is no reason to expect such a behavior if life is just a giant fluctuation.
Now, if closed systems do not provide us with an explanation of increasing structures, at least in principle, we may ask what happens in

open systems? A typical open system is one into which energy is pumped from an energy source and eventually energy is given away into an energy sink.

A typical example for such a system is provided by the earth which receives a flux of energy from the sun and which, especially during the night, dissipates energy into the very cold universe. Such a system is kept far from thermal equilibrium. But then we have a number of questions immediately arising. Can one define entropy for an open system? This is actually a question which is at least open if not to say that it is still under dispute. Secondly, thermodynamics does not offer us any principle or mechanism of how order arises.

In statistical physics we may define an entropy function. This allows us to immediately check some statements made by people who based their work mainly on thermodynamics. For instance they tell us that the entropy decreases when a system far from thermal equilibium goes from a disordered state into an ordered one. But actually more recently I could show in detail that such a statement is wrong, the entropy may even increase.

Quite evidently new principles are needed which explain to us, why order can be created in systems far from thermal equilibrium.
But these new principles must not be in contradiction to thermodynamics, rather they must be added to it. So in a way the situation is reminiscent of Euclidean geometry. Euclid tried to derive the existence of parallels from his axioms, but nowadays we know that a new axiom - the parallel axiom - was actually needed to establish this fact.
I was very lucky that I came across a physical system more than 25 years ago which allowed me to find such principles. The system I am referring to is the laser.

2. The laser paradigm

I briefly remind the reader of such a system. On the one hand a laser is composed of a cavity, this means that two mirrors are mounted on the end faces of the laser device (compare fig. 1). In such an arrangement standing axial waves can develop. On the other hand the laser-active material is assumed to be composed of atoms which we distinguish by an index μ and we assume that each atom has a dipole moment p_μ.

Let us consider the electic field strength of a standing wave

$$E(x,t) = A(t) \sin kx. \quad (1)$$

We decompose the amplitude A(t) into a rapidly varying part $\exp[-i\omega t]$ multiplied by a slowly varying amplitude E(t) and, of course, we have to add the conjugate complex. The frequency ω occurring in

$$A(t) = E(t)e^{-i\omega t} + E^*(t)e^{i\omega t} \quad (2)$$

is just the optical transition frequency of the atom which supports the laser action. Here and in the following we shall actually assume that there is a perfect resonance between the field mode with frequency ω and the optical transition frequency of the individual atoms.

In analogy to the decomposition of A(t), we decompose the dipole moment $\hat{p}_\mu(t)$ according to the formula

$$\hat{p}_\mu(t) = p_\mu(t)e^{-i\omega t} + p_\mu^*(t)e^{i\omega t}. \quad (3)$$

I don't want to repeat the derivation of the basic laser equations here, rather I should like to write down their form in order to be able to draw some important conclusions. The slowly varying field amplitude E(t) changes in time due to various causes.

$$\dot{E}(t) = -\kappa E + g \sum_{\mu} p_{\mu} + F(t). \tag{4}$$

First of all the light field may escape through the mirrors which lead to a damping $-\kappa E$.
On the other hand the field mode is driven by the oscillating atomic dipole moments which in the approximation used here is described by the sum occurring in equation (4), where g is the coupling constant between E and p_{μ}.
Finally the function F represents a fluctuating force. As we all know, whenever there is dissipation in a physical system there are also fluctuations. Therefore, for instance, the electrons in the mirrors which cause a damping of the field strength, at the same time cause fluctuations acting on the field strength E.
The field reacts on the atomic dipole moments so that we have to consider equations for them. According to quantum theory one can show that the dipole moment of the atom μ changes in time due to various causes.

$$\dot{p}_{\mu} = -\gamma p_{\mu} + gEd_{\mu} + F_{\mu}(t). \tag{5}$$

First of all because of the interaction of the atom with its surroundings including the effects of radiative transitions into all possible modes, the dipole moment will be damped by means of a term $-\gamma p_{\mu}$.
On the other hand the field drives a dipole moment which is described by the second term on the right hand side of this equation. Here a new dynamical variable occurs namely d_{μ}. This is a consequence of quantum

mechanics which in our case applies to a system of atoms each having two levels only. Now quite clearly, energy may flow from the atom into the field if the atom is in its upper state. On the other hand the atom will absorb energy from the field if it is in its lower state.
Therefore there is a specific sign of the energy flow and this sign is determined by the difference of the occupation numbers of the upper level and the lower level. This difference is called the inversion which is given by

$$d_{\mu} = N_{2,\mu} - N_{1,\mu}. \tag{6}$$

Now because of the processes going on in the laser, the inversion also changes as a function of time as described by the following equation:

$$\dot{d}_{\mu} = (d_0 - d_{\mu})\gamma_{\parallel} - g(E^* p_{\mu} + Ep_{\mu}^*) + f_{\mu}(t). \tag{7}$$

Here the first bracket describes a relaxation process which is caused by the pump introduced into the atomic system from the outside and simultaneously by nonradiative transitions or radiative transitions into modes which do not lead to laser action.
Thus the first term describes a relaxation of the atomic inversion d_{μ} towards a prescribed inversion d_0. On the other hand the atom interacts with the field and exchanges energy with it. This is described by the term in the second bracket of this equation. The last term then still describes fluctuations which are connected with the pump processes.

This set of equations, which we have just written down, is a rather complicated one. First of all it has very many variables, for instance in a typical laser we may have 10^{18} degrees of freedom.
Furthermore these equations are nonlinear as is shown by the term Ed_{μ} or by the terms in the second bracket in the last equation.

Fortunately enough it has turned out to be possible to reduce this complicated system quite considerably. Namely in most lasers the inequality $\gamma \gg \gamma_{\parallel} \gg \kappa$ holds. That means the damping constant of the dipole moments is much bigger than the damping constant of the inversion which in turn is much bigger than the damping constant of the field in the cavity.

Now consider the first equation (4). Its first term on the r.h.s.tells us that the field decays at a rather slow rate, namely described by the damping constant κ. On the other hand in the second equation, (5), the field E acts as a driving force. When we are close to a steady state, the p_μ will behave similarly as E. That means, on the left hand side of equation (5) we practically obtain a term κp_μ which, of course, is much smaller than γp_μ. But the resulting inequality $|\dot{p}_\mu| \ll |\gamma p_\mu|$ implies that practically we may put $\dot{p}_\mu$ equal to zero. But when doing so, we may immediately solve equation (5) with respect to p_μ and we immediately obtain the result

$$p_\mu = \frac{1}{\gamma} E d_\mu + \frac{1}{\gamma} F_\mu(t). \tag{8}$$

This result tells us that the dipole moment p_μ is immediately determined by the field strengh E. This is in fact the slaving principle in its simplest form. Quite generally the slaving principle, at least in the present context, tells us the following: Quickly relaxing variables, namely p_μ, are slaved by slowly relaxing variables, namely E.

Similar statements hold for d_μ but it is immediately seen that by these slaving principles p_μ and d_μ can be directly expressed by E. In other words they can be eliminated from the equations (4), (5), (7). Therefore we can find an equation for E alone which has the following form at least for values of E which are not too big.

$$\dot{E} = (G-\kappa)\, E - C\, E|E|^2 + F_{tot}(t). \tag{9}$$

Here the constant G is called the gain constant and is proportional to d_0 that means to the inversion described by pumping and relaxation processes. Equation (9) is not quite trivial because on the one hand it is nonlinear and on the other hand it contains a fluctuating force, i.e. it is a nonlinear stochastic equation.

When we resort to mechanics however, we can easily interpret the meaning of this equation. Let us identify E with a particle coordinate q and let us add an acceleration term mq to the equation for E. Then we may write this equation in the form

$$m\ddot{q} + \dot{q} = -\frac{\partial V}{\partial q} + F_{tot}(t) \tag{10}$$

where V is a potential function which can be easily constructed to the driving force on the right hand side of equation (10).
In order to discuss the behavior of E, let us first assume that the gain G is smaller than the loss κ. Then the potential V can be represented by fig. 2.
The effect of the fluctuating force can be represented by individual random pushes which are exerted on the individual particle. After each push it will relax towards the equilibrium position. When we plot the field strength E versus time, we will find the envelope of the curve shown in fig. 3.

In order to find the field strength, we have to multiply E with $\exp[-i\omega t]$ and then to take the real part. This is then indicated in fig. 3 by the oscillatory curve.
Let us now assume that we increase the gain constant G so that the potential curve becomes flatter (fig. 4). Quite evidently the

particle will fall down the potential hill at the lower speed which means that the wave tracks shown in fig. 5 now decrease more slowly than those of fig. 3.

As we know from optics, the decay constant is responsible for the line width $\Delta\nu$. Because the decay constant becomes smaller, the decay actually occurs more slowly, the line width will decrease. So we find a decrease according to the formula

$$\Delta\nu = \frac{const}{P} \tag{11}$$

where P is the output power of the laser. In this way we have recovered the famous Townes formula.

But let us now consider what happens if the gain G becomes bigger than the loss κ. Under this condition the potential function V acquires a form as shown in fig. 6. Here apparently a new stable state has arisen which is connected with a stable amplitude of the field E. When we again multiply E with the function $\exp[-i\omega t]$ and take the real part, we obtain the solid line of fig. 7.

So we are immediately led to the idea that we have here a field with a stabilized amplitude. That means we expect a very pronounced coherence. Such a field has also a new kind of photon statistics. Because of the fluctuating forces there will be a small amplitude phase fluctuations.
It is rather straightforward to calculate the intensity fluctuations which stem from the amplitude fluctuations. If we divide the intensity fluctuations by the average output intensity and plot this ratio versus the gain, fig. 8 results.

In addition one may calculate the line width which now turns out to

be given by the formula

$$\Delta\nu = \frac{const}{2P} . \tag{12}$$

When I derived the result shown in figures 7 and 8,
I found myself in opposition to all previously published papers and therefore I asked some of the experts, whether such a behaviour may happen. And they told me: No, this cannot be the case because the laser will approach a potential curve as shown in fig. 4. The only fact happening is that this potential curve becomes flatter and flatter which is connected to a higher and higher output of the laser and the line width becoming narrower and narrower. But I was so much convinced of the correctness of my idea that I published my results and fortunately enough two American physicists, Armstrong and Smith, became interested in my results and did experiments on semiconductor lasers measuring the intensity fluctuations. Their measurements entirely confirmed my predictions.

From this time on, I have learned that one must not trust experts. Rather one really has to convince oneself whether concepts or theories are right or wrong. Why did I tell you this old story about the laser? Now, the reason is that it will guide us into all sorts of problems of self-organization. But first let me consider the relations to other concepts.

3. Relations to other concepts

When we plot figures 3 and 6 within one, we obtain fig. 9 where the curve with one minimum refers to a region below threshold and the curve with the two minima to the region above threshold, $G>\kappa$. Actually I should mention that in reality fig. 9 is somewhat more complicated because we have not only two minima but some sort of a circular valley which we obtain by rotating the whole curve around the V-axes. But let us consider the more simplified case with two minima only.

Quite evidently the right hand position is equivalent to the left hand position of the minima. Clearly when we change from the curve with $G-\kappa<0$ to $G-\kappa>0$ the position at $q = 0$ becomes unstable, but at the same time the system must break the symmetry between the by now possible left and right hand positions of the newly generated minima. Such a phenomenon is therefore called "symmetry breaking instability". Furthermore, as we have seen before, when we increase the gain below threshold the particle relaxes more slowly, a phenomenon called critical slowing down or equivalently one says that a soft mode occurs.

Finally we may observe that with a flatter curve the restoring force becomes smaller and in this way the fluctuations become bigger. These are the socalled critical fluctuations close to threshold. All these phenomena are strongly reminiscent of phenomena of systems close to phase transition points, but in such a case, the phase transitions occur in sytems in thermal equilibrium.
Here on the other hand we have a system, namely the laser, which is driven far from thermal equilibrium. Therefore the transition we found in it can be called a non-equilibrium phase transition and this detailed analogy was demonstrated by Graham and myself in 1968.

Actually this analogy between phase transitions of systems in thermal equilibrium and far away from equilibrium can be made quite rigorous. For instance, one may derive the distribution function $f(q)$ which has the form

$$f(q) = N \exp[-V(q)/Q]. \qquad (13)$$

In this form V corresponds to a free energy but only in a formal sense. In this way one may establish a formal analogy with the Landau theory of phase transitions where q or equivalently E plays the role of an order parameter. It must be stressed, however, that there is a basic difference between systems in thermal equilibrium and away from equilibrium. While the expression (13) is an exact one for the system here far from equilibrium, we know that the Landau theory is not sufficient for systems in thermal equilibrium where rather the Wilson approach is required.

Another relation may be established when we plot the equilibrium position q_0 versus the gain parameter G or equivalently versus $G-\kappa$ as shown in fig. 10.

Quite clearly when $G-\kappa<0$, only one equilibrium position $q_0=0$ exists. On the other hand beyond the critical point $G = \kappa$, the curve splits into two branches which have the shape of a fork. Therefore this phenomenon is called a bifurcation in mathematics and there is a whole literature on bifurcation theory available nowadays. But from a physicist's point of view one must stress that the concept of a non-equilibrium phase transition including its mathematical treatment is far more general than the concept of bifurcation. For instance in non-equilibrium phase transitions, we consider also the neighbourhood of the newly developing stable states and in particular we take into account the fluctuations which play a decisive role close to instability points.

Further contact can be made to problems in biology. Namely what is most striking here is the pronounced coordination of the individual parts of a system for instance of muscles and neurons in animals. So let us again consider the laser under this aspect.

Consider first the case in which the order parameter E is small. From formula (8) we may deduce that in such a case the fluctuations will dominate and we will have a situation as shown in fig. 11.

Here the dipole moments point into random directions and we observe microscopic disorder. Now let us consider the case in which E is comparatively large. In such a case all the dipole moments will point in a specific direction (fig.12). On these now ordered states small fluctuations described by the second term in equation (8) will be superimposed.

But at any rate we realize that when E increases, microscopic chaos of fig. 11 will be replaced by microscopic order (fig.12). But this microscopic order becomes also manifest on macroscopic scales. Here we have a typical example of self-ordering. The order is not imposed on the system from the outside but rather generated by the system itself. Therefore we have here a typical example of self-organization. At the same time we observe an enormous reduction of the degrees of freedom. For instance a typical laser has 10^{18} atoms and one light mode, but as we have seen here due to the occurrence of macroscopic order, the whole system is governed by the single order parameter E, that means by a single degree of freedom.

Finally, contact can be made with information theory. Just consider fig. 13. Here apparently the system can stay in the state 0 or 1. In other words our self-organized system possesses 2 holding states or in other words, it can store one bit of information. As we shall see at another place, we may now establish some kind of information theory which is based on self-organizing systems.

Before I come to the central topic of my paper, namely the definition of synergetics, let me again add another point concerned with lasers.

As we know in a laser not only a single mode may exist but we may have several modes as indicated in fig. 14.
Now let us consider another arrangement namely as shown in fig. 15 where instead of the standing waves of fig. 14, we have running waves and one may construct the device in such a way that the waves are all running in one direction. As we know from quantum mechanics, the individual waves are occupied by specific numbers of photons. So wave with mode number 1 may be occupied with n_1 photons, mode number 2 with n_2 photons, and so on.

Many years ago we studied what happens in a ring laser when we give all the modes initially the same chance, i.e. if we occupy them initially each with the same number of photons. Then what is happening is shown in fig. 16. First the individual mode numbers are multiplying, but their multiplication rate is different depending on the distance of the photon frequencies from the center of the emission line.

Thus, first we find what is called a segregation, one kind of photon is multiplying more rapidly than others. But when time elapses, eventually only one kind of photon namely the one which was multiplying fastest, survives and all the others dye out
Therefore we observe here a situation which is strongly reminiscent of Darwinism in the animate world and I have drawn this analogy nearly 20 years ago.

To come to the decisive step, let me briefly summarize what we have seen so far:
First of all we have seen that there are non-equilibrium phase transitions in lasers which are strongly reminiscent of phase transitions in systems in thermal equilibrium. Phase transitions in thermal equilibrium are a widespread phenomenon. Therefore the question

arises whether the non-equilibrium phase transitions are not also a widespread phenomenon and the laser is just a specific example!

Second we have just seen that there is a Darwinism of laser photons. On the other hand Darwinism of the animate world is quite a general principle of its evolution. Therefore the question arises, whether Darwinism is not also quite a general principle in the inanimate world. When we put these questions together, we are lead to the general question, whether there are general principles in the inanimate and animate world close to phase transition points, that means to points where new structures are formed.

4. Synergetics

This brings me directly to the definition of the new interdisciplinary field which I called synergetics. The word is taken from Greek and means: "science of cooperation". I introduced this term in 1969 during a lecture given at the University of Stuttgart. As we all know, most objects of our study in science and the humanities can be decomposed into individual parts, or subsystems, or elements. But through the cooperation of these subsystems, a total action on a macroscopic level is produced or macroscopic structures are generated.

The question I then posed is: Are there general principles which govern this generation of macroscopic spatial, temporal, or functional structures, irrespective of the nature of the subsystems?

This question, at first sight, seems to be crazy because the subsystems may be as diverse as atoms, or molecules, or photons, or cells, or organs, or even groups of humans. But in a way I have been lucky because I could find some general principles, provided we focus our attention on those situations where the system changes its properties

qualitatively. But now what are qualitative changes on macroscopic scales?

To this end I have first to explain what I understand by qualitative changes and secondly I have to give you examples at least, what we mean by macroscopic scales. First I present a counter example against a qualitative change. To this end let us consider fig. 17, where two kinds of fish are shown, namely a porcupine fish and a sunfish. The famous Scottish biologist D'Arcy-Wentworth-Thompson drew one of these fishes on a grid, i.e. a coordinate system and then deformed that grid like a rubber sheet. Then he could show that one obtains the sunfish by a mere deformation. A mathematician calls such a transformation structurally stable. That means an eye is transformed into another eye, a fin into a fin and so on, where all the relative positions are maintained. Biology provides us also with numerous examples of transitions which are not structurally stable but which give rise to qualitative changes. Fig. 18 shows the developmental stages of a california newt. Here the fertilized egg starts to develop incensions due to cell division and so on until the whole animal develops its extremities.
Quite clearly each state differs from the foregoing one by a qualitative macroscopic change. In synergetics we shall be concerned with such qualitativ changes. Now let us explain what we understand by macroscopic scales.

When we look at the sky we occasionally observe cloud streets. Here the molecules of the water vapour organize themselves into streets which have dimensions of many hundreds of meters if not kilometers. A similar phenomena can be generated in the laboratory. A famous example is provided by the Benard instability where a fluid layer is heated from below and develops a specific pattern, for instance in the form of honeycomb cells, if the temperature difference between the lower and the upper surface is big enough. Other examples are provided by chemistry where we may find chemical oscillations, or spiral waves, or concentric waves of dimensions of several millimeters to centimeters. Further examples are provided by flames produced by plane burners.

Let us now briefly discuss the general case, though it will be certainly far beyond the scope of this presentation to give you mathematical details. The general case refers to a variety of fields, namely physics, chemistry, biology and many other fields including specific aspects of economy and sociology.

In our quantitative treatment we start with evolution equations for a statevector $\underline{q}$. Such a statevector $\underline{q}$ may comprise in the case of the laser the electric field strength, the atomic polarization, the atomic inversion, or in the case of a liquid it may comprise the density of the liquid, its velocity field, and its temperature field.

Evolution equations are of the general form.

$$\dot{\underline{q}} = \underline{N}(\underline{q},\alpha) + \underline{F}(t) \qquad (14)$$

where $\underline{N}$ is a nonlinear function of $\underline{q}$ which may still depend on control parameters, α, which control the system from the outside, for instance by temperature, a flux of energy into the system and so on.

$\underline{F}(t)$ represents fluctuations which are either internal in the system or external. There are still more complicated formulations possible, for instance where the fluctuations depend on the state vector $\underline{q}$ itself.

The idea now is that we start from a given control parameter, or a set of control parameters, and assume that for such a set of parameters the solution of a specific solution of (14) is known. Now we change the control parameter and study whether the system still remains stable. For instance, when we heat the liquid only weakly it will remain at rest. When we increase the temperature at the lower surface we shall

find an instability which eventually gives rise to the formation of rolls or hexagons. Linear stability analysis is a standard procedure but it allows us to derive the collective modes which may be growing or decaying.

For instance a specific kind of rolls may grow in amplitude, whereas other kinds of modes may decay even if they have been generated by a spontaneous fluctuation or artificially. Those collective modes which have a growing amplitude are called order parameters and allow us to describe the order of a system. In general there are few order parameters. All other modes, namely the decaying modes, can be expressed by means of the slaving principle by the order parameters.

This allows us to reduce the total number of degrees of freedom of the system appreciably.

Therefore we may establish order parameter equations which have a rather simple structure, in particular because they are close to instability points the order parameters are small and there are symmetries available. This allows us to cast the order parameter equations into universality classes which explains the fact that for instance a single mode laser, a roll pattern in a liquid and a certain chemical oscillation behave in quite the same way, though they belong to quite different physical or chemical phenomena.

The formalism then allows us to calculate the formation of spatial, temporal, or functional structures. When we increase the control parameter more and more, the system may run through an instability hierarchy, and quite often after a few steps we arrive at states which may be called deterministic chaos. The whole formalism has been applied by us to a great number of different systems and the next few figures show just a few examples of its application to physics and chemistry. In section 6 we shall discuss one of its applications to biology.

5. Some examples from physics and chemistry

Fig. 19 shows the calculated evolution of an initially random velocity field of a fluid heated from below in a regular hexagonal pattern.
Fig. 20 shows the temperature field of a liquid layer (atmosphere) on a sphere, heated at the sphere and cooled from the outside, and subject to a rotation symmetric gravitational field. Here a static pattern evolves.
Fig. 21 same as fig. 20, but here a rotationary temperature wave evolves.
Fig. 22 same as fig. 20, but here a chaotic temperature field evolves.
Fig. 23 finally shows the calculated patterns of flame fronts on plane burners.

6. Modelling of Complex Systems by means of the Order Parameter and Slaving Concepts: An Example from Biology

When we observe the motion of humans or animals, we are struck by their precise movement which is based on an extremely high coordination between the activities of neurons and muscles.

One may speculate that this high coordination is produced by specific programs, socalled motorprograms, of the neuronal net. More recent experiments and their interpretation by means of synergetics indicate rather different mechanisms, however. To this end let us consider a rather simple, though still quite surprising, experiment which was done by Kelso.
He asked test persons to move their fingers in parallel and then he asked them to move their fingers more quickly (fig.24). Surprisingly it turned out that when the frequency of the finger oscillation was increased a sudden involuntary change of the mode of motion occurred.

Namely, instead of a motion in the form as shown in figure 24, a new symmetric motion occurred (fig.25). Let us try to model this abrupt change of behavior. To this end we write the elongations of the finger tips in the form

$$x_1 = r_1 \cos(\omega t + \phi_1) \qquad (15)$$

$$x_2 = r_2 \cos(\omega t + \phi_2) \qquad (16)$$

where ω is the basic frequency of the hand movement, while the amplitudes r_1, r_2 and the phases ϕ_1, ϕ_2 are time dependent quantities, whose time dependence is assumed to be much slower than that defined by the frequency ω.

We define the relative phase by

$$\phi = \phi_2 - \phi_1 \qquad (17)$$

In order to describe the change of phase we adopt our basic ideas introduced above. We may expect that the order parameter equation is of the form

$$\dot{\phi} = - \frac{\partial V}{\partial \phi} \qquad (18)$$

where V is a potential function in some analogy to that introduced above. In search for a model we make a few rather obvious assumptions about V. Since ϕ occurs under cosine or sine functions, the properties of a physical system must not change when ϕ is replaced by $\phi + 2\pi$. Consequently, we shall postulate that the potential V is periodic:

$$V(\phi+2\pi) = V(\phi). \qquad (19)$$

Furthermore we introduce the assumption that both hands play a symmetric role. In such a case the behavior of the system must not depend on the way we label the right hand and the left hand. This means, that V must remain unchanged when we exchange the indices 1 and 2 of the two fingers. This in turn means that the potential V is symmetric:

$$V(\phi) = V(-\phi). \qquad (20)$$

We assume that V obeys the conditions (19) and (20) in the simplest possible form which explains the above mentioned experimental results. To this end we write V as a superposition of two cosine functions:

$$V = - a \cos \phi - b \cos 2\phi. \qquad (21)$$

As we have seen above the behavior of the system obeying equation (18) can be easily described by identifying ϕ with the coordinate of a particle which moves in an overdamped fashion in the potential V. This potential V is represented in figure 26 for various values of the ratio b/a where we assume that b/a decreases with increasing frequency. Quite evidently at a critical value ω_c the ball makes a transition from the state $\phi = \pi$ to $\phi = 0$, or equivalently we may say that the antisymmetric hand movement makes a transition to the symmetric hand movement.

On the other hand, when we decrease ω starting from high values, the system all the time remains in the $\phi = 0$ state, even if ω drops below ω_c. This "hysteresis" phenomenon which easily follows from our simple model, is also found in the real experiments.

This model has been refined in our original paper to treat the oscillatory motion of the hands explicitly. However, in the context of our lectures we still wish to dwell on the analogy with the phase transition in particular with respect to the phenomenon of critical fluctuations which we have mentioned above.

Looking at our model and having in mind the typical critical fluctuations of synergetic systems close to their transition points, we suggested to Kelso to look for such fluctuations.

Figure 27 shows his experimental results. In this figure both the average phase and the phase fluctuations, i.e. more precisely the root mean square of the phase fluctuations, are plotted. In the case of the transition from the antisymmetric to the symmetric hand motion big critical fluctuations occur indeed.

We have modelled this transition under the impact of fluctuations by means of adding a fluctuating force to the equation (18) I.e., we have treated the equation

$$\dot{\phi} = - \frac{\partial V}{\partial \phi} + F(t).$$

Using the Fokker-Planck equation, we have studied both the behavior of the root mean square as well as correlation functions and results are found in excellent agreement with the experiment.

What is most interesting and important is the consequence of this treatment. Before we discuss it we briefly mention that by extension of our model which takes into account the oscillatory motion of the hands, we may reproduce the experimental curve as shown in fig. 28.

But let us now discuss the important consequences. Namely when we first assume that the transition between one kind of hand movement to the other kind is caused by the change of the motorprogram of the neurons, it will be very hard to understand why any fluctuations should occur at all. Indeed a motorprogram is a fixed program and no fluctuations should be expected. The way the transition occurs in the hand movement rather indicates that we are dealing here with a typical act of self-organization. This system organizes itself, that means, the individual neurons and muscles act jointly as if the whole system acts as a total autonomous system.

Quite clearly this introduces an entirely new paradigm in biology and it can be hoped that similar mechanisms and models apply to more complicated motions, where the next step will be to study the change of gaits of horses. Other highly coordinated motions may most probably be treated very much the same way, for instance rhythmic motions like breathing and heartbeat and their coordination.

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Figure captions

Fig. 1:
Typical set-up of a laser

Fig. 2:
Effective potential for $G - \kappa < 0$

Fig. 3:
The electric field strength of the emitted light consists of individual wave tracks.

Fig. 4:
With increased gain the potential curve becomes flatter.

Fig. 5:
The electric field strength for the emitted light consists again of wave tracks which for increased gain decay more slowly, however.

Fig. 6:
Potential curve for $G - \kappa > 0$

Fig. 7:
The electric field strength has become an amplitude stabilized wave.

Fig. 8:
Normalized intensity fluctuations of a laser versus pump power

Fig. 9:
The potential curve for $G - \kappa < 0$ and $G - \kappa > 0$

Fig. 10:
Bifurcation diagramm

Fig. 11:
If the order parameter E is small, the dipole moments are at random.

Fig. 12:
If the order parameter E is sufficiently large, the dipole moments become ordered.

Fig. 13:
A double well-potential can store one bit.

Fig. 14:
Standing waves inbetween two mirrors.

Fig. 15:
Running waves in a ring laser.

Fig. 16:
Darwinism of laser modes. At time t_0 all modes have the same number of photons. At a later time t_1, a segregation has taken place. At a sufficiently large time t ,only one kind of photons has survived.

Fig. 17:
The porcupine fish left and the sun fish right can be transformed one into another by a simple coordinate transformation (after D Arcy-Wentworth-Tompson)

Fig. 18:
Developmental stages of a California newt

Fig. 19:
Computer calculation of the development of pattern in a rectangular container of a fluid (after Bestehorn and Haken).

Fig. 20:
Temperature field on a sphere (compare text), (after Friedrich and Haken).

Fig. 21:
Temperature field in the form of a rotating wave (after Friedrich and Haken)

Fig. 22:
Temperature field showing in its time evolution chaos (after Friedrich and Haken)

Fig. 23:
Hexagonal wave front of flames (after Schnaufer and Haken)

Fig. 24:
Parallel arrangement of fingers

Fig. 25:
Symmetric arrangement of fingers

Fig. 26:
The behavior of the mean phase and its variance when the frequency is increased (after Kelso and Scholz)

Fig. 27:
Out-of-phase and in-phase motion of the two fingers as a function of time when the frequency is increased at the same time continuously (after Haken, Kelso, Bunz)

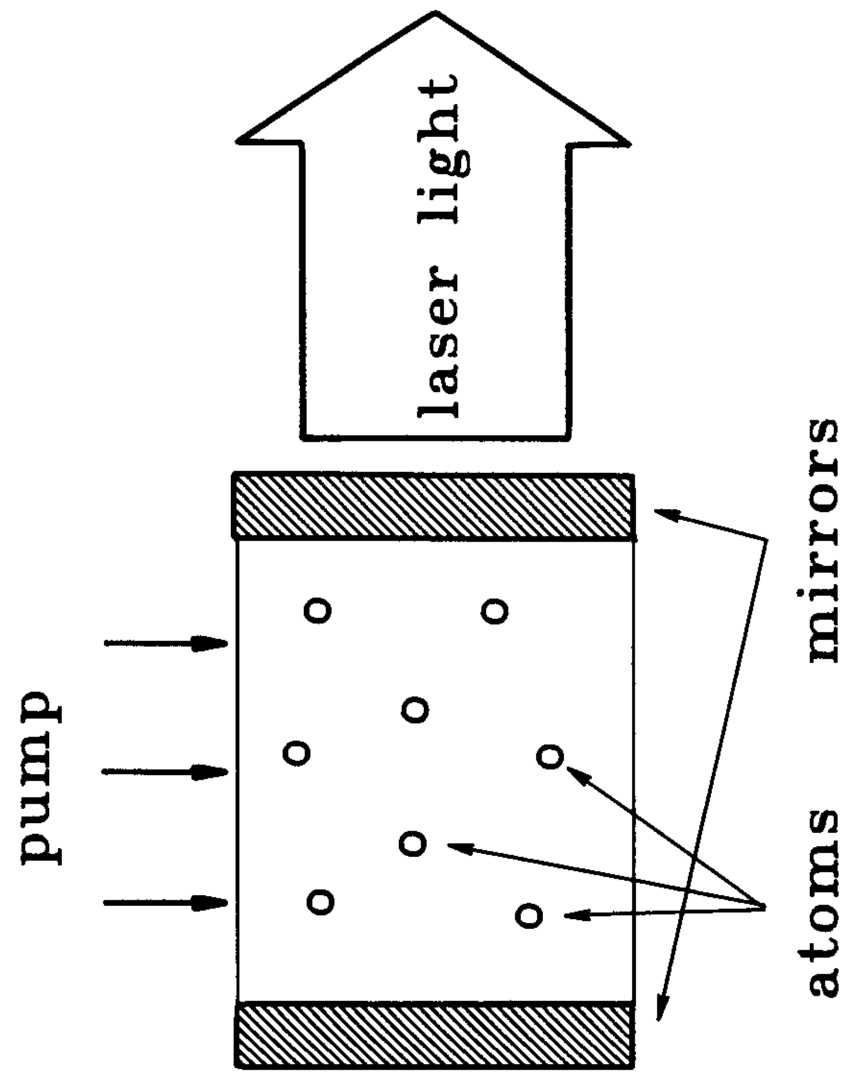


Fig.1

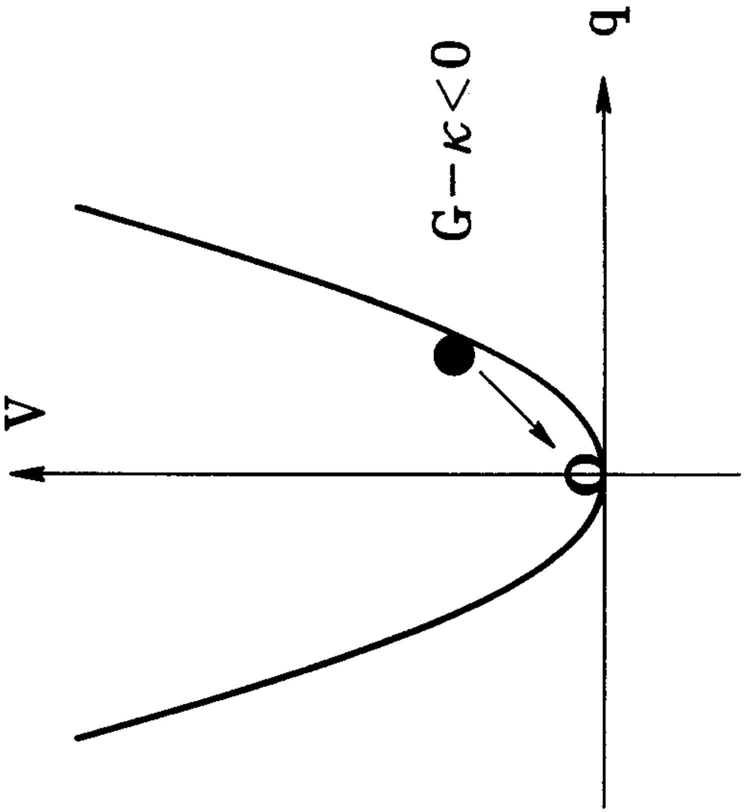


Fig.2

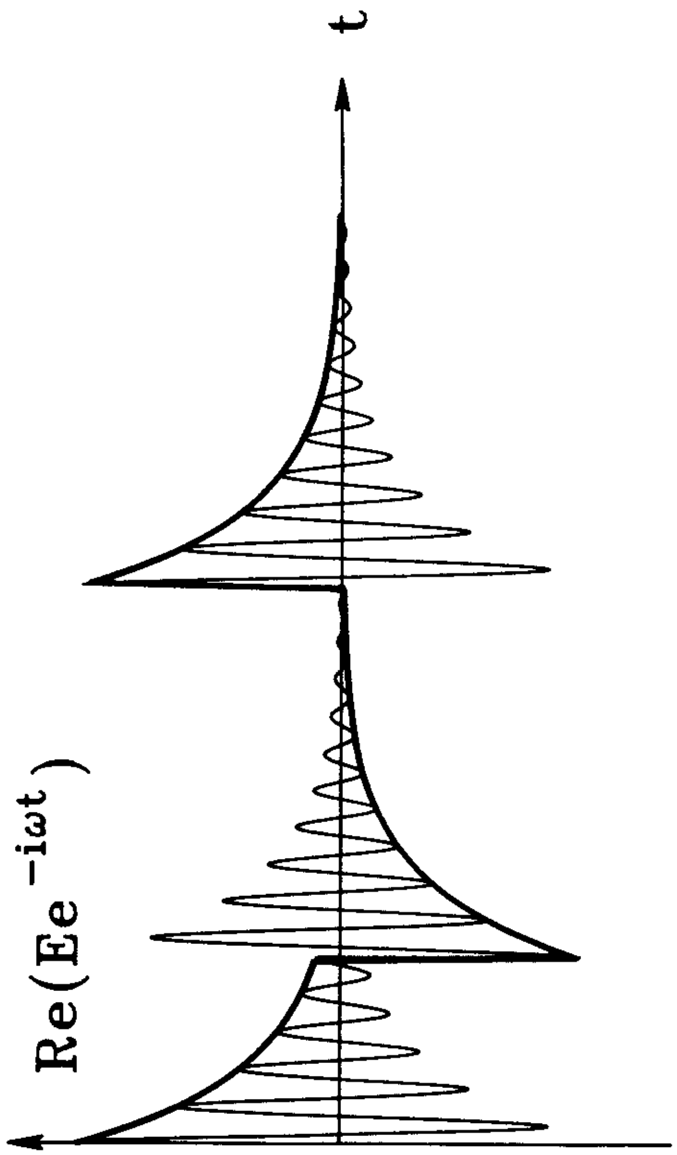


Fig.3

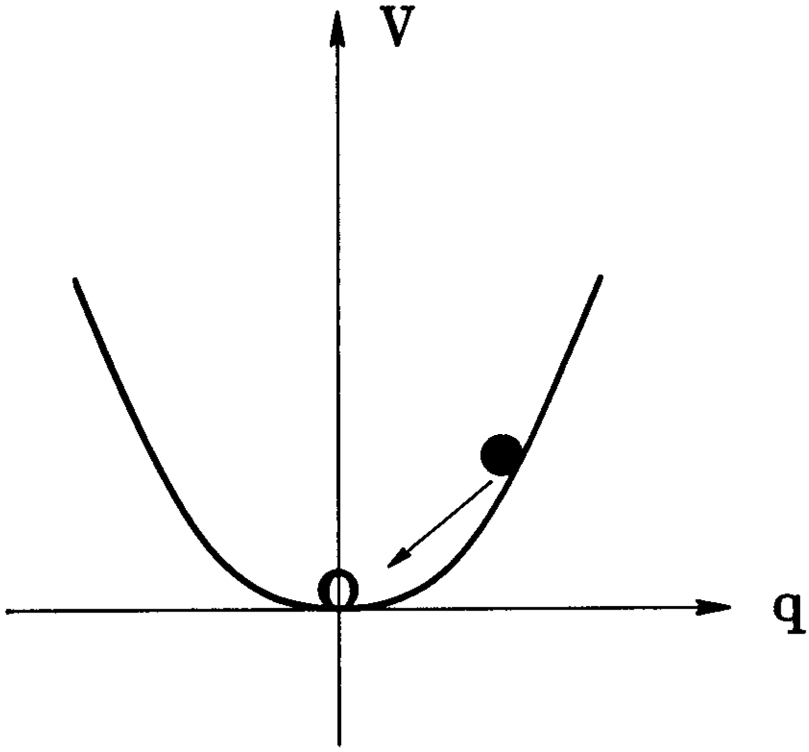


Fig.4

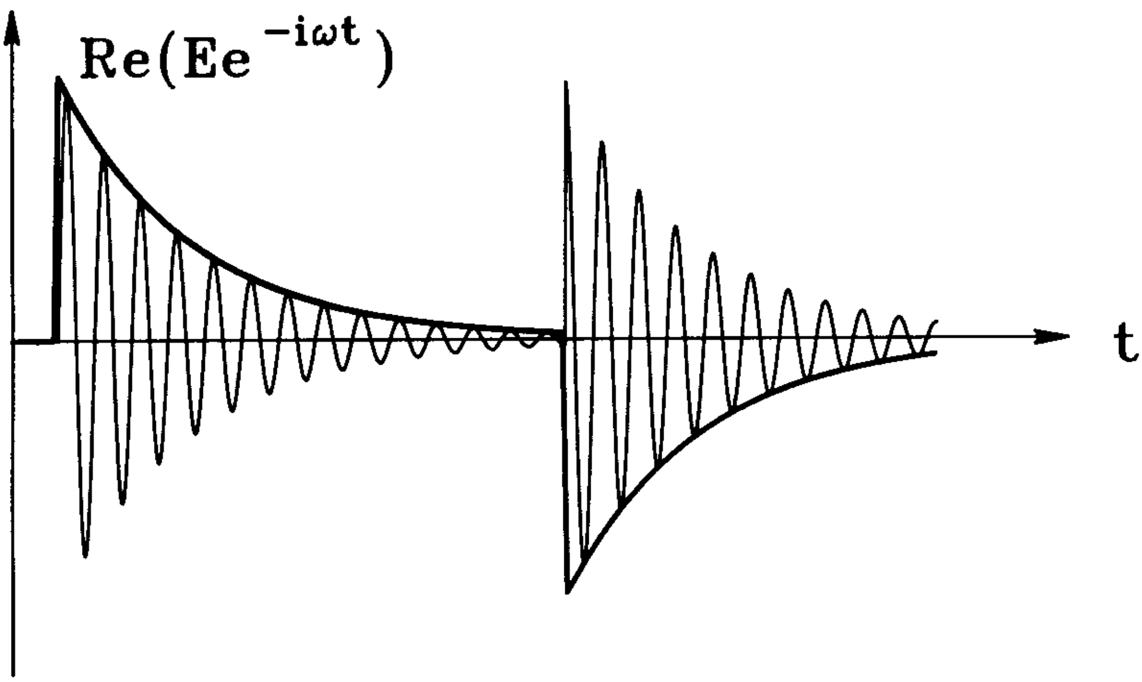


Fig. 5

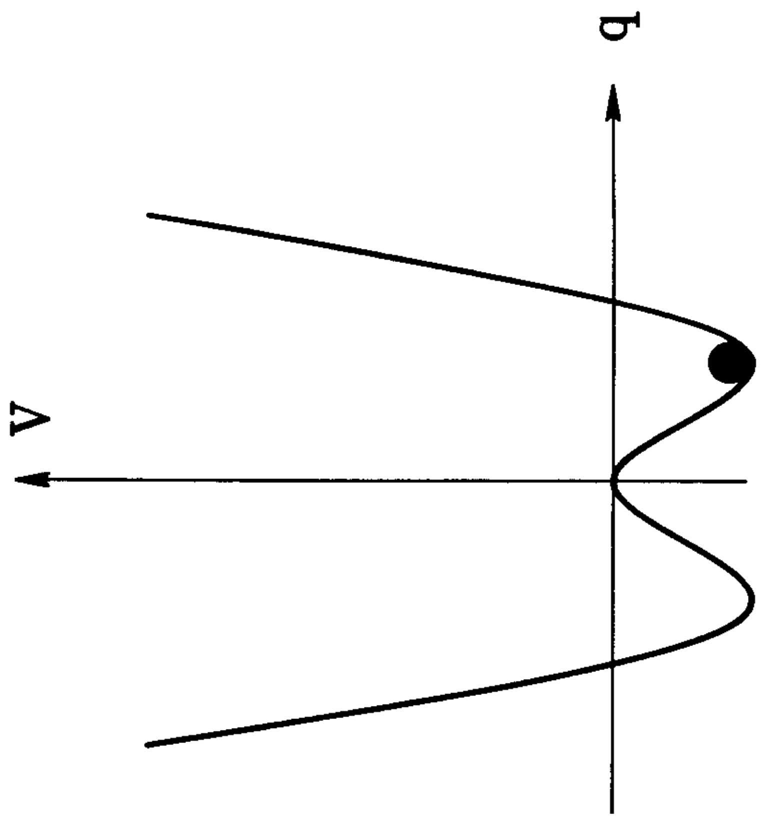


Fig. 6

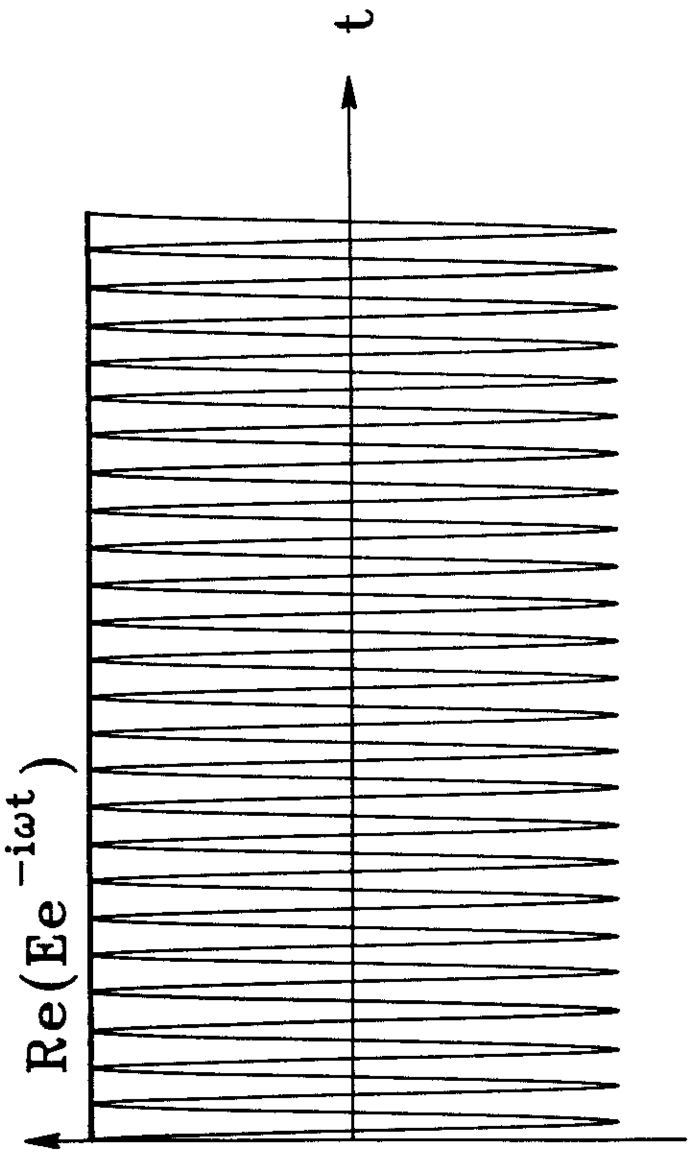
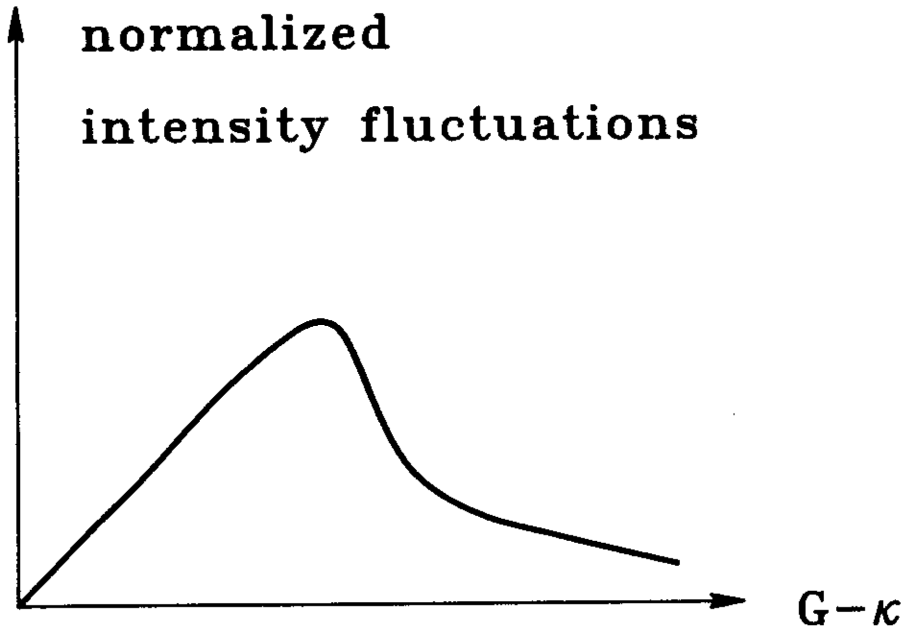


Fig. 7



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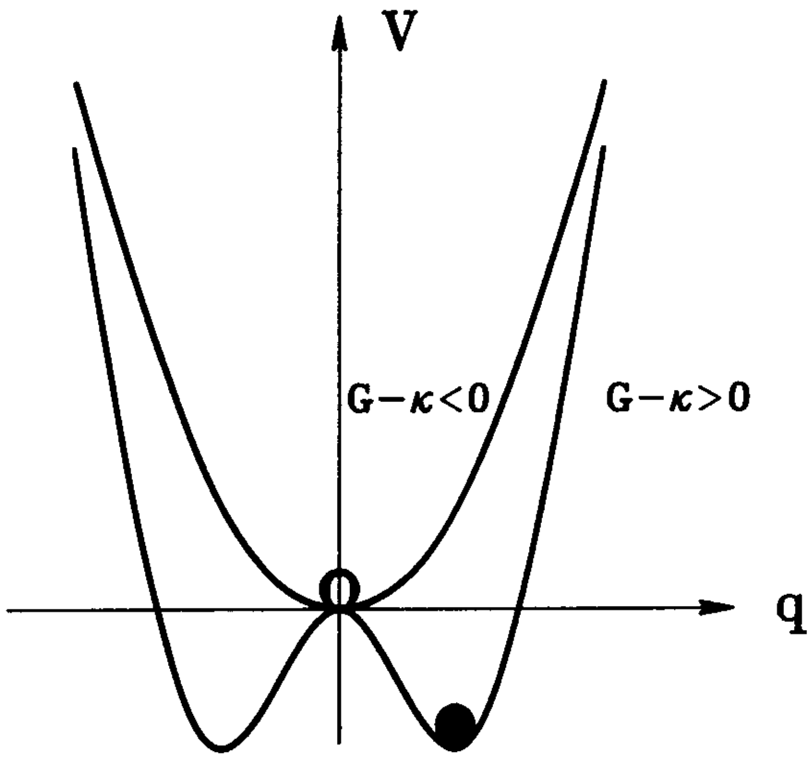

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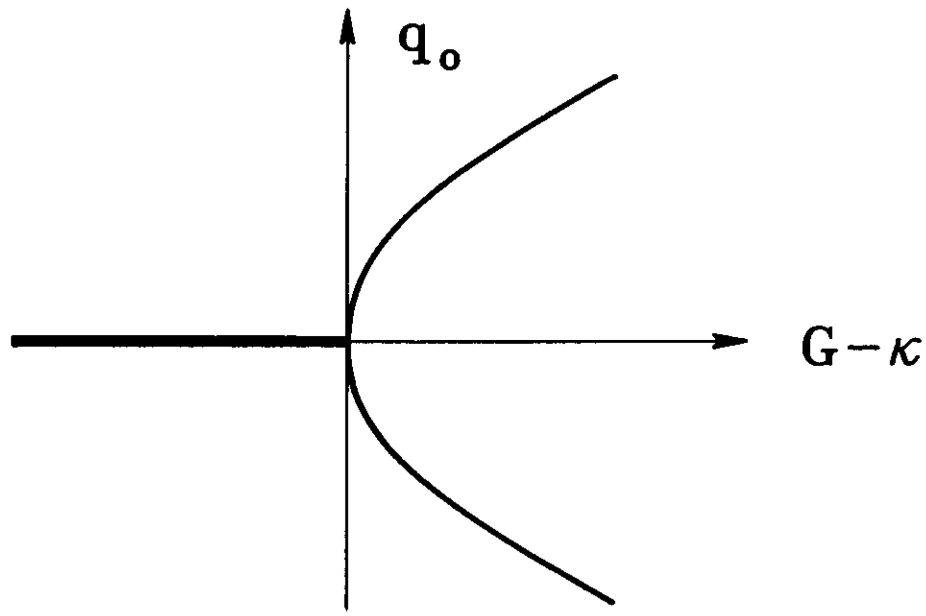
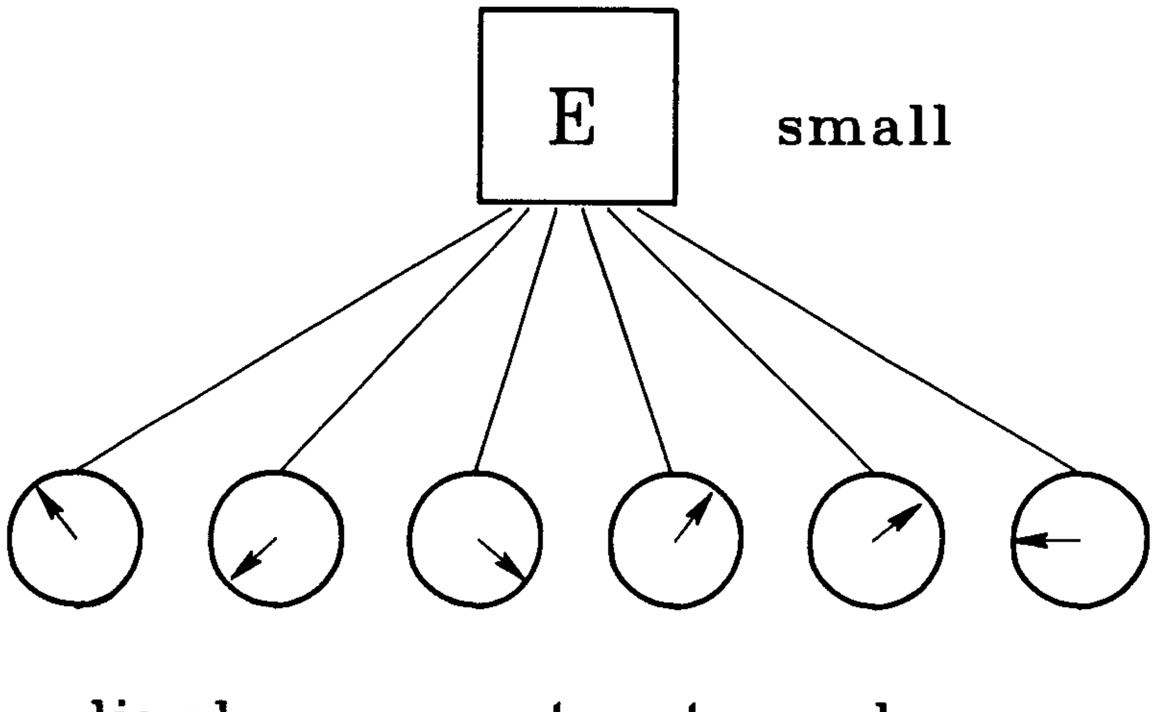


Fig. 10



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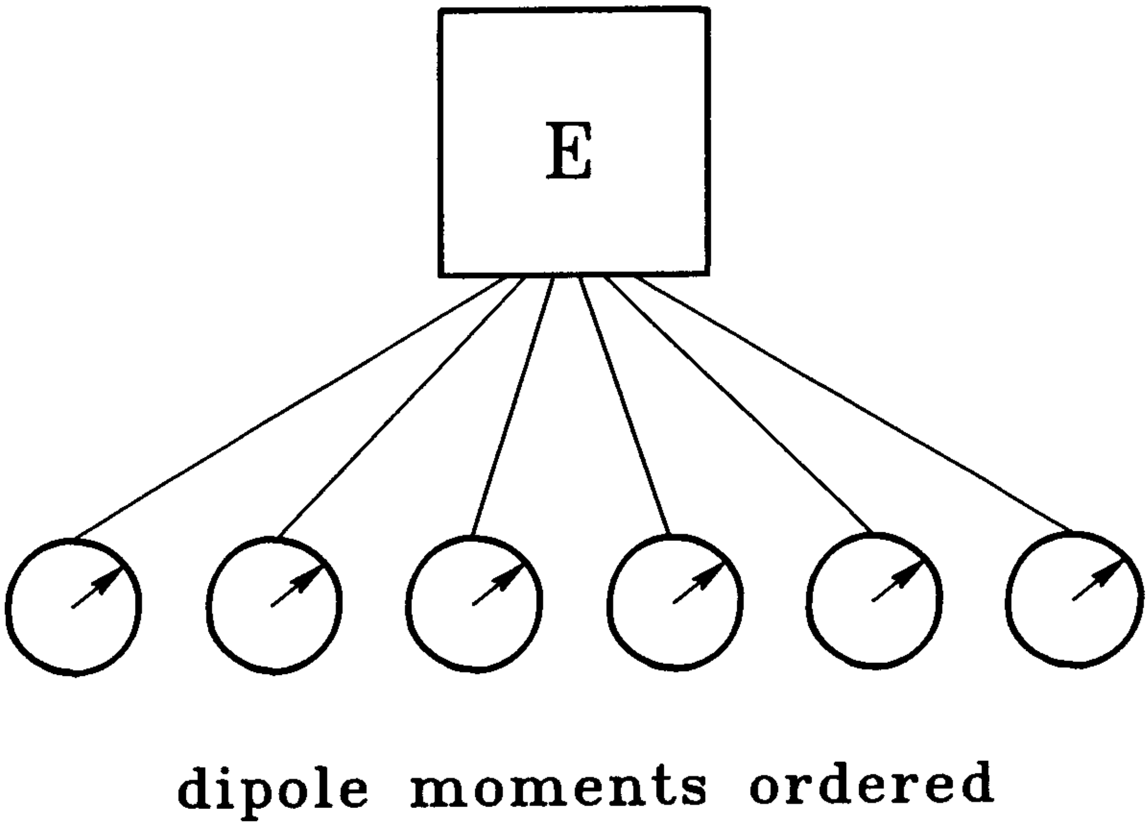

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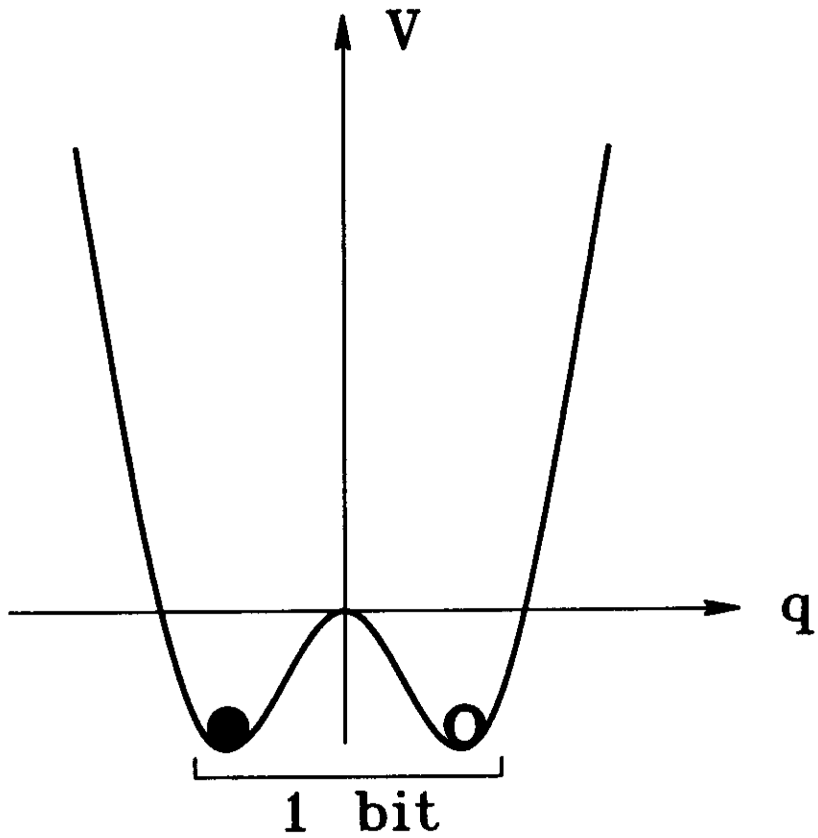

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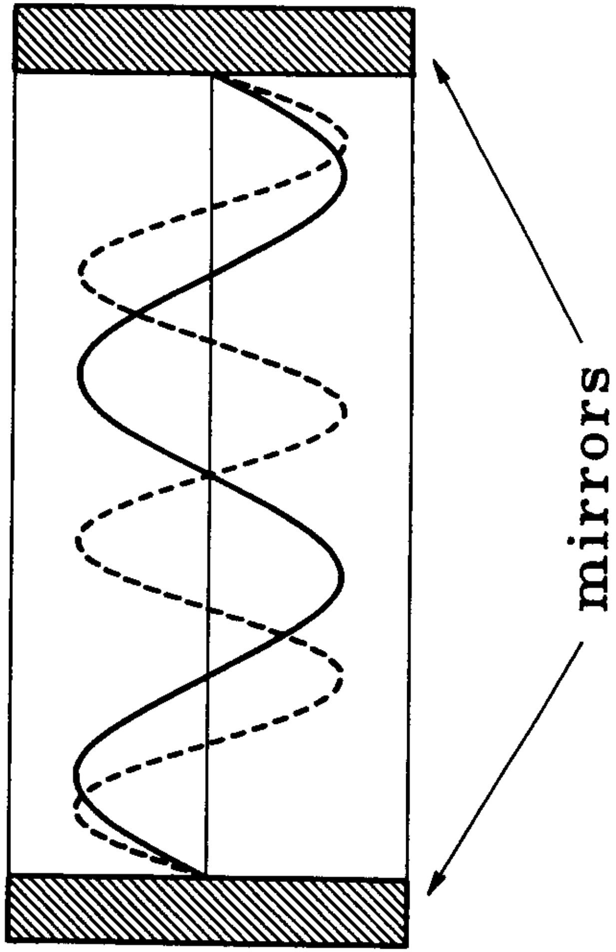

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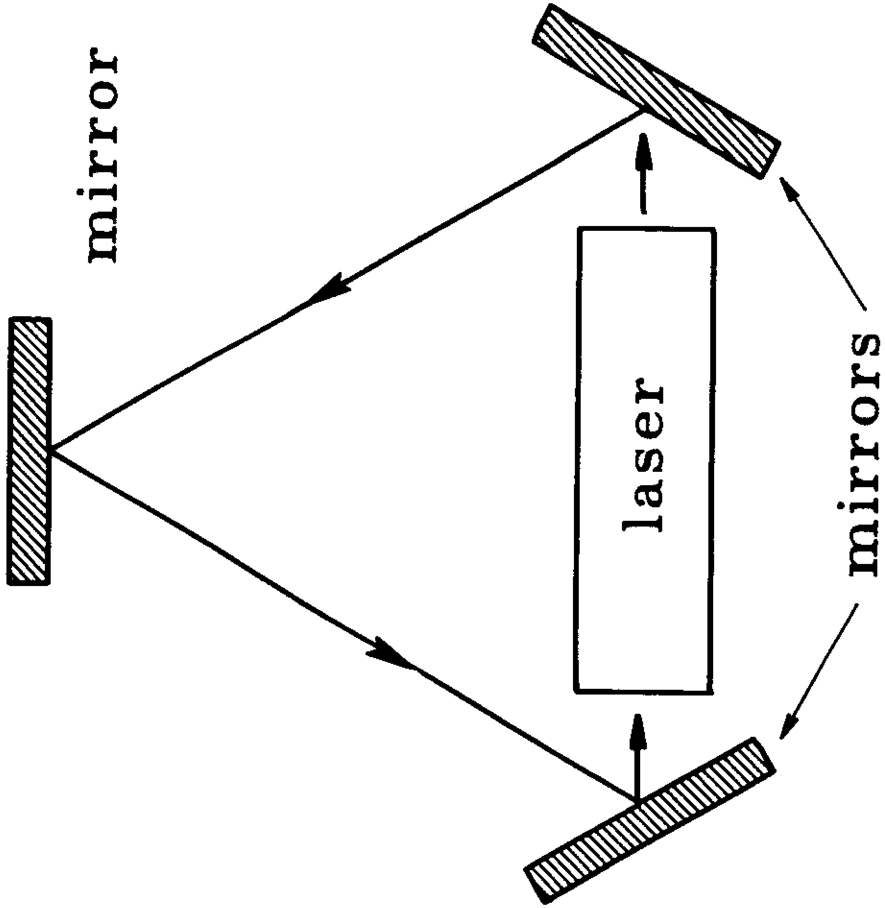

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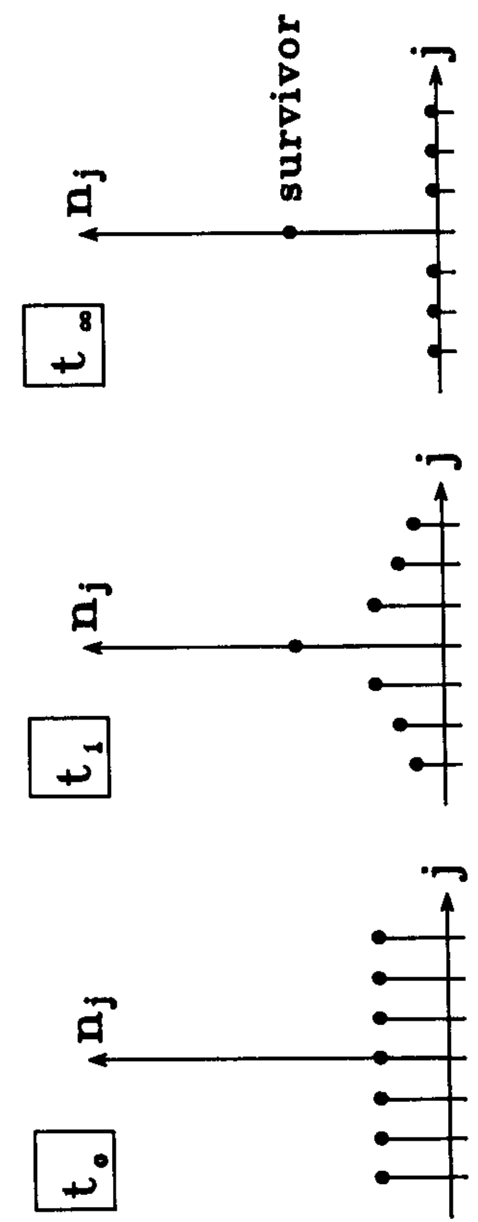

Fig. 16

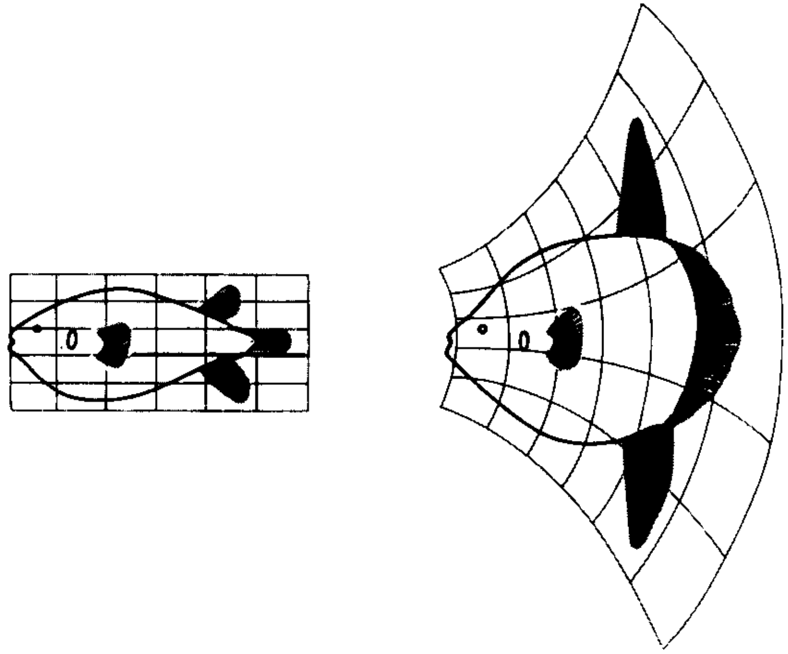

Fig. 17

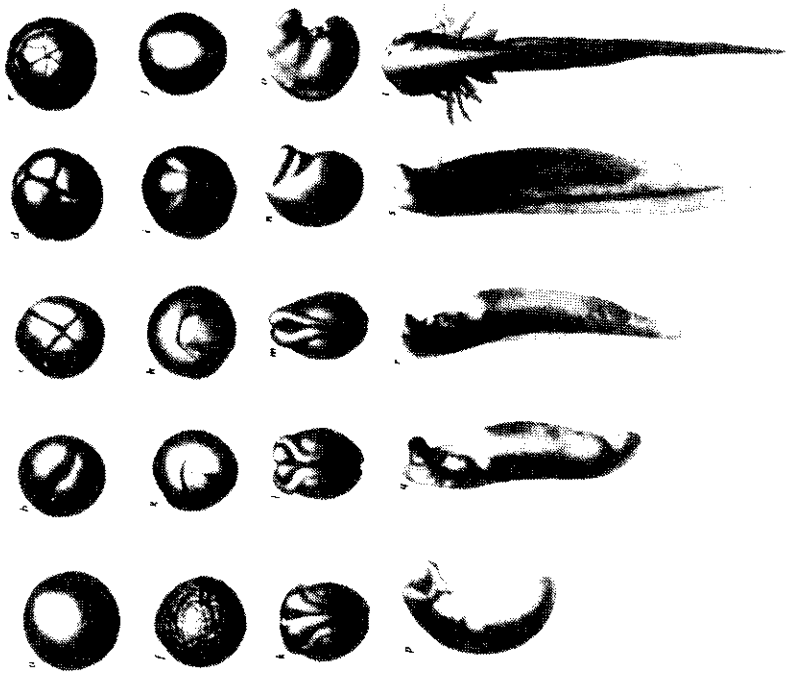

Fig. 18

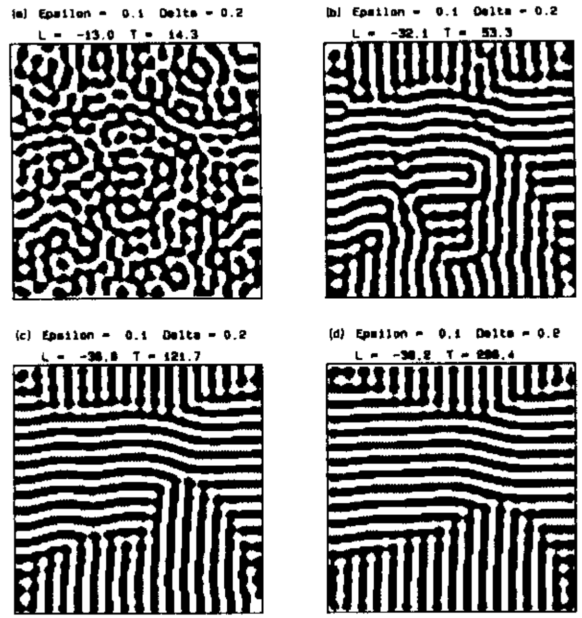
(a) Epsilon = 0.1 Delta = 0.2
L = -13.0 T = 14.3
(b) Epsilon = 0.1 Delta = 0.2
L = -32.1 T = 53.3
(c) Epsilon = 0.1 Delta = 0.2
(d) Epsilon = 0.1 Delta = 0.2

Fig. 19

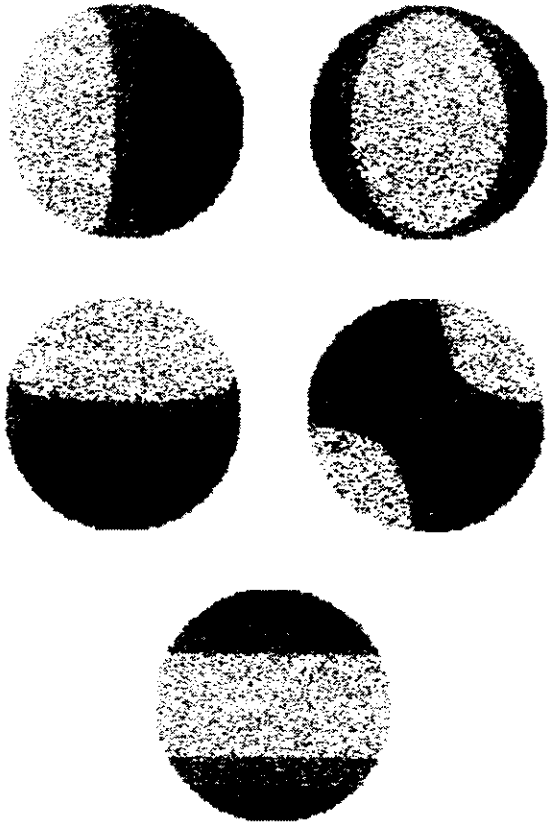

Fig. 20

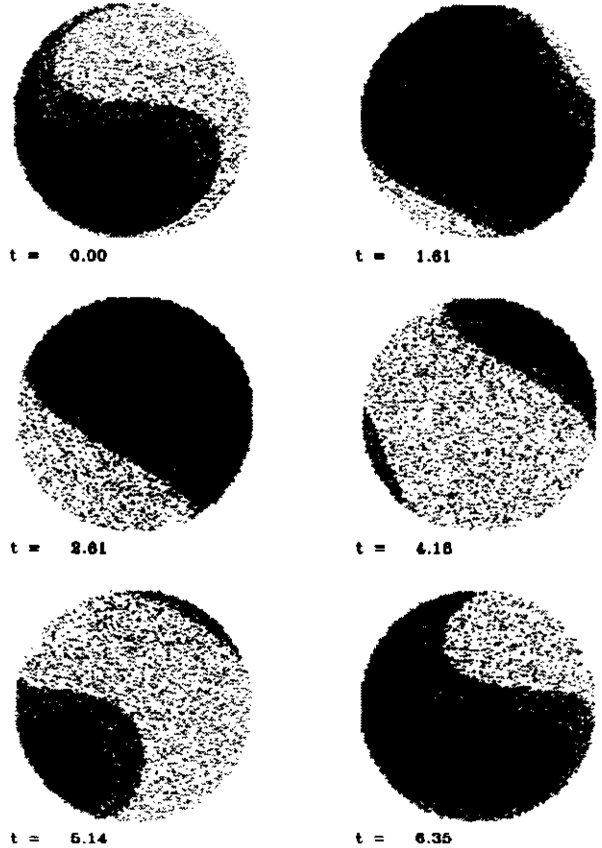

Fig. 21

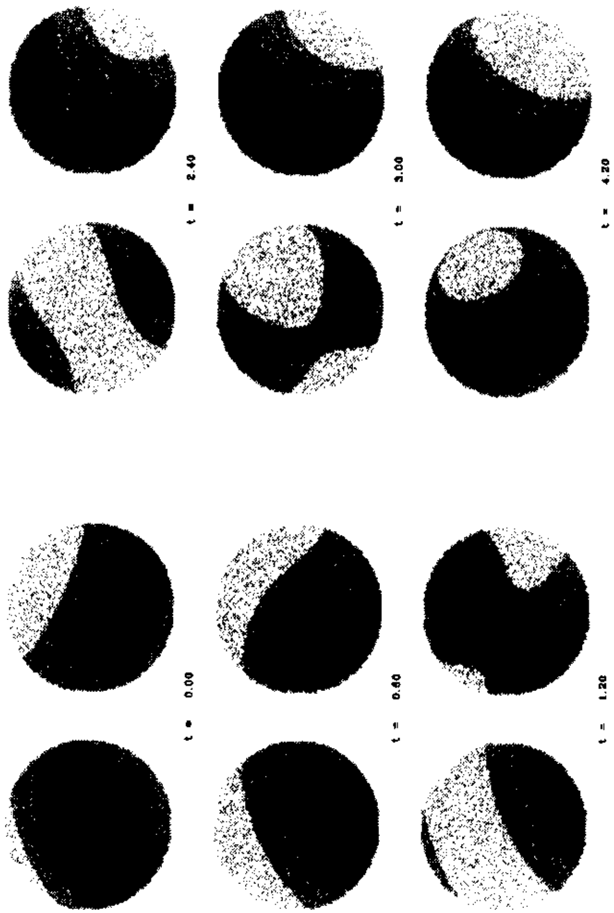

Fig. 22

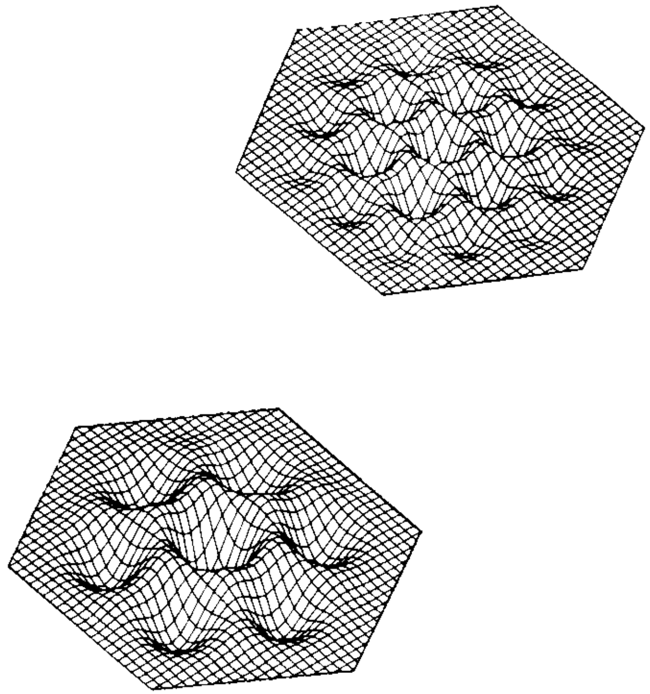

Fig. 23

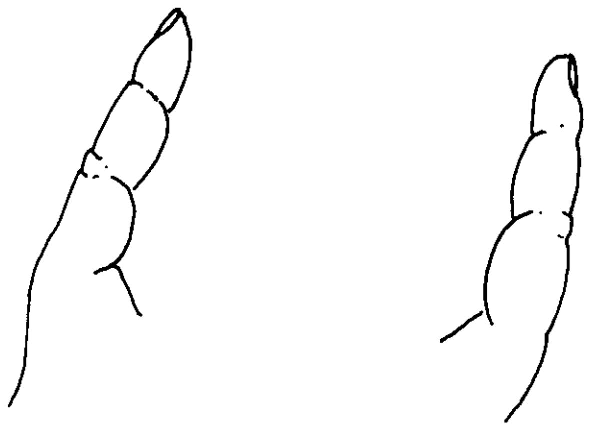

Fig. 24

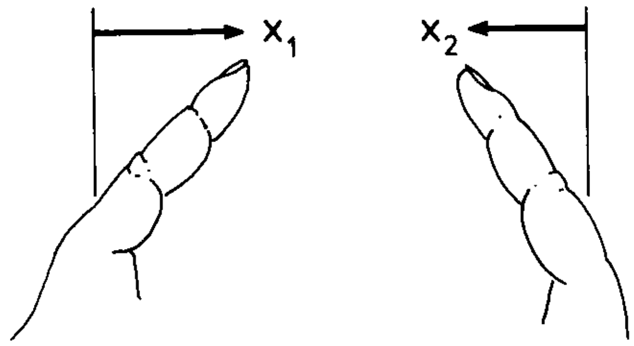

Fig. 25

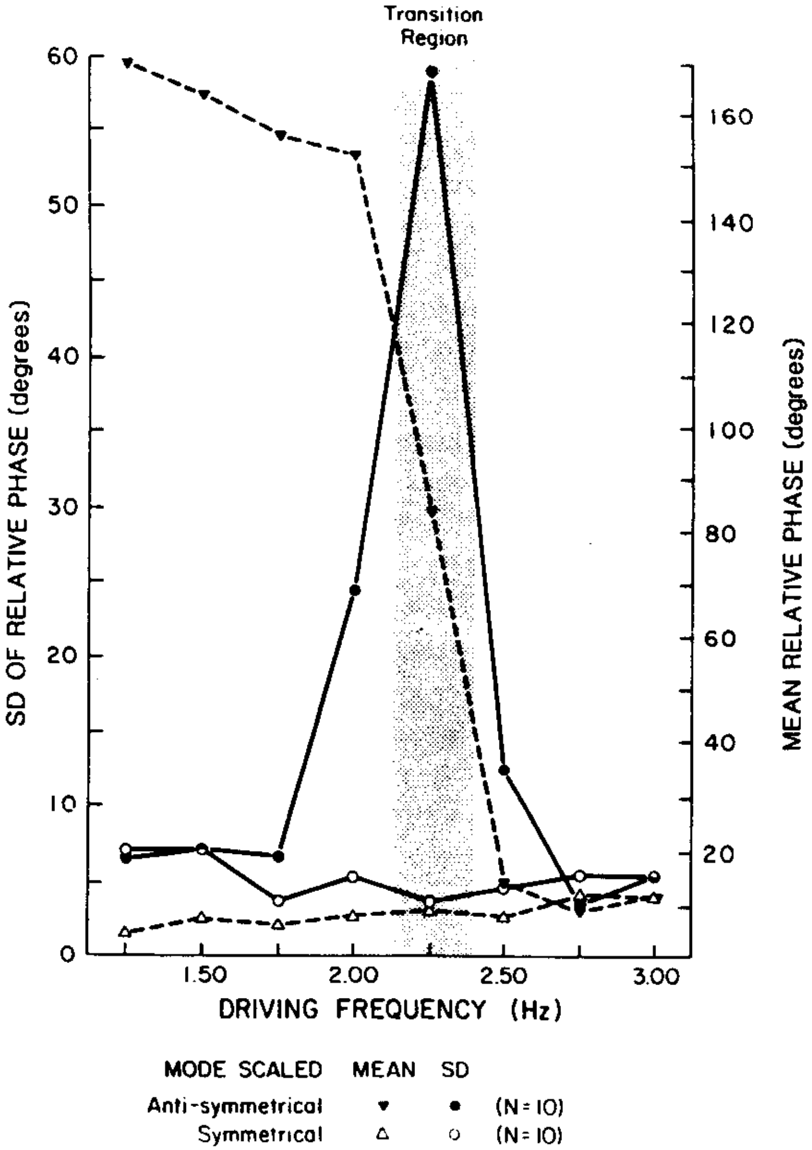
Transition Region
SD OF RELATIVE PHASE (degrees)
MEAN RELATIVE PHASE (degrees)
DRIVING FREQUENCY (Hz)
MODE SCALED MEAN SD
Anti-symmetrical ▼ ● (N=10)
Symmetrical △ ○ (N=10)

Fig. 26

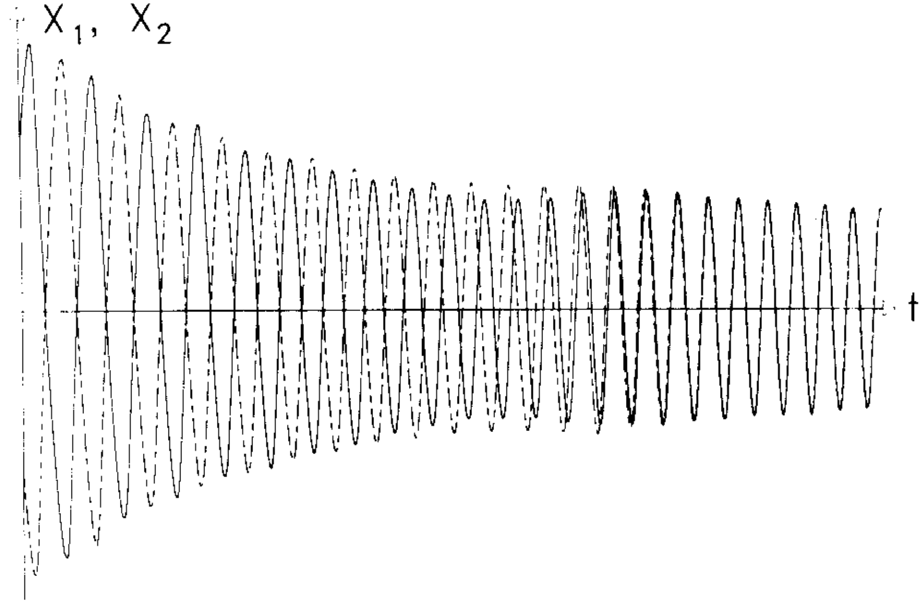
X_1, X_2
t

Fig. 27

THE PROPER PUBLIC FOR SCIENCE

Maurice Goldsmith

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May I begin by asking to be excused if I base myself on what is primarily my European experience. However, I do recognize that in saying this I may be accused of doing so from the perspective of what is termed 'Orientalism'. This is to use ethno-centrically derived concepts to describe the East. 'Orientalism' - a term coined by the Palestinian scholar, Edward Said, in 1980 -tends to ignore the intellectual achievements of non-European people. I hope I shall not be accused of 'Orientalism' in that sense. But I am obliged to state that the dominant conceptualization of what science is, for obvious historical reasons, expresses a Burocentric view. However, I believe the generalizations from my European experience, have an appropriate relevance.

I recall discussing with the distinguished physicist, Lord Blackett, when he was president of the Royal Society, the periodicals he read. He surprised me by confessing that he had given up reading the well-known weekly, Nature; he only glanced through it, for most of it was incomprehensible to him.

This story is not new. It reflects the condition of the time. A condition with which we are all familiar, which we describe as 'the

age of specialization', 'the age of the information explosion', or 'the age of the fragmentation of science', etc. All true, but being generalizations, unlikely to help us solve the basic problems they reflect: how to keep up with what's new that is not in one's own narrow field.

We are familiar, also, with the ignorance about science and technology among the general population. That reflects the condition of the times, too. What is this condition? So far as the mass of the people are concerned, whether in a first- or third-world country, it is that we have in the scientific method an approach to a coherent philosophy, but we cannot make this a living reality, an accepted - therefore experienced - focus of our lives.

Too few people have an understanding of what science is. They see it through spectacles which have lenses grounded in cliches, so they cannot see its many faces. Nor can they hear its many voices as they listen through mono-tuned hearing aids.

The word 'science' began to enter the English language during the Middle Ages (the beginning of the 17th century). It came from France, and was synonymous with knowledge. But the early Latin translators of Aristotle gave the adjective 'scientificus' a technical meaning, and this was transferred to science to mean accurate and systematised knowledge. The Aristotelian theory of knowledge was the guide: you had 'scientific knowledge' when you arrived at it demonstratively, not by experiment.

But with the beginning of modern science - first with the Copernican revolution in the mid-16th century, and then with the great age of science inspired by Galilec and Newton in the 17th century - the expression 'scientific knowledge' came into use to distinguish this form of knowledge from common knowledge: that is, science and knowledge were coming to be regarded as no longer synonymous in England. Science came to stand for a particular kind of knowledge, whether derived by straight deductive logic (as in Euclid), or whether using observation and experiment (as in Bacon and Harvey). But the full realization of this did not come until almost the mid-19th century, as expressed, for example, in Herschel's Discourse on the Study of Natural Philosophy, in 1830.

In the 17th century, with the emergence of modern science, the new systems of the world began to be part of the education of the well-read person, and the new ideas were made available to the aristocracy and the middle class. It was at this period that what has been described as 'the first systematic written attempts at scientific popularization' appeared. The first of the great popular expositors was the Frenchman Bernard le Bovier de Fontenelle (1657-1757). He must have been a delightful person. Voltaire considered him as the most universal genius he had met. He was a rare person in his combination of scientific knowledge and love of literature.

Fontenelle wrote particularly for the public of the salons. His Entretiens sur la pluralité des modes (1686) is in the form of a dialogue and is addressed to the needs of an imaginary marquise, 'jeune, aimable et ignorante'. His intention, he declared, 'is to deal with philosophy (he meant principally astronomy and physics) in the least philosophical manner possible. I have tried to develop it to a point where it shall be neither too dry for the gentry nor too superficial for the scientists ...'

For Fontenelle, popularization was a class matter. The plebs had no place in his dissemination. His works and those of the writers who followed him, such as the Spectacle de la Nature (1732) by the Abbé Pluche, were primarily for the aristocracy, the wealthy bourgeoisie and the ladies of the Court. The story is told of Fontenelle that one day at the Café Procope, the famous intellectual centre of Paris in the 17th century, he declared: 'If my hand were crammed full of knowledge, I wouldn't open it for the people.' And on the sixth day of his Entretiens, he advises the marquise: 'Let us content ourselves with being a select little band and not disclose our mysteries to the people'.

In fact, the popular presentation of science to a general public could not come about until public forms of education had made literacy more general, until the media of dissemination were more widespread, and until there was a demand. People needed to realize that there was something to know which they were missing. The Entretiens may have been written for a need already expressed: for example, Moliere's Femmes Savantes appeared 15 years before the Entretiens, and his middle-class women spent evenings in their attics trying with a telescope to see 'the people on the Moon'. However, I do not regard Fontenelle as a popularizer of science, not unless we broaden the function to describe 'a popularizer' as a person concerned with dissemination not purely to a mass, popular audience, but also to a specialist, intellectual audience.

I distinguish, therefore, between the 'mass popularizer' and the 'specialist popularizer'. Historically, this distinction reflects the status and development of science in the last decades of this century. It could not have arisen before.

During the early part of the 19th century, there were efforts - following the impetus of the industrial revolution - to make science available to mechanics, etc, but the movement in Britain, to give working men a scientific education was doomed to failure. It could not be secured by imposing instruction in the sciences upon a highly inadequate system of State education.

Similarly, the Royal Institution, founded in 1779 to train mechanics, within a few years became a centre of scientific 'entertainment' for a select few. Thomas Webster, who was Clerk of the Works in the early days of that Institution, wrote to the scientist Count Rumford in 1799 with a proposal to found a school for mechanics in the house of the Royal Institution. Rumford was delighted with the scheme and it was accepted by him. But by 1802 Webster had been granted sick leave and the project was abandoned. Why? I quote Webster's words, but we must bear in mind that these were written in 1837, 35 years after the events, and Webster was by then an old and rather frustrated man. He wrote, "I was asked rudely (by an individual I shall not name) what I meant by instructing the lower classes in science. I was told likewise it was resolved upon that the plan must be dropped as quietly as possible. It was thought to have a dangerous political tendency. I ws told that if I persisted I would become a marked man." The popularization of science was still designed for a few and not for the masses.

From my shelves I have selected at random a number of definitions of science, all given during recent decades. For the biologist J.B.S. Haldane, himself a distinguished popularizer, science is first, 'the free activity of man's divine faculties of reason and

imagination. Second, it is the answer of the few to the demands of the many for wealth, comfort and victory. Third, it is man's gradual conquest, first of space and time, then of matter as such, then of his own body and those of other living beings, and finally the subjugation of the dark and evil elements in his own soul.'

For another distinguished biologist, C.H. Waddington, 'Science is the organized attempt of mankind to discover how things work out as causal systems'. For the writer Aldous Huxley, 'Science may be defined as a device for investigating, ordering and communicating the more public of human experiences'.

For the American, Warren Weaver, 'Science is not technology, it is not gadgetry, it is not some mysterious cult, it is not a great mechanical monster. Science is an adventure of the human spirit. It is essentially an artistic enterprise, stimulated largely by curiosity, served largely by disciplined imagination, and based largely on faith in the reasonableness, order and beauty of the universe of which man is part'.

These definitions are acceptable. They have the virtue of not being imbued with a late 19th century emotion which perpetuates the myth that there is really only one form of science, called variously 'basic', or 'pure', or 'fundamental', or 'science for its own sake'.

There are other definitions: for example, that of the philosopher, Sir Karl Popper, 'I think we shall have to get accustomed to the idea that we must not look upon science as a body of knowledge, 'but rather as a system of hypotheses: that is to say, as a system of guesses or anticipations which in principle cannot be justified, but with which we work as long as they stand up to tests; and of which we are never justified in saying that we knowl they are "true" or "more or less certain" or even "probable".'

What is important is an understanding that the idea of definition does not apply strictly to a human activity which has undergone many changes in its history: an activity which, as the crystallographer J.D. Bernal expressed it, 'is so linked at every point with other social activities, that any attempted definition can only more or less inadequately express one of the aspects, often a minor one, that it has had at some period of its growth.'

If we ask, 'What is the purpose and meaning of science?', we find that today's answer is different from that given yesterday, and different sorts of people would give different answers at different times. Thus, as Bernal put it, no anatomical definitions of science is worthwhile. To be understood, science requires to be seen as a social phenomenon, linked organically with all other forms of human behaviour. All human activity is charged with change: today's Hamlet is a being different from the Hamlet of a generation ago. Similarly, today's science is different from yesterday's and will be different again tomorrow.

Science is part of the process of social and cultural evolution, and, therefore, is as subjective and psychologically conditioned as any other branch of human endeavour. Thus, the proper public for science will vary from period to period, dependent upon the answer given to the question, 'What is the purpose and meaning of science?'.

In the Western world, the attitude of 'science for its own sake' can be traced to the influence of the classical Greek contempt for manual labour, which was expressed by the 'pure scientist', who, aloof in his ivory tower, disdained those whom he regarded as using tradesman's standards to judge the usefulness of knowledge. The 'pure scientist' could avoid having to ask awkward questions on the effects of his researchers: would not need to consider, 'What is my science for?', 'What is my responsibility as a scientist not only to society, but also to science itself?'. In this content, the 'applied scientist' was a lesser being.

That was the social atmosphere in Cambridge, England, in the years before 1939 (outbreak of the second world war) when students, such as C.P. Snow, distinguished as a novelist, began their scientific work. Snow was different: in a sense, therefore, more fortunate. He was doing research in the 1920s in a renowned laboratory, the Cavendish, and he wanted to write books. Thus, he said, 'There have been plenty of days when I spent the working hours with some scientists and then gone off at night with some literary colleagues ... It was through living amongst these groups and back again that I got occupied with the problem of what, long before I put it on paper, I christened to myself as the "two cultures".'

That most felicitious phrase - a phrase that to his surprise so caught the imagination that it has become incorporated into our everyday language - he defined in 1959 in the Rede Lecture in Cambridge to describe 'the gulf of mutual incomprehension' that separated literary intellectuals at one pole and scientists at the other. He believed the intellectual life of the whole of Western society was being split increasingly into those two polar groups.

Snow ended his lecture with a plea for the closing of the gap as 'a necessity in the most abstract intellectual sense, as well as the most practical. When these two sense have grown apart, then no society is going to be able to think with wisdom'.

In his second look at the two cultures in 1964, Snow 'rephrased the essence of the lecture' as follows:

> 'In our society (that is, advanced Western society), we have lost even the pretence of a common culture. Persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their major intellectual concern. This is serious for our creative, intellectual and, above all, our normal life. It is leading us to interpret the past wrongly, to misinterpret the present, and to deny our hopes of the future. It is making it difficult or impossible for us to take good action.'

> 'I gave the most pointed example of this lack of communication in the shape of two groups of people, representing what I have christened "the two cultures". One of these contained the scientists, whose weight, achievement and influence did not need stressing. The other contained the literary intellectuals. I did not mean that literary intellectuals act as the main decision-makers of the Western world. I meant that literary intellectuals represent, vocalize and to some extent, shape and predict the mood of the non-scientific culture: they do not make the decisions, but their words seep into the minds of those who do. Between these two groups - the scientists and the literary intellectuals - there is little communication and, instead of fellow-feeling, something like hostility.'

How far during these past decades have we come to bridging the gulf, to ending the dangerous division into the 'two cultures', and to securing a 'one culture' in which, whatever our specialist academic background, we can communicate understandably with each other? The answer is - not at all. The gulf today is wider than it was in 1959. We heard Snow's warning, but we could not heed it.

Historically, the rejection was inevitable. The gulf is too deeply rooted in Western cultural experience to be bridged overnight.

One root has grown from a meeting of the Fourth Lateran Council in 1215, at which it was agreed that the dogma of transubstantiation should be explained, and it could be, in terms of then existing theory of matter.

How is it possible for Christ to be present in the consecrated bread and wine of the altar? The answer lay in the distinction between the substance of matter and its transient qualities. For instance, the substance of water remained unchanged, although it could appear, also, either as steam or ice.

It was logical, therefore, to assume that in supernatural circumstances the substance of matter might be changed without affecting its external characteristics. Thus, the bread and wine of the altar continued to look like bread and wine even though in the hands of the priest they had become the body and blood of the incarnate God.

In the years that followed, more emphasis was laid on thus deifying matter, and on making an understanding of this a prime spiritual concern. Coincidentally, Europe was becoming the leader in the development of quantitative mathematics. There was not a better approach to an understanding of matter than through measurement and numbers. This emphasis had an important cultural effect through the different attitude it brought to the traditional seven liberal arts. These were divided into the Trivium, made up of grammar, rhetoric and logic: that is, concerned with verbal methods and analysis; and the Quadrivium - arithmetic, geometry, astronomy, and music (really the study of acoustical propositions): that is, concerned with measurement and calculation.

Until the end of the 13th century, theologians and those concerned with science were brought up in a common routine: they shared the same academic background, and could discuss easily with each other using the same cultural language. However, as the effects of deifying matter became clearer, there followed increasing emphasis on the quadrivial approach, and a decline in trivial argument. The scientists tended to narrow their research methods to the mathematical, and their subjects of study to the physical. They tended to become concerned with the tangible. And problems of the intangible of values, of such non-measurables as beauty and goodness become the concern of others.

Over the centuries, the alleged antithetical character of scientific and moral (or aesthetic) modes of thought was intensified, and expressed in our educational system. The gulf that took shape was based on the late mediaeval emphasis on the importance of matter, and on mathematics as the only basis for rational certainty.

Intertwined with this root is another which has developed within the past two hundred years. It is a new phase of what is known as 'the romantic reaction'. It is an expression of the inability to co-ordinate two modes of knowing, to marry fact and value, matter and mind. For example, the partnership of science, engineering and capitalism in the last century led to the choice of the machine as the key symbol of the emergent industrial system. Novelists and poets have used the metaphor of the machine to convey the sense of human inadequacy.

Throughout the 1800s, the machine as symbol served as a figure for the complex force shaping the age, and became also an explicit

measure of value. Writers in Victorian England consistently used the word 'machine' in a pejorative sense, because it was for them a manifestation of the scientific habit of mind, seeking always to reduce the complexities of society to a few simple, measurable laws. And that symbol of the machine as representing the scientific mind is opposed in Victorian writing to what might be termed 'organic' metaphors, expressed belief in an instinctive creative ability degraded by mechanized production.

The conflict has grown sharper: there is a growing discrepancy between what science provides in the way of certain, verifiable knowledge, and what we understand by the quality of life. There is a widespread view that there is no possibility of a more harmonious relationship between man and nature, and science has come to be identified with acute forms of alienation from nature.

It would be foolish not to recognize that the gulf between the 'two cultures' has grown, so that the scientist is seen as a stranger in the society in which he lives, and not to recognize that a debate is going on which in its significance far overshadows all previous discussions. We have moved far from the simple polarization of knowledge. The new debate is concerned with the awesome problems of the limits of scientific inquiry: with questions such as, 'What is the status of new knowledge?', 'Do we need to encourage or restrain its growth?'. Not so many years ago, the intellectual climate of the day would not have conceived of such questions being posed. Only a few voiced such thoughts, and then most privately.

The public for science has been regarded always as the'bourgeois educated who were contrasted with the supposed illiterate masses.

Science for the latter had to be made popular, a condenscending approach which has failed miserably to achieve any real understanding of the nature of modern science, or of the basic laws underlying present-day scientific achievement. But nor could science be made popular for the alleged literate middle class. The British educational system is concerned with producing specialists, not with culturally rounded beings.

Thus, the public for science remains undefined and confused. Illiteracy in science and innumeracy are the hallmarks of a social system in which the engineer is still very low in public esteem compared with the financier, property developer, pop star, or pure scientist.

A new debate began in 1945 with the first practical demonstrtion of the capture of nuclear energy. The Bomb at Hiroshima started off that debate, which demanded a new definition of the public for science. Two waves of thinking began: one, a wave of anti-scientific response which has taken us well outside the 'two cultures' concept. It was fuelled by the horrors of the Vietnam war, in which the new techniques of devastation, both physical and mental, alienated a large part of the young in our industrialized world from involvement in scientific and technological work performed in the service of the government.

Indeed, Snow's 'two cultures' statement was made on the eve of a most powerful formulation of the counterculture which arose during the 1950s. It found vivid expression on the writings of the American, Thomas Roszak. He singled out the scientific world view as the root cause of what is most alarming about modern science:

> 'I have insisted', he wrote in 1973, 'that there is something radically and systematically wrong with our culture, a flaw that lies deeper than any class or race analysis probes and which frustrates our best efforts to achieve wholeness. I am convinced it is our ingrained commitment to the scientific picture of nature that hangs us up. The scientific style of mind has become the one form of experience our society is willing to define as knowledge. It is our reality principle, and as such the governing mystique of urban industrial culture.'

For Roszak, the scientific world view is the critical variable in what he regards as a suicidal pattern of collective behaviour. He identifies the quasi-religious belief in Reason as the motive force behind urban industrialism. His supporters use the terms 'technology', 'the system', and 'the machine' interchangeably. And they point the finger at the controlling network of large institutions - government, business corporations, universities - as the real sources of power because they control 'the machine'. Roszak's arguments are persuasive in terms of emotions. What has helped the counterculture is the loss of confidence in themselves which sections of the scientific community are displaying in public. This is linked up with an intense debate on the social responsibility of the scientists, and the ethics of their behaviour.

Advances in science and technology seem to have escaped our control and they are regarded as acting not only independently of us, but even against our will. In philosophical terms, we are witnessing the alienation of science and technology from culture generally.

According to this view, science is a foreign body which culture must fight and control; it must be always an outsider because it is the incarnation of the rational and foreign to any cultural tradition. This is a nonsense, but it is part of the second wave of thinking for which the Bomb was responsible. It is in the field of biological research that the problem is posed sharply. Quetions posed are, 'Should limits be placed on biological research because of the danger that new knowledge can present to the established, or desired, order of society?', 'Is placing limits on biological research a threat to intellectual freedom and creativity?'.

The wider debate goes on. Attention is drawn to other fields of research in which it is claimed new knowledge may have the most considerable implications. For example, in the development of nuclear energy devices, or the widespread introduction of microprocessors (the chips). Are then areas of research that should be forbidden, or considered taboo, because of their potential 'harmfulness' to our society? I put the word in quotes because desired change is harmful, too, when society is not prepared for it with the necessary social mechanisms. I believe an answer cannot be provided by the scientific community alone, for it concerns all of us, and the answer is laden with policial and social values. Now we are beginning to arrive at a contemporary definition of the proper public for science.

We are at the beginning of the age of public participation in science - whether we like it or not, whether we wish it or not, whether we are aware of it or not. This has occured as it has become clearer that science is not a private game, but is for everybody: that it has a function in society: and that if used in a planned way could improve our condition immeasurably. Opposition to this viewpoint is mostly on the grounds that any attempt to constrain scientific research, to canalize it into ordained channels, would introduce authoritarianism. This, it is alleged, would stifle creativity, and would have consequences harmful to science itself. This change is

highly debatable. In practice, a general problem of social importance provides as good a basis for the unplanned discovery as does complete freedom. Real novelty seems to spring as readily from consideration of some practical as it does from out of the blue.

But the situation is not easy to resolve. We need to ask, 'What forms can such public participation take?', 'What are the implications of these demands not only for science, but also for the dissemination of scientific information?'. If, through successful research, we arrive at such an understanding of genetic inheritance that obstacles to genetic engineering are removed, which is happening, then I suggest the demand for public participation is clear and acceptable.

The once widespread feeling that scientists alone should have domain over the scientific enterprise is being challenged. The question posed, and fought out in many arenas, is, 'Who should be responsible ultimately for decisions about controversial scientific and technical issues?'. When scientists seek to maintain as much autonomy as possible, it is quite natural to regard them as a political interest group with powerful career concerns. To speak more plainly, the autonomy of science up to now has been the result of a promiscuous collusion between the scientist and the politician. New knowledge can no longer serve as a justification for introducing risks to the public, unless an informed public is willing to accept those risks.

SCIENCE AND TECHNOLOGY AND THIRD WORLD DEVELOPMENT

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Of course, the concept of the Third World (TW) is a nonsense, designed to foster the view that there is a coherent group of countries with status sufficient to be regarded as ranking with the First and Second Worlds. As I believe it is a nonsense, why do I continue to use the term? Because I dislike the concept of 'developing countries'.

This ensures a patronising approach, which assumes that economic development along First World lines is the major route to national well-being, and which carries with it the implicit assumption of social and cultural backwardness. However, I continue with the term TW because for me it has the merit of an imposed mathematical neutrality. However, I am not wed to it.

What is there in common between Saudi Arabia and the People's Republic of Vietnam, between Israel and Yemen, between Cuba and Brazil? The World Bank ranks countries in order of level of development, based on such indicators as: GNP per capita, food production, annual production growth, adult literacy and life-expectancy rates. Thus, Kampuchea ranks lowest and the United Arab Emirates highest. This is a simplistic approach. Apart from the impossibility of obtaining valid figures for most countries, the unequal per capita distribution of wealth, with its profound social implications, is covered up. Certainly, deep inequalities divide peoples and individuals: in 1980 the average per capita gross product in the industrialised countries was $10,660, in the low-income TW it was $250.

My concern here is to consider what are the special problems in presentation of science and technology in the TW, and by this I mean in the impoverished nations in which live the majority of the Earth's people. I include countries such as India, Brazil and Mexico, in which there is great wealth with an affluent bourgeoisie, but in which most citizens are

illiterate, hungry and poor. There are approximately 4.5 thousand million inhabitants of our planet, and some time within the next 30 years that number will double - given no nuclear war or other catastrophe. About one-third who live in the industrialised countries have a reasonable standard of wellbeing, enjoying averagely good health, sufficient food, and the estimated maximum life-span. Almost all of the other two-thirds live with the fear of constant hunger and debilitating disease, and with a life-span far below that of the other third. Depending on the criteria used, the World Bank estimates there are some 800m living in a state of absolute poverty, and the ILO about 1,100m poor.

In this complex mix of social problems, I propose to concentrate on just two aspects: the basic needs of health and food. But before I do so I want to consider the concept of 'modernisation'. This implies that National development and wellbeing are linked intimately with the view that Third World countries, especially the poorer ones, should move towards modes of production and organisation of economic activities current in the First World.

But modernisation means different things in different contexts. People who are described as 'traditional' or 'non-modern' are usually poor. They need money, purchasing power, to obtain material goods. To what extent can S&T help them? This is basically a political question which ordinary people cannot resolve without themselves taking a political stand.

We have many examples of the way in which the hunt for modernisation leads to pauperisation. For instance, in Chile between 1977 and 1981 credit cards were introduced. Banks were liberal in supplying credit. The low rate of exchange for US currency allowed cheap imports to flood the country. Here was a remarkable example of modernisation. Scotch whisky was half the price of the local products, and electronic gadgets and toys were freely available. But this could not last. Local industries went broke, unemployment rose, and when international interest rates rose the Chilean peso could no longer be kept strong artificially, and the process of pauperisation began.

Is there another aspect of modernisation a TW could consider? There is: it arises from a deliberate policy not merely to seek to introduce First World industrialisation, but to develop the psychological, social and cultural conditions to apply S&T to the development of the country's resources, natural and human, in the interests of all the inhabitants so that all, and not a privileged few, can secure a decent and dignified life.

Let us be clear. S&T are perceived and used by TW governments as a special source of national power, an instrument to strengthen their political base. The decision-makers give the impression that S&T can provide the answers to their problems. But S&T can do so only if they are seen as an instrument for solving social and economic inequities.

Governments are not prepared to understand that development, seen as a linear and sequential process following the application of S&T, leads to social pauperisation, in addition to the economic. In that process, traditional technology and cultural values are destroyed and there is greater dependency on, and exploitation by, the foreign industrialised powers.

Let us look at Africa in this context. Modern technology to be of service is: highly mechanised; has a high energy consumption (thus, modern agriculture uses five times more energy than it produces in the form of agricultural products); has large production units (which demand sophisticated infra-structures, a large population, markets and a high purchasing power); and is capital intensive. And with these there is also know-how, administrative ability and innovation capacity.

Traditional technology has none of that. By contrast it is manpower intensive, with a low energy consumption, has small production units, and is less capital intensive.

I shall develop this with reference to health and food.

The World Health Organisation (WHO) make clear that the aim of health for all by 2000 rests in great part on overcoming poverty and malnutrition, which are stimulated by overpopulation, which in itself is a cause of disease, poverty and malnutrition. There is increase of population because large families provide food-winners, and there is the near certainty that at least half of the children will die in infancy or early childhood.

Annual deaths are estimated at some 15m . They die mainly from diarrhoea diseases caused by contaminated water supplies and faulty hygiene, and malnutrition. The other major health problem for all - adults and children - is from parasitic disease: 500m threatened by amoebiasis; 1.2 billion by malaria, with about 175m infected each year; 70m by trypanosomiasis. These are morbidity, not mortality, statistics. Actual annual deaths are very much smaller. Thus, the problem is of living with chronic, debilitating and often incapacitating disease, a burden on an impoverished community. The numbers are large: some 15m lepers and some 20m blind from trachoma. The crippling loss of human energy and productivity is significant in economic terms.

Much can be done to counter these diseases. In the last century, drinking water contaminated by human faeces was the greatest single cause of disease in the Western world. Typhoid fever, cholera and dysentery were rampant until sanitary engineering with good plumbing took over. And it was only 50 years ago that the industrialised world had available new techniques for treating and preventing infection on a large scale, so that the killer diseases of tuberculosis and rheumatic fever, and crippling tertiary syphilis have been conquered. Preventive medicine is the key, yet in TW nations the emphasis is still on curative medicine. Observe the contrast: China practises preventive medicine, Brazil does not: China's per capita GNP is one-fifth that of Brazil, but the average expectation of life in China is several years more than in Brazil.

So far as parasitic diseases are concerned, there is great basic ignorance about the pharmacological and immunological aspects. Much research is needed, and now is the time to engage in this. Cellular biologists can cultivate malarial parasites, immunologists are active in work on surface antigens, and molecular biologists are about to clone the genes responsible for the surface agents with which malaria parasites protect themselves against the infected human host. A malaria vaccine is on the way (but nobody can say when); and if a vaccine can be produced against the trypanosome infection in humans and farm animals, agriculture would have available in Africa alone a vast fertile area at present almost uninhabitable. Resources made available for parasitology research should provide new frontiers of social and economic benefit. Agriculture can be transformed by genetic manipulation, which will improve the stress tolerance and disease resistance of crops and grasslands. This would make available some 40% of the world's uncultivated but potentially productive land.

How is this transformation to be secured? It requires action on an international, coordinated scale in close collaboration and consultation with the countries affected. A conclusion to be drawn from this positive use of S&T is that population growth might be halted as parents develop confidence that their children will not suffer an early death. This would be linked with the upswing in basic health standards and in food. But two things are needed: one, communal stress on economic self-reliance; and two, the development of confidence and endogenous expertise. Neither can be secured without the popular presentation of S&T, for self-reliance is meaningless without the understanding and motivated support of the people.

Most people in the TW live in the countryside. It means their life-styles are traditional, relatively unaffected by industrial civilisation. To be self-reliant they must insist on asserting their cultural identity, to develop their cultural heritage. For instance, in countries such as India, where there are rich cultural traditions, rural people drink water out of a clay pot in every house; this practice must be reinforced so that it is not replaced by the imported metal container, which in time kills the local technology. The shaping of clay by a variety of techniques - unbaked or baked to become terracotta - has been, and is, a medium to serve art, religion and everyday needs. A pot, also, is made in an extremely scientific manner. It represents linear links with traditions going back some 4000 years.

I give the clay pot as one example of the approach needed in popular presentation. It presents S&T as part of general culture, for, as distinct from Western society, as I stated in my first lecture, there is no dichotomy between endogenous technology and its application.

But the imitative pressures of urban society are oppressive. A warning is necessary. Imitation of First World institutions needs to be most carefully considered. TW countries have tended to extrapolate from happenings in industrialised countries, often their former colonial rulers, and mechanically to apply solutions designed for basically different - but seemingly similar - situations. Examples are the Academies of Science and the Associations for the Advancement of Science which have come into existence in a number of TW countries. As with the transfer of technology, the transfer of institutions can be most harmful. There is a view that the creation of such institutions is an indication of national development. It is usually a status symbol conferring a false dignity on office holders: possibly an indication of flattery to the country's leader or ruling party that all goes well. There may be, also, the influence of the concept of 'less developed' or 'underdeveloped' or 'developing': that is, a TW country may be stating, 'Look, see how we are advancing ...' in using technologies which are culture-bound to another environment. It is true that there are no distinct techniques which without reservation can be applied to meet poverty and economic backwardness. That is why 'indiscriminate' borrowing may flourish.

Many TW countries and regions are creating associations of S&T writers. I would advise them to wait. Perhaps an entirely new form of association is needed, and will develop. What is required is not the presentation of Western-dominated, laboratory science, but the presentation of basic information in, say, coping with health problems and developing agriculture, always using local resources.

The written word is of little use. Most rural people are illiterate. In many communities of limited literacy, the habitual response is, 'We can't speak, we have no education.' There is a belief in educational inferiority, and there seems to be almost a compulsion for self-denigration before the mystique of education. According to Unesco, 41 in every 100 - and in some cases, 60 - are illiterate. The 123m children of primary school age have no opportunity to attend school, and of 314m adult illiterates, 60% are women.

In these circumstances, a technique I am much in favour of is the medium of popular theatre, so called because it is aimed at the whole community, not just those who are educated. Its forms include drama, puppetry, song and dance. Performances deal with local problems and situations with which people can identify. They are given without admission charge in a public place to ensure maximum attendance, and in the local language. But it is more than entertainment. It aims at securing what good popular presentation of S&T always dreams of - helping people to get interested in problems of concern to them, and then wanting to do something about solving them.

Experience in the use of the popular theatre has shown that if there is to be action, then people need to talk about the problem in common, to agree communally on what to do, and if necessary, to seek further information and skills: for example, on how to make a new type of latrine, or how to grow vegetables. Popular theatre fails if it is not combined with such extension work as discussions, demonstrations and practical activities.

A great advantage is that there are no special or difficult skills to be learned. Rural life in the TW is full of songs, dances and stories, and the popular theatre builds on the fact that people sing while they work, dance at parties, and act out stories around the fire.

The actors who, as in the Laedza Batanani project in Botswana, are linked with the University's adult education extension programme involving agricultural, health and community development staff, use the popular theatre to explore and expose problems they want people to talk about. They improvise their own songs, plays and dances. All they need is a little time for preparation and practice, but not major rehearsals and routine memorising of lines. Spontaneity, more or less, is the keynote in providing a show, which can be organised speedily.

Each year the popular theatre campaigns are usually one-week programmes in which the team of actors tour the major villages in a district, with one day in each village, providing a one-and-a-half hour show, including drama,

puppetry, dancing, singing and drumbeat poetry. The aim is to stimulate community participation, discussion and action, so after each performance the actors and other extension workers involved divide the audience into groups and organise discussion of the problems.

A District Extension Team is responsible for planning and organising the campaign. They work out the detailed timetable and select problems they consider to be appropriate to be included along with those suggested by the community. Choice is made usually of such small tasks as a clean-up campaign, which can be done easily, and the result of which is clearly visible. Those tasks are done with local rather than with government resources and action. Problems selected are those whose solution can be aided without difficulty by regular extension work.

In 1975, for example, the Laedza Batanani team chose poor diet as their topic. The solution needed an integrated approach involving improved nutrition, home gardens, and new cookery methods. Other issues presented included cattle theft, inflation and unemployment, the effect on community and family life of migrant labour and the drift to towns, the conflict between modern and traditional practices, school-leavers, and family and health problems. The District Team is responsible, also, for working out the costs of the campaign. Normally, this is not expensive. Many costs, such as transport and salaries, are met by the university department, and equipment costs are minimal, usually for the stage backdrop (a piece of painted canvas) and a puppet stage.

TW popular theatre presents much of value to the industrialised world. Its value lies in its role of social transformation. In Latin America it is used as a form in 'the struggle for the transformation of society' (TW Popular Theatre Newsletter, 1982): in Bangladesh, as a tool working 'closely with popular organisations committed to the struggle against the social, economic, political and cultural oppression of the people.'

I am not concerned here with the obvious fact that the popular theatre has the ability to transform its presentations into direct political statements. The Catholic Church in Latin America is well aware of the impossibility of avoiding such statements, despite the negative voice of Rome. I am convinced that appropriate technological solutions for TV countries are not available yet, and that such solutions will have to be derived by making use of and developing new criteria and approaches. Popular theatre is an important way of having people come to grips with reality, of ensuring self-reliance is not concerned with romanticising a cultural heritage, but with developing and implementing realistic and enlightened policies.

What of the other forms of mass communication - radio and the press?

Radio is of importance because for the majority of people the spoken word is still the most important form of communication. Most people live in rural areas and have been brought up in an oral tradition, learning about their village and the people who live there through songs and stories, many of which have been passed down by word of mouth for generations.

Against this background, radio is the only form of mass communication which is likely to have any impact on these communities. Although television undoubtedly would have an appeal, the sheer expense of the equipment needed to make and receive programmes places TV way beyond the local means.

According to the latest International Broadcasting and Audience research figures published by the BBC, in most African countries it is impossible to measure how many TV sets there are because they are so scarce. Radio sets, however, are common. In Nigeria, for instance, there are 17 radio sets per 100 of the population, and in Equatorial Guinea 27 per 100 of the population. This is not impressive when compared with Great Britain, where almost everyone has a radio set, but they are impressive figures in countries where it is usual for a village to use one set communally. People gather to listen to the news bulletin or a particular programme.

In the Pacific and Caribbean regions, where village and tribal links are not so strong, many more people own radios personally: for example, in

Fiji and Jamaica more people own radio sets than in Portugal (in Fiji 61, and in Jamaica 40, per 100 of the population.)

The great advantage of radio over other forms of communication are flexibility and comparatively low cost. Transistor radios are within the means of most people who earn a wage. Also, it is quite cheap to make a programme. One person with a portable tape-recorder can make perfectly adequate programmes.

In countries where most people have little or no access to formal education, neither newspapers nor books will have an impact, and both these media are comparatively expensive to produce and to distribute in remote areas where transport and communication lines are unreliable. The radio is used instead.

The Gambia, in West Africa, uses radio extensively to inform and educate in a wide variety of subjects, including technology and science. The Gambia, as with many African countries, has many different local languages, and this presents an added reason why printed matter is difficult and expensive to produce. This presents little problem for radio. The national radio station divides its output during the day into four main sections, and carries material in all the local languages, and in English.

Programme-makers can be very mobile, collecting material from remote areas and involving local people in programming. This generates much interest in the output of a radio station. In The Gambia, for instance, two most successful programmes are one for farmers, which includes interviews with Gambian farmers, and a self-help development magazine, called Tesito, which also includes interviews with local people running such schemes.

This approach to programming is common in the tropics. Fiji Broadcasting divides the day up to allow programming in Hindi, English and Fijian. And it will send programme-makers out into the communities with portable equipment.

This ability to control programming effectively is the main reason why radio is not going to be superseded by TV in the near future. Fiji, for instance, could afford a TV service, but has chosen not to because it would not be able to afford to produce all its own programmes. The government see that Fijian culture would suffer if air time was taken up by cheap imported American films and videos.

Radio is a powerful medium. Its impact can be considerable because it makes great demands on its audience. As the listener has to supply his own mental images, a good deal of imagination is required, and there is considerable audience involvement. Listeners to the BBC World Service often identify strongly with the announcers: a retired BBC announcer, Peter King, has newspaper clippings from African papers to prove that people in Ghana have named their children after him!

By and large, the press in the TW cannot handle a science story if it has not been interpreted by the overseas press or news agency. This is becoming less true as the regular presentation of science is coming to be accepted as a normal function of the leading Third World newspapers or popular magazines. A few papers may have a part-time scientific correspondent.

By contrast, the Chinese Science Journalists' Association (CSJA), founded in 1981, has about 600 members, all editors and reporters in the mass media. Two-thirds have a scientific or engineering background, and the remainder have been trained in journalism. The majority are college and university graduates.

What is needed urgently is to train the press and the scientists to get to know each other. An interesting pioneer example was when about 60 journalists, publicity experts and agricultural scientists met early in 1985 at the International Institute of Tropical Agriculture (IITA), in a three-day work hop on the role of the mass media in food production in Africa. It was designed, as IITA director-general Ermond H.Hartmans put it, to 'create new pathways between the research station and the farm' by establishing a partnership between science and journalism.

There is much good research carried out in universities, and in publicly-funded research institutions. Most TW countries have research

departments dealing with such basic topics as agriculture, fisheries, forestry and health. And some individual countries host international research institutes, for crops such as cocoa, palm oil, rice or rubber. There are good stories in each of these. Journalists need to be made aware of them.

Special mention must be made of the rural newspaper, with a content and style linked with the specific information needs of the community, much as is the English local paper, and read only locally. In Africa, such papers are recent: they began in Liberia in 1963 and in Niger in 1964, in the form of mimeographed bulletins concerned with literacy. In 1972, following a survey of 11 African countries which indicated the practicability of a rural press where printing facilities and basic journalism skills were available, and where there was an on-going literacy or rural development campaign, Mali launched a rural paper, Kibaru, under the direction of the National Agency of Information and of the daily paper, L'Essor. This followed certain guidelines suggested by experts, and the paper soon had a circulation of 10,000 copies.

A Unesco survey published in 1981 states that at present not one African rural newspaper is economically autonomous, and their future expansion cannot be left to chance. However, throughout Africa there do exist training and research institutes for rural journalists, and the papers do offer a field for the expression of science in relation to local needs. This should be linked with a national scientific and technical information service.

HOW TO TACKLE THE SOCIAL AND ECONOMIC PROBLEMS OF INDUSTRIALIZED COUNTRIES WITHOUT DAMAGING DEVELOPING COUNTRIES: A CASE STUDY OF THE NETHERLANDS

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This article is concerned with a small, open and industrialized economy, namely the Netherlands, in the face of a rapidly changing world economic structure.

Many Europeans consider that things are not going well in their region because of world-wide economic problems. This is not entirely correct. During the 1970s, for example, Latin America grew at a rate of more than six per cent and Southeast Asia at more than eight per cent per annum. European growth, however, was not more than two-and-a-half to three per cent during the 1970s. In times of economic down-turn and rising unemployment, the industrialized countries and particularly the smaller ones, will be tempted to put the blame on factors outside their control rather than to look actively for policy changes that they would be able to influence. In other words, they will be tempted to become inward-oriented, protectionist, and to move against trends that were initiated during the 1970s with respect, for instance, to the setting-up of a new international economic order.

It is all too easy to criticize the industrialized countries for becoming more protectionist and for moving against a one-world

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approach, but the pressures within these countries, coming from interest groups of all kinds, not least the trade unions and employers' associations, are such that defensive policy measures are almost inevitable.

We are faced here with a typical situation in which important policy measures are taken within industrialized countries which have major implications for the rest of the world, including the developing countries. The question is whether it is possible to identify policy changes addressed to economic and employment problems in the industrialized countries, which are not only effective within these countries but which do not go against the legitimate interests of developing countries.

This article is a first attempt at a case study of the conditions that need to be fulfilled by a relatively small industrialized country in order both to tackle its own problems and to continue to move in a one-world direction.

The article first provides the background to the economic slowdown in the Netherlands before describing the nature of the unemployment problem that faces the country. It then considers the policy problem, namely, how to return to a qualitatively acceptable rate of economic growth and to realize full employment 'new style'. The latter condition, in particular, must be fulfilled if the country is to resist tendencies towards protectionism and towards stifling the economic structure even further with measures dictated by short-term employment objectives that go against both the long-term interests of the Dutch economy as a whole and the interests of the developing countries.

I. CHANGES IN THE STRUCTURE OF THE WORLD ECONOMY

The world economy has seen numerous developments during the past decade, while some previous trends have been continued and intensified. The oil-producing countries, for instance, successfully established their cartel, with subsequent effects on oil prices. Enormous sums of OPEC money have been re-cycled with the aid of the European credit market, and balance-of-payments problems have become all too familiar in the oil-importing countries. Decreased growth by industrialized countries has been coupled with an increased inclination towards protectionism. This impeded the trade liberalization which had made reasonable progress in the 1960s, and had a negative effect on LDC attempts towards industrialization.

Another new element which made itself felt in the 1970s has to do with international monetary relations and, although heralded even before the developments described above, is closely connected to them, i.e. the financial position of the poor countries, which are becoming ever harder pressed. The crucial problem here is whether or not the implementation of development strategies will be further hampered by the LDCs' growing financial deficits. The transfer of technology from North to South will also continue to be a major problem, mainly because of the insufficient control exercised by governments, and is likely to be enhanced by the new labour-saving technologies such as micro-electronics.

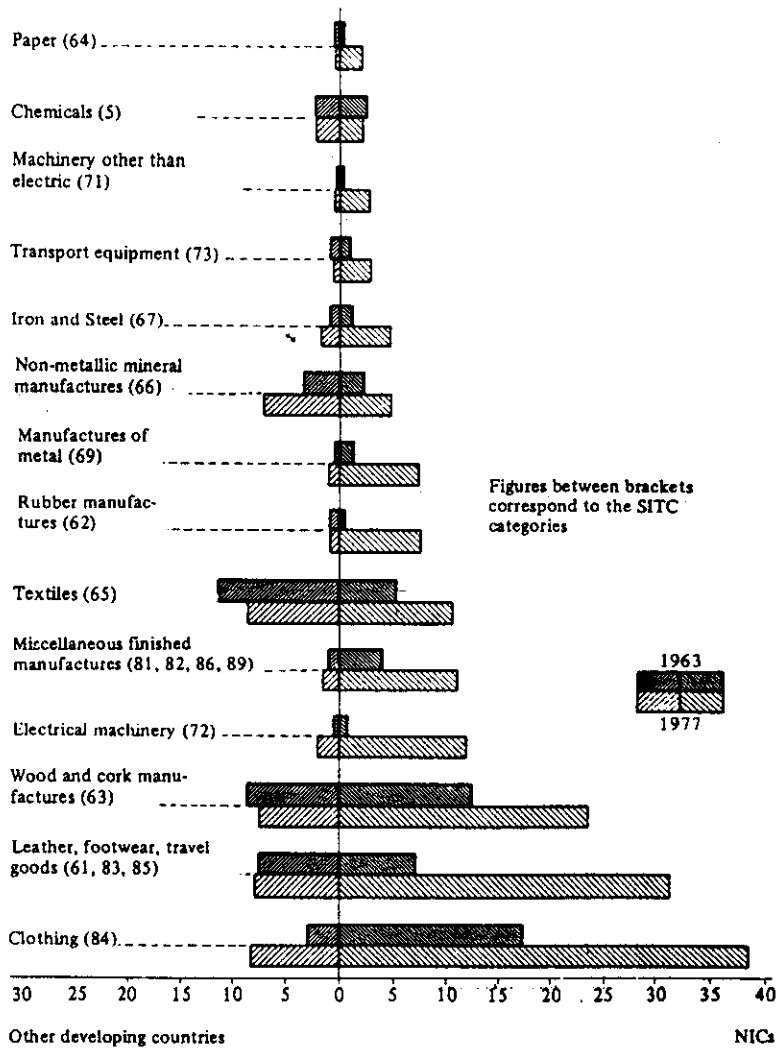
Thus, the factors that determine changes in the world economic structure in the 1980s will continue to be many and complex. Within the scope of the present article, an analysis must necessarily be restricted to those factors which are likely to become of increasing significance. I shall therefore make brief reference to shifts in the geographical location of industries and in the allied trade flows, and to the importance of the Newly Industrializing Countries (NICs).

Although the greatest trade flows still take place among industrialized OECD countries, particularly if oil is excluded, this does not alter the fact that some NICs have made considerable progress as regards their share in OECD imports. Their role in the transformation of the world economy which has taken place since the early 1960s is indicated by a recent OECD study.[1]

The geographical distribution of industrial production (with the exception of the Eastern bloc) changed during the 1960s and 1970s: the share of Brazil and Mexico, of the four Asian states (Hong Kong, Singapore, Taiwan and Korea) and of four Southern European countries (Spain, Portugal, Greece and Yugoslavia) increased rapidly, from 5.4 per cent in 1963 to 9.3 per cent in 1977. The share of the industrialized countries, with the exception of Japan, showed a corresponding reduction.

An examination of product groups shows that NIC exports (and those of other developing countries) have concentrated on specific products, conform with their comparative advantage and supported by selective export promotion. This, in combination with their adverse employment situation, has caused the rich countries to draw up plans of action by which to counteract market penetra-

Figure 1. *Share of the NICs and of Other Developing Countries in Total Imports of OECD Countries, According to a Number of Commodity Groups, 1963-77 (in per cent)*



Source: OECD: *The Impact of the Newly Industrializing Countries on Production and Trade in Manufactures* (Paris, 1979).

tion by 'aggressive' developing countries. There is indeed sharp competition and a rapid growth in some product lines. In other words, although market penetration on the whole is still fairly modest, it is quite significant for certain products, e.g. clothing, leathergoods and footwear, wood and cork, and to a lesser extent textiles. The share of developing countries, including the NICs, in total OECD imports of such products has increased to almost 40 per cent (see Figure 1).

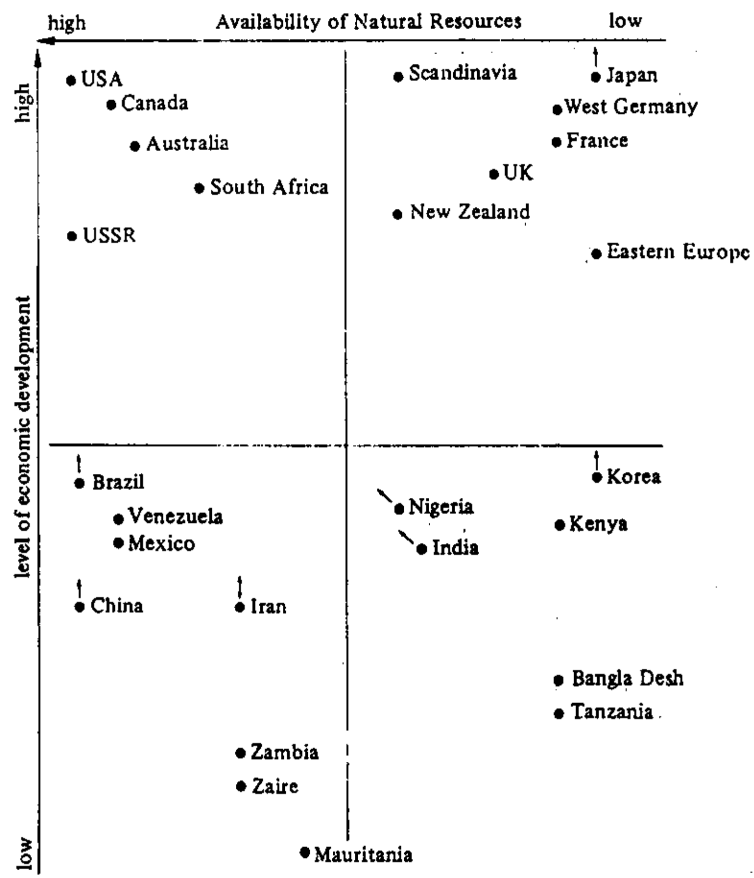
The damage thus caused by the LDCs to certain industrial branches of the rich countries (frequently in regional concentrations) may be the reason for the present general anxiety and for the tendency shown by many industrialized countries towards protectionism. Without under-estimating the economic, regional and individual problems caused by such penetration, the fear that the employment situation will be worsened by trade with the LDCs and by opening-up markets to their products, is not substantiated by a series of recent empirical studies.[2]

In the industrialized countries in which these studies were carried out, including the Netherlands, fewer workplaces have been lost due to increasing imports *from* LDCs than have been gained due to the increasing exports *to* those countries.

Figure 2 enables us to take a quick glance at the future for various countries, including the USA and Japan. These are arranged on a four-quadrant graph constructed from two axes, one indicating actual per capita income, and the other the availability of natural resources, thus illustrating their growth potential. Within these limitations, specific factors play a role, e.g. the availability of technology, social structures, international relations. The first of these will become increasingly significant. The traditional model of the optimal international division of labour is based too emphatically on the assumption that labour-intensive industrialization will occur in the developing countries and capital-intensive production in the industrialized countries.

Micro-electronics in particular give the developing countries — principally those in the lower lefthand quadrant — a chance to join the leaders more rapidly. These LDCs, which so far have not been successful in providing even the most basic needs for their peoples, may well take the view that labour-intensive technology is a pitfall and that their economies would best be stimulated by a changeover to a technology that would provide an enormous stimulation to their productivity and consequently to their level of production.

Figure 2. *Global Division of Countries According to their Development Potential*



Source: L. J. Emmerij: 'Mogelijke gevolgen van de micro-elektronica voor de internationale arbeidsverdeling' (Possible consequences of micro-electronics for the international division of labour), *Economisch Statistische Berichten,* 12 March 1980.

The classification used in Figure 2 would seem to indicate possible global shifts rather better than those more commonly used. The horizontal axis shows (potential) available natural resources and raw materials, climbing from right to left. The vertical axis represents the level of economic development.

The lefthand upper quadrant shows those countries that are wealthy as regards both income and natural resources. Top right are those nations which, although rich as regards income, are short of natural resources. In the lefthand lower quadrant we see the probable climbers, i.e. those countries that are at present poor as regards income but which have enormous potential due to their wealth of natural resources. And finally, in the lower righthand quadrant, are those which are poor as regards both income and natural resources. In each of the quadrants a few countries only have been used for illustrative purposes.

On the basis of the global spread of the two criteria and of the related opportunities for the application of technology, Figure 2 should give us some idea of the future direction of the international redistribution of income and wealth.

An interesting fact is that Europe and Japan are both in the upper righthand quadrant. Their relative lack of natural resources entails that they must continue to rely chiefly upon their knowhow, on their managerial skills, on the initiatives of their peoples, etc. They will need to make great efforts as regards education and research and also to gain and maintain a lead in the technological sphere. It seems very unlikely, however, that those rapidly-industrializing countries which are able to buy themselves into the nuclear race, will not do the same as regards micro-electronics. On the contrary, they will inevitably play a part in the production and particularly the use of micro-electronics, whatever attitude is taken by the governments of the rich nations and by the multinationals.

The important fact, however, is that the USA and Japan are far ahead as regards the development and use of micro-electronics, so that the position of Europe is increasingly threatened.

II. THE DUTCH ECONOMY IN TURBULENT TIMES

Structural Changes

For policy purposes, it is important to trace any 'typical' national

characteristics in a given economic structure or pattern of specialization. The Dutch economy, so badly damaged during the war, was rapidly reconstructed during the 1950s. The 'social partners', i.e. employers and employees, were both agreed that growth and reinvestment of profits were prime necessities, and major wage conflicts did not occur. Consequently, the country enjoyed strong economic growth with reasonably stable wage levels.

Due to the war, the Netherlands had a five-year technological backlog, while that same war had given rise to countless new techniques. The result was a considerable propensity to invest. Partly due to wage constraints, the country was able to enjoy a comparative advantage over other countries, and the volume of Dutch exports rose rapidly. Unemployment was at first still fairly considerable due to lack of capital for investment purposes, but by the mid-1950s the economy was fairly stable and unemployment figures had dropped.

Economic growth accelerated during the 1960s, partly due to the rapid increase in world trade and partly to the country's continuing competitive position. The influence of the European Economic Community was also beginning to be felt. In the early 1960s, even, this high and sustained growth caused a shortage of manpower, which had a series of consequences:

- wage conflicts, resulting in major wage increases in 1964, 1965 and 1966;
- investments became more labour-*extensive*; and
- the Netherlands became an immigrant country.

The tide began to turn in the late 1960s, both as regards the world economy and as regards the domestic situation. Processes had been set in motion which caused an upward pressure on prices and domestic prices rose sharply. Automatic price compensation was introduced and price increases were immediately made good in the wages, leading in turn to the introduction of labour-saving techniques. In 1973 the situation was aggravated by the oil crisis, when oil prices quadrupled almost from one day to the next. To many, all this merely confirmed the gloomy prospects outlined in the first report to the Club of Rome, published in 1972 and entitled *Limits to Growth*. In retrospect, however, the victims of the crisis were not so much the Western countries as the poorest of the Third World. At the same time, another disturbing phenomenon made itself felt, i.e. the simultaneous increase of inflation and of unemployment, the so-called stagflation.

Table 1. *The Growth of Production and Employment in Dutch Industry 1953-1977 (percentage change per annum)*

	1953-1963 Production	1953-1963 Employment	1963-1973 Production	1963-1973 Employment	1973-1977 Production	1973-1977 Employment
Food industry —farming products	5.2	1.6	4.0	0.8	0.8	-1.9
—others	3.2	-0.1	3.6	-1.3	1.1	-3.4
Alcohol and tobacco	6.0	0.3	7.6	-1.7	5.0	-0.9
Textiles	3.2	-1.0	0.8	-5.5	-4.5	-7.2
Clothing, leather and footwear	3.0	0.8	-2.8	-6.6	-9.6	-12.7
Paper and graphical industry	8.9	3.1	4.7	0.5	2.1	-1.3
Wood and building materials	6.3	1.0	5.2	-1.0	0.3	-3.4
Chemicals and rubber	9.7	3.9	12.2	1.4	2.5	-0.7
Basic metals	10.5	6.4	9.3	2.7	-2.5	-1.4
Metal products and optical industry	6.2	2.2	5.7	—	1.5	-1.6
Electro-technical industry	14.5	5.3	7.9	1.2	2.5	-1.7
Transport	3.1	-0.1	4.9	1.5	-1.7	-2.3
Petroleum	8.0	3.4	9.0	4.6	-2.4	-1.1
Total	6.3	1.6	6.1	-0.7	0.8	-2.7

Source: Adapted from Tables 6.5 and 6.7 in C.A. van Beld: 'De-industrialization in the Netherlands?', in F. Blackaby (ed.): *De-industrialization* (London, Heinemann Educational Books, 1979), 124-140.

We are now in a situation of increasing unemployment and of inappreciable economic growth, and significant sectors of industry are structurally in very poor condition. This is shown by Table 1 which gives the growth of production and of employment in the industrial sector from the early 1950s to the late 1970s. It will be seen

that output grew most rapidly in the oil-refining, electro-technical, basic metals and chemical industries, all of which evolved more quickly than the industrial average in the period 1953-73.

In the 1950s and early 1960s the electro-technical industry realized an annual growth rate of 14.5 per cent, while the chemicals industry grew by an annual average of 12.2 per cent in the 1960s and early 1970s. Both these instances were double the growth averaged by the industrial sector for those periods.

The specialization pattern of the Dutch economy, as has been confirmed by a recent report,[3] shows the following characteristics: large-scale rather than small-scale; restricted rather than pluriform specializations; bulk-oriented rather than differentiated or refined; intermediary rather than capital goods; and processing rather than engineering skills.

Table 1 shows that the turning point in industrial development announced itself in the 1960s and intensified in the following decade. The Dutch specialization pattern is based particularly on capital- and energy-intensity. More specifically, the Netherlands had comparative advantages in those goods which require highly-intensive use of skilled labour, research and energy. Capital intensity in itself has never been sufficient.

All these elements, which determine the structure of the Dutch economy, have undergone considerable change during the last few years, and as a result the country is now less competitive. This has been due not only to developments on the wage front, including the burden of social security, or to the increased value of the guilder. It has also been caused by the fact that short-term employment objectives were considered more important than the long-term health and robustness of the economy, so that the economic structure has not evolved in line with changes in the world economy.

Changes in the Employment Situation

To achieve and maintain a situation of full employment, the national economy needs to grow in such a way that sufficient workplaces can be created, complementary to increases in labour productivity which imply that the same amount of goods can be produced with less people. If, for example, labour productivity rises by four per cent per year and the labour force by one per cent, then a growth rate of approximately five per cent is needed if full employment is to be guaranteed. The growth rate can only rise above five per cent if machines are made more productive (technological adaptation) or if extra labour is brought in (housewives, part-timers, immigrant workers).

For 25 years after the war, in fact, the Dutch growth rate was such that it was felt that times of great unemployment had been left behind. Tremendous technological change in a particular sector had its spread effects in other sectors so that, globally speaking, jobs lost in one sector were more than compensated by new jobs elsewhere.

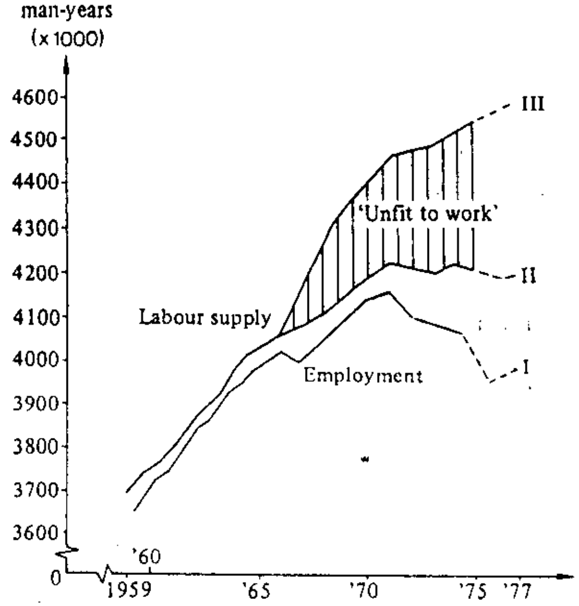
Table 1 also shows, however, that since the second half of the 1960s industry has ceased to expand as provider of employment. Early in the 1970s the industrial workforce began to diminish, to be followed by the building and trade sectors. Notwithstanding the creation of new jobs by government, problems also began to appear in the services sector (retrenchment by the banks due to automation). Since that time it has no longer been possible to create sufficient new jobs and unemployment has increased.

In actual fact, the decline in employment had started much earlier, but had been screened from public view because the expulsion of labour was expressed not in unemployment figures but in the rapidly increasing numbers of those who were declared 'unfit' to work, a fact that is clearly illustrated by Graph 1.

Prior to 1965-66 labour demand and supply had risen by approximately the same degree, what little unemployment there was being mainly of the 'frictional' type, i.e. caused by the time involved in finding other (available) employment. Employment then began to climb less rapidly (curve I in the graph evens out) until, around 1970-71, it began to show a definite drop. Labour supply (curve II) at first appeared to keep pace with this trend, but after 1971 this was no longer the case and unemployment began to rise. If we examine curve III, however, which represents those who were unfit to work, we see that the 1955-65 trend continues. As employment began to stagnate after 1970, the numbers of 'unfit' continued to rise.

All this makes it delusive to believe that labour supply did indeed keep pace with employment. Since the late 1960s, in fact, much of the expelled labour has not been expressed in the unemployment figures but has been 'hidden' in the increasing numbers of those who are 'unfit' — unless, of course, we are so gullible as to believe that the country has been hit by an epidemic which has made a multitude of people unfit to work.

Graph 1.



Source: C.H. van Ardenne & J. Muysken: 'De structurele werkloosheid...een somber perspectief' (Structural unemployment...a sombre outlook), *Economisch Statistische Berichten*, 10 November 1976.

The only feasible conclusion must be that the category 'unfit to work' hides many people who are unemployed rather than unfit.

Before making an attempt to outline a framework for future policy, at least one tentative conclusion should be drawn with regard to the present. In a rapidly changing world economic structure, the Netherlands is now on the defensive. Unintentionally and unexpectedly, we have drifted into a zero-growth situation which gives rise to growing unemployment and social tension. Our economy lags behind changes that take place elsewhere in the world, and our technological prospects are not encouraging.

What can be done?

III. THE CHOICE OF A SCENARIO

The *export scenario* takes as its starting point that small and open economies such as the Netherlands are largely dependent for their survival on their reactions to economic events outside their own frontiers. This scenario therefore emphasizes the export of goods and services. The stimulation of exports, it is believed, will crank-up the entire economic machinery. This will not necessarily create more workplaces in the export sector itself. Augmentation of our economic carrying capacity, however, would make it possible to do more in the collective sector, over and above the favourable effect that would radiate from a flourishing export sector. The instruments necessary for the enactment of this scenario may be found not only in an incomes policy, but above all, in a policy of economic restructuring which has an eye to the future.

The point of departure of the *public sector scenario* is that this sector should provide the economy with a new and viable basis, giving particular consideration to greater satisfaction of needs in the fields of education, health and geriatric care, welfare work, culture and recreation, etc. This sector would offer workplaces that are more suitable for women, who are likely to enter the labour market in greater numbers. The scenario requires a 'socialization of demand', i.e., that the government or the public sector workers in effect will decide which of the people's unsatisfied needs should be fulfilled — and it also threatens the continuation of the present distinction between 'male' and 'female' professions and jobs.

Under the *redistribution of work scenario*, unless it is combined with one or both of the other two, zero growth, or at most an extremely low economic growth, is taken as the point of departure. Attention is concentrated wholly on the supply side of the labour market in an attempt to ensure that available work is divided among more people, thus reducing the numbers of unemployed. Various instruments may be used for this purpose, including shorter working hours, early or flexible retirement, paid educative leave, etc., all of which will be discussed below. In the majority of cases, this scenario will demand a redistribution of income. Moreover, it is questionable whether a policy that is oriented solely towards safeguarding employment will be able to preserve even very limited economic growth.

Apart from certain advantages, all three scenarios have fairly considerable disadvantages. In practice, of course, a scenario should be adopted which combines elements of all three. My own preference, however, is for one in which the export sector is given pride of place, redistribution of work is given second place, and the public sector comes last, for the time being.

In brief, the emphasis on exports and on redistribution of work

would mean excluding the public sector as principal scenario. The expectation that employment is likely to be expanded in the public sector in the effort to meet needs that as yet have not even been felt, is dubious to say the least. Moreover, the public sector scenario is seen primarily as something to 'fall back' on: there is little choice left for anyone who does not believe in the feasibility of the export scenario or in redistribution of work. Finally, an important factor in the choice made here is that the public sector needs a base which only the export scenario can strengthen. Economic growth based only on an export scenario also has its shortcomings, however, and it is therefore essential that there should be clarity as to which sort of growth is to be pursued in the short term. The kind of economic growth in which we are interested will seek to produce not only more but better goods and services. In other words, their nature and costs will be better attuned to the needs and financial capacity of their users.

In addition to a considerable increase in prosperity, the growth of the 1950s and 1960s caused a great many problems which previously had been largely unknown. Since the end of the 1960s, as a result, it has increasingly been felt necessary that the industrialized countries should gradually reach a situation of equilibrium, in which everyone would have sufficient prosperity and further growth would not be necessary.

The desirability of such a situation was advocated primarily by those interested in environmental issues, people who were convinced that, within the foreseeable future, continued growth on the part of the industrialized nations would inevitably lead to the unacceptable pollution if not total destruction of our natural environment, and to the rapid exhaustion of scarce resources. This view was strengthened by the first report written for the Club of Rome (*The Limits to Growth*), which was published in 1972 and which received overwhelming attention, particularly in the Netherlands. This report came to the following conclusion:

> If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity (p. 29).

Development policies supported the idea of gradual stabilization of the economy in view of the growing conviction that continued growth by the industrialized countries would only aggravate the backlog of the LDCs. The RIO Report (1976), based on Tinbergen's 'quantitative illustration', advocated that the industrialized countries should reach a situation of equilibrium without further growth in roughly four decades. This was necessary in order that the ratio of real income per capita of the ten per cent of richest and poorest countries could be reduced during that period from 13:1 to 13:2 or preferably even 13:4.

The Environment Conference held in Stockholm in 1972 made the general public realize for the first time that living conditions are determined not only by a country's socio-economic development, but also by its natural environment. This is expressed in the 'eco-development' strategy which rejects both one-sided protection of the environment and one-sided economic growth.

Early in the 1980s the Dutch economy drifted into stagnation, and we realized that zero growth, if sudden and unintentional, can cause almost insurmountable problems. Not only has the economic base of our welfare state been affected, but also the economic latitude that is necessary for any socio-economic restructuring and redistribution of incomes.

In general, we shall have to orient ourselves towards growth in those goods and services whose benefits of production and use will surpass the costs involved. Both benefits and costs, of course, must be given the widest possible interpretation. Benefits will include the ways in which basic needs are satisfied, employment, and the regional spread effect. The costs must include the use of non-renewable energy and resources, and the calls made on the environment.

The following aspects should be given particular attention.

— *Energy*: in view of rising energy prices, the growing unreliability of supplies, and the increasing demands made on the environment as a result of our expanding use of energy, priority should be given to energy-extensive production, to production oriented towards the saving of energy, and to the development of other sources of energy.

— *Non-renewable resources:* in view of the increasing scarcity and rising prices of non-renewable resources, priority must be given to production that is raw materials-extensive and oriented towards renewed use of these resources or substitution by those which *are* renewable.

— *Environment:* in addition to more economic use of energy and of non-renewable resources, there is a strong preference for production systems which will reduce the pollution of air, soil and water, and which are oriented towards the renewed use and safe storage of residuary products.

— *Employment:* the production systems that are to be created or adapted should be easily adjustable to socio-economic change and technological innovations; this may be stimulated by encouraging small and medium-sized industry.

— *Quality of labour:* this will improve proportionately as production becomes divided into fewer stages and can be carried on in smaller units. Although the production organization will continue to play a role, it is the nature of the production process which is often of decisive significance.

— *The Third World:* the growth target should not have a hampering effect on the Third World. In other words, growth must not be accompanied by increased protectionism as regards imports from developing countries. An anticipatory policy of economic restructuring should be adapted to an increasing supply of (semi-)finished products from the Third World.

IV. GROWTH AND EMPLOYMENT NEW STYLE

In the 25 years after the war we experienced such growth that many began to think that times of major unemployment were a thing of the past. But industry ceased to attract new labour even as long ago as 1965, employment has declined from 1970 onwards, and unemployment has been on the increase since the early 1970s.

It seems unlikely that we shall achieve a return to full employment during the 1980s. In fact, there seems little prospect that the economy will pull itself up to any considerable extent under present-day policies; moreover, the relatively high labour productivity (in relation to the low economic growth) makes it unlikely that many jobs will be created during the coming few years.

As far as West European economies are concerned, the international division of labour and the comparative advantages are pushing them into an ever more labour-extensive direction. Between 1973 and 1978, therefore, the Dutch government intervened on a fairly massive scale with financial aid to industry, and it still does so to some extent. A very large proportion of these aid measures has been oriented towards preserving jobs, for political and also for humane reasons. At the same time, however, it has sometimes been difficult from both the legal and the economic viewpoint, to understand which criteria have been used by government in deciding to grant many millions of guilders in aid to enterprise A, but to refuse any sort of assistance to enterprise B, which may be in an equally serious situation.

The economic logic of providing direct subsidies to individual enterprises is only tenable if a firm is in temporary difficulties which have nothing to do with structural changes in the world economy and/or with changing comparative advantages. It seems indisputable that most of these subsidies have been granted in the hope of compensating for losses in the international markets. In other words, and with hindsight, the necessary adaptation of the Dutch economy to changes in the international division of labour has been hindered to the tune of billions of guilders. And all this has been done in an extremely disorganized, if not chaotic, manner.

It is obvious that export targets and employment objectives can be contradictory to one another. Economic restructuring is an important element of any policy that is intended to redirect the economy into an acceptable growth path. In the case of the Netherlands, incentives for such growth must be sought in foreign markets; the stimulation of international demand, therefore, can help to pull up our own economy. But even if it were possible to return to an economic growth rate of two to three, or even four to five per cent, it is doubtful whether full employment 'old style' could ever be achieved, particularly if such growth would be dependent on a restructuring which is likely to be labour-extensive. Clearly, therefore, any proposal intended to stimulate our economy in a certain direction must be accompanied by a credible employment and labour market policy. It is not enough to criticize the subsidization policy without suggesting alternative policies with which to attain the growth and employment targets.

Why Economic Growth?

Growth of the net national income means a greater national cake, and this is needed for a number of reasons. The total population of the Netherlands increases yearly by roughly 0.7 per cent. The national cake needs to grow at an equivalent rate if we are not all to

take a step backwards. The age composition of the population is also changing: the percentage of the aged is increasing and that of the young is decreasing. If the national cake does not grow, the result will be increasing pressure on the incomes of those in the 20-65 age group because old people are more 'expensive' than the young. The government 'intercedes' for the young with investments in education, but the aged require pensions and a complexity of social and medical provisions. An approximate annual growth of 0.4 per cent is necessary if the situation is not to deteriorate. This means a minimal requirement of 1.1 per cent 'statistical' growth if we accept zero growth per head and per age group.

The desire to achieve economic growth of roughly three per cent per annum derives from another objective, i.e. that as many people as possible should have employment. Economic growth is essential to create jobs in the public sector and to restrict the fall of employment in the private sector. Other ways of increasing employment, such as job creation in the non-commercial service sector, can only be introduced at the cost of reducing the funds available for other purposes.

The redistribution of employment means that the work that is available has to be shared among more people. The *amount* of work can only increase with economic growth, which is also essential if the quality of labour is to improve. The weak point in this reasoning is that all this is also possible without growth, but in that case other patterns of investment and distribution of income are necessary. For example, if job security is to be increased, less money will be available for investment. Redistribution of work also entails that one man must make sacrifices in order to help another. It ought to be possible without further growth, but this would place (too) great pressure on the democratic system if, as at present, we drift unpreparedly into zero growth. I would therefore advocate economic growth *now* in order that a balanced situation of qualitative growth might be achieved *later*, on the basis of careful planning.

Redistribution of growth is naturally a far more gradual affair. It increases the flexibility of society and avoids the almost insoluble problem of economizing at the expense of existing facilities and acquired rights. In the following we shall discuss two policy areas in which a qualitatively acceptable economic growth might be set in motion which will take account of the constraints imposed by the international division of labour and the development possibilities of the LDCs. These two policy spheres are economic restructuring and the stimulation of international demand. Their implications for the employment situation will also be examined.

Economic Restructuring

There is a growing current of opinion that we should switch from the defensive to the offensive and that we should adopt a policy of anticipatory economic restructuring. This is no simple matter, particularly in times of fairly high unemployment. In the past, many people have advocated that jobs should be retained at all cost. But such a defensive policy is short-sighted and would eventually cause a de-phasing of our economy with regard to the rest of the world. If we adhere to rigid structures for too long, our economic growth will decline even further, and the medium- and long-term employment situation will become even worse. This is a trend which must be brought to a halt. In a small and open economy it is necessary to foresee changes in the structure of the world economy, while the results of those changes may in no way be ignored.

Before discussing the instruments needed for an anticipatory restructuring policy, it is important to distinguish between the phases of industrial development: innovation or introduction; expansion; stagnation; decline. Under a policy of anticipatory restructuring, aid will be given primarily to industries in the introductory or expansion phase, and not to those that are in stagnation or decline. Aid to the latter should only be given if the intention is to maintain a strategic minimum, to overcome a cyclical downswing, or to ensure that the restructuring takes an orderly course. It is questionable whether the same treatment should be given to an entire industrial branch, and instruments should be designed with which to work across sectors. Even in sectors that are in decline, some industries may be innovational or expansionary. A coherent package of instruments must therefore be created, such as:

— improvement of the *entire framework* in order that the mobility of (skilled) labour, capital, technology and management may be increased;

— encourage the introduction of *innovations* by keeping up-to-date with scientific and technological research in order to accelerate the innovational process and to reap the accruing financial benefits;

— support to *medium- and small-scale industry*, in order to accelerate the application of new technological developments, e.g. in the field of micro-electronics, and to promote exports;

— support to *individual enterprises* in the innovational or expansionary phase;

— considerable support to a *few spearhead industries* over a longer period (5-10 years), not only in the financial sphere (subsidies or tax facilities) but also in the substantive sphere (university and technological research).

These are instruments that are applicable to all sectors, whether agricultural, industrial or commercial.

As regards the non-commercial services sector, the so-called quaternary sector, it is clear that if our main concern is to make the economy strong and healthy again, this sector is of relatively less importance than the others, with the exception of such items as education and research. Here, too, short-term employment targets should not be allowed to stand in the way of economic viability in the medium and long term. The quaternary sector is financed almost entirely out of public funds. Decision making is in considerable danger of being affected by the preferences of those who are employed in this sector. It is well known that many measures taken in the past with the intention of expanding employment in the quaternary sector have improved the secondary employment conditions of those engaged in that sector rather than the services provided.[4] This can only cause further pressure on public expenditure, which has its own consequences for the rest of the economy.

Stimulation of International Demand

It is of vital importance for the traditional industrial nations that they should have an effective economic restructuring policy. But the economic story also has its demand side.

It is absurd that part of our productive capacity (human and physical) cannot be used because of the economic depression, while hundreds of millions of people in the world have to go without the most basic necessities that would enable them to lead a reasonable existence. A country such as the Netherlands, again because of its open economy, should stimulate international demand in order to achieve further growth. Many proposals have been made in this respect, most recently in the report of the Brandt Commission: *North-South: A Programme for Survival.*

All these proposals advocate an important increase in capital transfers to the developing countries, particularly to the poorest among them. This will be in the interests of the poor countries, at least inasfar as such transfers enable them to stimulate their own economic development. It will also be in the interests of the rich nations who will be able to increase their exports to the developing countries. Such proposals have their snags, of course. Pressure will be brought to bear to ensure that industries which are in trouble will benefit from export orders. This would interfere with economic restructuring and, in the long run, would have a negative effect. Moreover, it would not be correct towards the poor countries — it would be a very happy coincidence if the developing countries just happened to be in need of those goods that are produced by our problem industries!

The restructuring policy proposed above must therefore allow for the effect of the needs of the poorest countries on the composition of our own export package. Institutional provisions might be introduced by which medium- and small-scale industries are mobilized within the framework of a plan for the stimulation of international demand. Such a plan is more likely to gain acceptance if it is oriented towards the realization of targets of general appeal, e.g. in the fields of energy, food, infrastructure, etc. Moreover, a regional or sub-regional alliance would enable both the poorest and the less poor countries to benefit. A major problem, however, is whether such a plan should be financed solely from development aid moneys, or whether other government funds should be used.

A plan for major capital transfers should be financed primarily from public funds (together with international levies, as suggested by the Brandt Report). The financing should be realized as much as possible through multilateral channels and should be tied to clear-cut targets, while the moneys should be spent within *all countries that participate in the plan*. On the European level, the Netherlands should make every effort to ensure that a European initiative is taken in this respect.

It has been remarked earlier in this article that a return to full employment in the traditional sense cannot be attained in the short and medium term. In the Netherlands the labour force is likely to increase by 50,000 per annum during the coming decade. At this moment (April 1982) the numbers of open and hidden unemployed are estimated at over 750,000: i.e. 500,000 open unemployed, 200,000 'hidden' unemployed who have been declared 'unfit' to work, and roughly 70,000 who want to work but who fall into the category of 'discouraged demand' (particularly women, who no longer register at the employment exchange because they do not believe that they stand any chance of finding employment). If we are to make up for this backlog, and keeping 'frictional' unemployment in mind, we shall need to create an extra 60,000 jobs each year for the coming ten years. In total, therefore, over 100,000 jobs *each year* during the 1980s.

Assume for a moment that an effective economic policy, as suggested in this article, would enable us to climb back to an annual economic growth rate of three per cent or perhaps even four per cent. Labour productivity would be responsible for at least two to two-and-a-half per cent of that growth, leaving at the most one to one-and-a-half per cent for job creation, i.e. 40,000 to 50,000 new jobs each year in the most optimistic hypothesis. This is obviously far from sufficient and something will therefore need to be done on the supply side of the labour market. Something is already done, of course, in the sense that surplus labour is relegated to the categories of unemployed, unfit to work, etc. The Dutch population has to provide *35 billion guilders each year* for this purpose, i.e. 35 billion guilders to expel people from the labour process and to keep them dissatisfied and unhappy!

What could be more simple than to use that enormous sum of money in a far more positive manner, e.g. by giving people the chance to withdraw from the labour market for some length of time in order to do things for which they feel motivated and which will enable them to become more resistant and flexible with respect to life in general and to the labour market in particular.

This brings me to a brief survey, from an employment perspective, of ways in which working time can be reduced and/or available work can be redistributed, all of which have attracted some attention.

Early retirement. To lower the retirement age from 65 to 63 will not free many jobs since more than half the 63 and 64-year-olds are already in the 'unfit to work' category. Many others are in jobs which will be done away with once these older employees disappear from the scene. This leaves maybe 20 to 25 per cent of the jobs presently held by older people which can be taken over by younger workers.

Raising the school-leaving age. To use the school as a parking place in order to prevent youth from entering the labour market is a somewhat negative measure. Moreover, most of the 16 and 17-year-olds already go to school and the remainder do not all seek employment. There remain 20 to 25 per cent of this age group who would normally enter the labour market but who will be obliged to stay at school — if and when the school-leaving age is extended to 18 years.

Some people contend that such a measure helps to achieve an important social objective, i.e. to keep working class youth at school longer in order to increase their educational opportunities. This objective could be achieved in another and more effective manner, however, to which I shall refer presently. A disadvantage of extending the school-leaving age is that more and more young people are obliged to remain at school without motivation. This increases the charges on the education budget while its contribution to the educational achievements of the young is dubious.

Longer vacations. This is only mentioned for the sake of completeness since, unless holidays become far longer (meaning, in effect, paid leave), such a measure has little or no effect on the employment situation.

A shorter working week. In the medium term this measure is unlikely to be of much benefit. The level of employment or of unemployment will not change, whether the working week lasts 48, 40 or 35 hours. Employers have always protested when a shortening of the working week has come up for discussion, but we have seen repeatedly that the result has been better than anticipated, the lost time being compensated by higher labour productivity and technological adaptations. Nowadays, the trade unions go to the other extreme, opining that such a measure would make it possible to create more jobs, but this is just as naïve as the position adopted

by the employers. Technology and labour productivity would very soon adapt to the new situation and a new cycle of worktime redutions would be needed. This is a typical example of a measure that is irreversible, which should be avoided at all costs in a society that has a growing need for flexibility. Also, such a measure would only aggravate the scarcity of certain qualifications. From the viewpoint of global employment at least, it would be a different matter if the working week were to be reduced with a comparable reduction of wages.

A shorter working day. This alternative would redistribute rather than free working places, and implies that income must be surrendered. In effect, this would mean a shift from the present situation of one job for one person to a situation of one job for two people. By definition, this measure means that far more people will be in paid employment since each job will be split into two. It is hardly surprising that the feminist movements show particular support for such a measure: not only will paid work be re-allocated but in principle the *unpaid*, e.g. household, work should also be affected. On the other hand, this measure would mean not only that everyone (particularly in the lower income categories) is obliged to seek a partner, but that that partner is also obliged to work. At first sight this might seem somewhat dictatorial unless a far more subtle and differentiated system is favoured which would have its own consequences on the effectiveness of the proposal. If this greater elasticity should make it possible for an individual to accumulate two jobs, however, the effect would soon be nullified, and the situation would be likely to worsen in the short term because people would work more than an eight-hour day.

Working less during the entire lifespan. In this concept the watertight divisions between life's various phases of school, work (whether paid or not) and retirement are discarded, and recurrent education and paid leave is introduced. The undeviating division of our lives relates less and less to individual aspirations and to the demands that socio-economic and technological developments make on the individual and society. The essence of this concept is that, dependent on economic circumstances, a larger or smaller part of the working population should be encouraged to withdraw temporarily from the labour market or their other 'normal' occupations in order to continue their education or to do other things. This system would create flexibility and, like an accordion, could be extended and again contracted. Instead of expelling hundreds of thousands of people from the labour market through unemployment, being declared 'unfit to work', etc., the same number would now be able to withdraw voluntarily and temporarily in order to do something positive. In this way we would have a continually changing group whose size would roughly equal that of the 'structural ejection' from the labour market. Weaker groups could thus be emancipated and need no longer be doomed to permanent unemployment. Women could be trained in such a way that they could re-enter the labour market without handicap (for this purpose, this is the only genuinely redistributive measure). The policy tool which could make all this possible is known as 'paid educational leave'; who knows, perhaps one day we shall also have 'paid creative leave'.[5]

In two respects, paid educational leave is distinguished from other work-sharing measures. Firstly, it is directed not only towards redistribution of labour, but also towards achieving equality of educational opportunity, towards realizing a flexible labour market policy, towards adapting to economic restructuring measures, and towards helping the individual to become socially more resistant. Secondly, paid educational leave will have a considerable effect that will extend far beyond the socio-cultural and economic spheres, although our interest here is almost solely in those characteristics that are of relevance to the labour market.

In the Netherlands, the Social Economic Council has concluded that reduction of working hours has little effect on employment, but that it has a negative effect on the growth of national income even if the workers surrender part of their wage and if the cost per hour worked does not change. Experiences with early retirement are also varied. In the metal and construction industries, roughly 70 per cent of the vacancies caused by early retirement have not been re-filled due to progressive automation; in the docks and harbours this amounts to roughly 30 per cent.

Both these systems are contradictory to a policy of economic restructuring which is active and oriented towards product innovation, since both of them are based on fairly passive endurance of non-employment. By linking shorter working hours to paid educational leave, however, the latter will form an effective link between economic restructuring and shorter working time. Paid leave makes it possible for employees to undergo re-training or to acquire

new skills. It offers a perspective for the employed and unemployed, and can also help to solve the problem of filling difficult vacancies.

Reduction of working time is a necessity, but most of the measures that have been suggested are based on the situation of the 1960s. 'More of the same' is their usual tenor. In no way do they seem to be inspired by present-day developments. As the starting point for recurrent education, paid educational leave would offer far more possibilities. It is no cure for all ills, but it would provide a hopeful prospect in that it links up both with the shortage of jobs and with the great changes that are likely to take place in the demand for labour, enabling variable groups of people to be removed from the labour market for re-training.

If paid educational or creative leave is not only to give the people more chance to determine their own future, but is also to help to solve the unemployment problem, then a start must be made by allowing people who are not in employment to leave the labour market; their places will then be taken by people who are involuntarily unemployed. The starting phase will be the most difficult in that it is always difficult to find guineapigs who can foresee the possibilities of a new situation. Once the initiative has been taken and the situation is stabilized, however, the benefits will be clear. At regular intervals, groups of people will leave the labour market temporarily on paid educational or creative leave, thus bringing about a situation in which, rather than being expelled from the labour market, people will be able to prepare themselves for their return at a later stage. This proposal would bring about a balanced situation in which economic restructuring is paralleled by individual restructuring, and investment in physical assets by investment in human resources.

A CONCLUDING REMARK

In this article I have tried to identify positive-sum-game solutions for the social and economic problems of a small industrialized country facing a rapidly changing world economic structure which is not moving in its favour.

At the moment of writing (April 1982), it is not clear whether Dutch policy will move in the direction indicated in the preceding pages. At present, emphasis is placed far too much on cutting wages and salaries, public expenditure and social security. The impression is often given that such measures alone are sufficient to solve the Dutch economic and social problems, and that there is nothing the matter with our economic structure, our export package, our labour market situation, etc.

The simple-minded and partial policies which, visibly at least, are being pursued, are putting the trade unions into an impossible situation; they are asked to surrender the gains they have made in the past, without any clarity as to what they will get in return. This heightens social and political tension, which does not augur well for enlightened policies such as have been described here.

If such a sequence of events were to occur in many industrialized countries, the big losers would be the poor countries rather than the rich — and within the rich countries, the poorly-off rather than the well-to-do.

● *NOTES*

1. OECD: *The Impact of the Newly Industrializing Countries on Production and Trade in Manufactures* (Paris, 1979).

2. For a recent synthesis, see G. Renshaw: *Employment, Trade and North-South Cooperation: An Overview* (Geneva, ILO, 1981).

3. Scientific Council on Government Policy: *Plaats en toekomst van de Nederlandse industrie* (Position and Future of Industry in the Netherlands; The Hague, Government Printing Office, 1980), 25.

4. Social & Cultural Planning Bureau/Central Planning Bureau: *De kwartaire sector in de jaren tachtig* (The Quaternary Sector in the 1980s; The Hague, 1980).

5. This suggestion is discussed extensively in L.J. Emmerij & J. Clobus: *Volledige werkgelegenheid door creatief verlof — naar een maatschappij van de vrije keuze* (Full Employment with the Aid of Creative Leave — Towards a Society of Free Choice; Deventer, Kluwer, 1978).

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AN ENGLISH ASTRONOMER ON THE ADRIATIC

Edmond Halley's surveys of 1703 and the imperial administration *)

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I

Edmond Halley, the English astronomer and navigator after whom the well-known comet is named, went at the request of the English government to make surveys of ports on the Imperial coasts of Inner Austria and was also in large part responsible for the speedy construction of batteries that he had suggested should be built to defend the harbour of Buccari (now Bakar). These tasks, which occupied Halley throughout most of 1703, were undertaken to provide a secure harbour in which an English fleet might winter in order to support the Empire in the War of Spanish Succession. This article is principally concerned with documents relative to Halley's mission and the support given him by the Emperor and his officials, that are mainly to be found in the archives of the *Innerösterreichische Hofkammer* at Graz, while indicating the bearing of that material upon some other aspects of the war at sea and the relations of the allies in the war.

*) My studies of Halley's surveys in the Imperial domains would have been impossible without the ready and courteous assistance I have had from many people, but here, writing especially about the archives in Austria, I am above all indebted to Dr. Christiane Thomas of the Haus-, Hof- und Staatsarchiv Wien, who suggested that I should contribute this article, who in her correspondence has given me the most valuable guidance and who has corrected the transcription of all documents. It is a great pleasure also to acknowledge the help I have had from Dr. Anna Benna, the Director of the Haus-, Hof- und Staatsarchiv, from Dr. Erich Hillbrand of the Kriegsarchiv Wien, from Dr. Tiepolo, the Director of the Archivio di Stato di Venezia, and Signora E. Zolla of that archive, as well as from Dr. Giorgio E. Ferrari, the former Director of the Biblioteca Marciana in Venice. I am very grateful for the help on questions on the sources from Graz which Dr. Heinrich Purkarthofer and Dr. Karl Spreitzhofer of the Steiermärkisches Landesarchiv Graz always were kindly willing to answer and explain. Professor Legović, Professor Munić and Dr. Danilo Klen of Rijeka have been of great assistance in connection with the topography of Buccari (Bakar), Professor Leonard Forster has kindly transcribed some of the documents from Graz for me, and Dr. Erwin Schmidl, Militärwissenschaftliches Institut/Heeresgeschichtliches Museum Wien redrew the figures and with Dr. Thomas cleared up some points connected with the sites of batteries. I wish to record, finally, the continued interest that Professor Antonio Marussi of Trieste took in my studies, up to his last months — he did not alas live to see this paper.

II [1])

The contemporary English political diarist, Narcissus Luttrell [2]), tells us that in 1703 Edmond Halley was sent by the English government of the day to survey ports of the Empire upon the Adriatic and he also tells us later on that when Halley had completed his mission, he was received by the Emperor Leopold I who presented him with a diamond ring to the value of £ 60. This account, slightly embellished, has appeared in subsequent notices and biographies of Halley from the time of his death until now. Halley was a very distinguished member of the very distinguished group of natural philosophers, contemporaries or younger associates of Newton, who to a large extent developed the methods of mathematical physics as we know them to-day. The great memorial of the age is Newton's work, *Philosophiae Naturalis Principia Mathematica*, and outstanding among Halley's notable contributions to science is the stimulation, continued encouragement and material support that he gave to Newton in the writing, printing and publishing of that fundamental work. Halley did much else. He was an active astronomer who became the second Astronomer Royal, the navigator who first made systematic surveys of the Earth's magnetic field in the North and South Atlantic Oceans and published the results in the form of the first maps on which were drawn lines joining places where the values of some quantity (here the magnetic variation) were the same; the navigator again who first studied and surveyed the tides and drew the first map of the tides in the English Channel [3]); the seaman also who had in those voyages, though a civilian, commanded a Royal ship with the rank of Captain. A skilled seaman, the best navigator of his day, enjoying the confidence of the Admiralty, this was the man the government in London sent to survey Imperial ports.

The occasion of Halley's visit was the War of Spanish Succession, in

1) A preliminary account of Halley's surveys is Alan H. Cook *Halley in Istria, 1703; Navigator and Military Engineer* in *The Journal of Navigation* 37 (1984) 1—23. A complete account of original English documents together with some material from Venice and Austria is being prepared.

2) Narcissus Luttrell *Brief Relation of State Affairs* 5 (Oxford 1857) pp. 228, 265, 278, 285, 306.

3) Norman J. W. Thrower *The three voyages of Edmond Halley in the Paramore 1698—1701* (London 1981).

which the Empire was allied with England and the Netherlands against the France of Louis XIV allied with Spain. Hattendorf[4]) has called attention to the way in which the hostile stance of Bavaria obstructed the major aims of the maritime powers with the consequence that the Blenheim campaign was planned to remove the threat from Bavaria. At the same time, it was important for England and the Netherlands to help, so far as they were able, the operations of the Imperial armies against the Spanish possessions in Italy. The campaigns in the two theatres interlocked and the most effective way for the maritime powers to help in Italy was to prevent the French fleets operating in the Mediterranean. At that time England had no naval base in the Mediterranean and her statesmen thought to use an Imperial port to harbour a fleet during the winter. The idea was in fact apparently first put forward by George Stepney, the English ambassador to the Imperial court, and when it was adopted in London, the choice of the government fell upon Halley to make the necessary surveys of possible ports.

In the English administration in the early years of the reign of Queen Anne, diplomatic and naval policy was formed by a small group comprising the Queen, the Lord Treasurer Godolphin, the Duke of Marlborough, and the Secretaries of State who were Daniel Finch, Earl of Nottingham and Sir Charles Hedges at the time of Halley's mission[5]). The regular correspondence with Stepney was in the hands of Hedges, but naval affairs were the particular responsibility of Nottingham and although Hedges included matters concerning Halley, Halley sent the reports of his mission to Nottingham when he wrote directly and not through Stepney, and the instructions that he received over the Queen's sign manual were recorded, along with his letter of introduction to Stepney, in Nottingham's letter book[6]).

Halley sent regular reports from the Imperial coasts about once a week, sometimes directly to Nottingham, sometimes to Stepney in Vienna who forwarded the complete letter or abstracts of it to London. It turns out that most of those letters, if not the complete set, along with many other documents related to Halley's visit are still conserved. Halley's own letters to London and Vienna survive in the *State Papers* in the Public Record Office in London, either among the letters received by the Secretaries of State or in the archives of the embassy in Vienna, and they form

[4]) John B. Hattendorf *English Grand Strategy and the Blenheim Campaign of 1704* in *History Review* 5 (1983) 3—19.

[5]) John B. Hattendorf *The Machinery for the Planning and Execution of English Grand Strategy in the War of Spanish Succession, 1702—1713* in *Changing Interpretations and New Sources in Naval History (Papers from the Third United States Naval Academy History Symposium*, ed. by R. W. Love Jr.) (New York—London 1980) Chapter 8 pp. 80—95.

[6]) Northamptonshire County Record Office *Finch-Hatton papers* 275, pp. 204, 206.

a notable addition to his known correspondence for they were not known to the compiler of Halley's papers[7]). Other parts of the correspondence are in the British Library or in private collections[8]).

Venice was very concerned about any naval operations in the Adriatic, as well as about commercial consequences of such activities, and in their regular despatches the Venetian ambassadors in London and Vienna sent a number of reports about Halley to the Senate, of which one is of particular value in reconstructing Halley's surveys. A third group of documents is in the records of the Innerösterreichische Hofkammer in the Steiermärkisches Landesarchiv in Graz, for the Adriatic coast was administratively dependent from the Hofkammer and it was that body that was charged by the Emperor with assisting Halley in his surveys and other works.

I have already published[9]) a brief account of Halley's journeys and surveys, and am now preparing for publication full edited transcripts (with translations where necessary) of the main documents written by Halley or directly related to the surveys, and my aim in this article is to describe the Imperial background to Halley's visits and the reaction of the Imperial authorities to it, as they appear from the archives in Graz and related material. The Imperial archives in Vienna (Haus-, Hof- und Staatsarchiv Wien) itself appear to contain little of significance. There are some scattered references in the correspondence of Count Wratislaw, the Imperial ambassador in London (*Staatenabteilungen England Korrespondenz* 32, 35 and 37), and there are a few administrative documents, such as a passport for Halley[9a]), but in particular there seems to be no record of an audience that Halley had with the Emperor at which he presented him with three maps and a *Memoriall* or report. Two contemporary copies of the *Memoriall* survive elsewhere, one the English embassy office copy, and the other a clandestine copy obtained by the Venetian ambassador to Vienna (Francesco Loredan) that is now in the Archivio di Stato di Venezia (Doc. 4 of Appendix 2). Of the maps however, nothing has yet come to light: there is not the slightest hint of their existence in the Austrian State Archives (Österreichisches Staatsarchiv), departments Haus-, Hof- und Staatsarchiv, Hofkammerarchiv and Kriegsarchiv, nor in the Austrian National Library (Österreichische Nationalbibliothek *Kartensammlung*); the best account of them is in a despatch from Loredan who had managed to see them (Doc. 5 of Appendix 2). It is worth mentioning that the original Despatches of the Ambassadors are now in the Archi-

[7]) Edward F. MacPike *Correspondence and Papers of Edmond Halley* (Oxford 1932).

[8]) In particular: British Library London (henceforth BL) *Add. Mss.* 7058 (Letters of Hedges to Stepney), and the *Finch-Hatton papers*, see note 6.

[9]) Cook in *The Journal of Navigation* 37 1—23. References to letters of Halley mentioned in the text will be found in this article.

[9a]) See also *Calendar of State Papers Domestic Anne 1702—1703*, Entry Book 104, Table VII vol. 1 p. 412.

vio di Stato di Venezia, but were kept in the Vienna archives when Venice was part of the Austrian Empire in the nineteenth century. Even after the loss of the Venetian possessions in 1866 the original *Dispacci* stayed in the Haus-, Hof- und Staatsarchiv in Vienna because of their great importance for the history of the Monarchy but Italy borrowed many volumes to have copies made by Italian specialists. Venice recovered the originals after World War I and left the copies to Vienna where they are still held [9b]): volume 185 of *Staatenabteilungen Venedig, Dispacci di Germania*, contains the third and latest copy (pp. 360—363) of Halley's *Memoriall*. The original despatches for the earlier part of 1703 with the more important material about Halley are in good condition and can be read clearly in Venice but the later ones (those of Daniele Dolfin who succeeded Loredan) are damaged and the copies in Vienna are more complete.

III

The records of the Innerösterreichische Hofkammer are assembled according to subject in monthly bundles. The first relating to Halley is labelled 1703-I-53, namely bundle 53 of 1703 January, although some documents in it are earlier than 1703 January and most are somewhat later. The most formal documents in any bundle are letters of command from the Emperor to the Hofkammer, with the sign manual in ink sprinkled over by golden blotting sand, particles of which survive on many of the letters. With each Imperial letter there is usually associated a similar letter from the Court Chancellor at Vienna, Count Julius Buccellini, and subsequently there may be a formal reply from the Hofkammer to the Emperor in which the Hofkammer reports the action that has been taken. The bundles contain related documents such as instructions from the Hofkammer to officers at Imperial ports, reports from those officers to the Hofkammer, notes or drafts for letters or documents, and some other material. Halley was instructed by the English government, in fact in a direct letter from the Queen, to survey ports that might possibly receive a fleet, and also to report on what naval stores and provisions were available in the region, and while to-day our interest is principally in Halley's surveys and military engineering, the matter that more occupied the Hofkammer was arranging to provide stores and provisions, and much of the correspondence is concerned with that and making arrangements with a contractor.

The Imperial government was itself also greatly concerned about the defence of the Adriatic coast, apart from Halley's mission. From the outbreak of the war in 1702, French ships had cruised in the Gulf of Venice and some of the documents at Graz contain reports and complaints from

[9b]) *Gesamtinventar des Wiener Haus-, Hof- und Staatsarchivs*, hg. v. Ludwig Bittner, 1 (Wien 1936) 559—561; Richard Blaas *Die Archivverhandlungen mit Italien nach dem Wiener Frieden von 1866* in *MÖStA* 28 (1975) 356—357, 359.

the coast to the Hofkammer. Surveys of the land border with Venetian Istria had been made just before Halley came out and the bundle *HK* 1703-IV-62 contains reports by Feldmarschall-Leutnant Count Hannibal Joseph von Heister and by the Imperial Engineer David Jacob von Rauschendorff, along with a map of their tour and reports from various border towns of actions taken upon their orders.

The bundles of the *Innerösterreichische Hofkammer* (henceforth: *HK*) with material about Halley are the following:

HK 1703-I-53
HK 1703-IV 62
HK 1703-VII 89
HK 1703-IX-11
HK 1703-IX-19
HK 1703-X-17.

The more significant papers are listed in Appendix 1.

IV

Halley was sent, as has been said, in response to a suggestion from George Stepney (cf. note 5) that some experienced seamen should be sent to view Imperial ports at the head of the Adriatic in which an English fleet might pass the winter in security. Lacking such a base, an English fleet could spend only a few summer months cruising in the Mediterranean and could do little to offer year long aid to the Emperor or continuous protection to English trade with the Levant and North Africa, a consideration that probably weighed more with the English administration than naval co-operation with the Empire. From the start of the war, the Adriatic coasts of the Empire had been subject to raids by French cruisers; thus on 14 August 1702 ships under the command of the Comte de Forbin, later to be a thorn in the English side in the North Sea, had bombarded Trieste from 10.30 a. m. to 3.30 p. m., although the damage they caused was scarcely serious:

"Forbinus nuper Tergestum fulmine terret
Si damnum quaeris porcus et gallus erit" [10]).

The archives at Graz contain in *HK* 1703-IV-62 a long report from Count Hannibal Joseph von Heister concerning the state of affairs in Fiume and Istria and seeking protection from French incursions [11]), and at a later date, Halley himself refers to French forces occupying Aquileia (near Monfalcone) and to French activity near Segna (Zengg, now Senj). The report from Count von Heister, together with a long account by

[10]) Quoted in Attilio Tamaro *Storia di Trieste* 2 (Roma 1924) p. 156: some houses and the Jesuit church were damaged.
[11]) *HK* 1703-IV-62: 1702 December 21:

David Jacob von Rauschendorff of a survey that he had made of the borders between the Empire and Venetian Istria [12]), shows that some military surveys had been made and some military preparations contemplated before Halley arrived. Rauschendorff was an Imperial engineer and subsequently he was responsible for carrying out works proposed by Halley (Section VI, p. 136).

If a fleet was to be sent to the Adriatic to winter in an Imperial port, it was evidently necessary that the administration in London should have first-hand knowledge of the state of those ports, how many ships they could accommodate, whether they were all protected from storms and the enemy, and whether stores and provisions could be obtained in the neighbourhood. The existing maps and plans were certainly inconsistent and contained, it would seem, no information about the depth of the water or the state of the sea bed. All these were matters upon which Halley, by the Queen's own instructions, was to report.

While many maps of the Adriatic coasts and plans of the ports had been prepared and printed before Halley's time, and although he says that he consulted printed maps that were available in Vienna, he does not say anywhere what maps he was able to see, and it would probably be impossible now to determine which they were. Some recent publications do however give an idea of the character of the maps in print in Halley's day. In looking at them to see what Halley had available to him it has to be remembered that the whole of the coast of Istria, from just beyond Trieste almost to Fiume (or St. Veit am Pflaum as it was sometimes shown on maps) was Venetian as were the islands and the coast south of Carlopago (Figure 1). Consequently the only ports in the possession of the Empire were Trieste and those along the coast from Fiume to Carlopago, that is along the shore of the Canale della Morlacca, and so those are the regions of which the delineation in contemporary maps concern us. An handsome collection of maps of Istria which gives a comprehensive idea of contemporary knowledge of those coasts, has recently been published [13]). Trieste appears in more or less its correct position on every map from the *Tabula Peutingeriana* onwards, but the harbour of Buccari, which Halley recommended as the naval base, which he surveyed in detail and subsequently fortified, is less certain. If, for example, we take one of the best-known European cartographers of the seventeenth century, Nicholas Sanson, we see in a map of Styria, Carinthia and Carniola [14]), that of Buccari and Buccarizza, the two little towns on the harbour of Buccari, the smaller, Buccarizza appears on the very distorted harbour and the larger, Buccari, is not shown, nor is Porto Re (now

[12]) Ibid. fol. 56—61.
[13]) Luciano L a g o — Claudio R o s s i t *Descriptio Histriae* (Trieste 1981).
[14]) Ibid. Tav. XC.

Kraljevica), the port at the entrance to the harbour on the map. On the other hand, the map printed by Ferrando Bertelli in 1569 [15]) shows Buccari upon its harbour, but neither Buccarizza nor Porto Re. The most accurate maps of the region of Buccari available at the end of the seventeenth century seem to be those of Vincenzo Coronelli. Versions of different areas and different dates exist, but a map of the whole of the Adriatic with a reasonably accurate representation of the harbour of Buccari was printed in 1688 [16]). Germany and Holland were also sources of maps of the Adriatic, but generally they do not give a good idea of the harbour of Buccari at the turn of the century. A further instance of the unreliability of printed maps is provided by Trieste. Halley himself refers to a little island to one side of the port, the Zuccho, connected to the mainland by a decayed mole, which may possibly have been of Roman construction. Nowadays the Zuccho and the mole are built over by later works (Molo Fratelli Bandiere) including a small lighthouse, which together form a rather inconspicuous feature of the modern port. On many of the maps dating from before the eighteenth century, the Zuccho is shown as a separate feature almost as prominent as the city of Trieste itself and much too far from the city.

The maps that Halley saw in Vienna must have shown the harbour of Buccari in reasonable detail, for before he went to the coast, he had already formed the opinion that Buccari was likely to be the most suitable port, but it is always possible that he had manuscript maps available that gave a more accurate view. A number of such maps survive in Venetian archives and libraries, but would probably not have been known in Vienna. There is also a great collection of manuscript drafts and plans and sketches of Istria and adjacent regions in the Steiermärkisches Landesarchiv in Graz, the work of Ivan Klobučarić, an Augustinian friar who was at one time prior of the Augustinian house in Fiume, and who was charged by the Archduke Ferdinand with making a complete survey and map of Inner Austria, a task that he undertook between 1604 and 1605. A sketch map and a water colour view, both of which include the harbour of Buccari, are quite accurate [17]), but it is unlikely that Halley would have seen them in Vienna, and I have not noticed anything to indicate that he studied maps in Graz.

There is also a manuscript map of 1702 in the archives of Graz [18]), with the legend *Geographische Charte von Istrien und Welchergestaldten Ihro*

[15]) Ibid. Tav. XXXVI.
[16]) Ibid. Tav. XCIV.
[17]) Reproduced in ibid. Tav. LXIX and LXX; for Klobučarić see for example Johannes I. G a v i g a n *Iohannes Globucciarich* in *O. S. A. Analecta Augustiana* 31 (1968) 74—90.
[18]) *HK* 1703-IV-62: fol. 133.

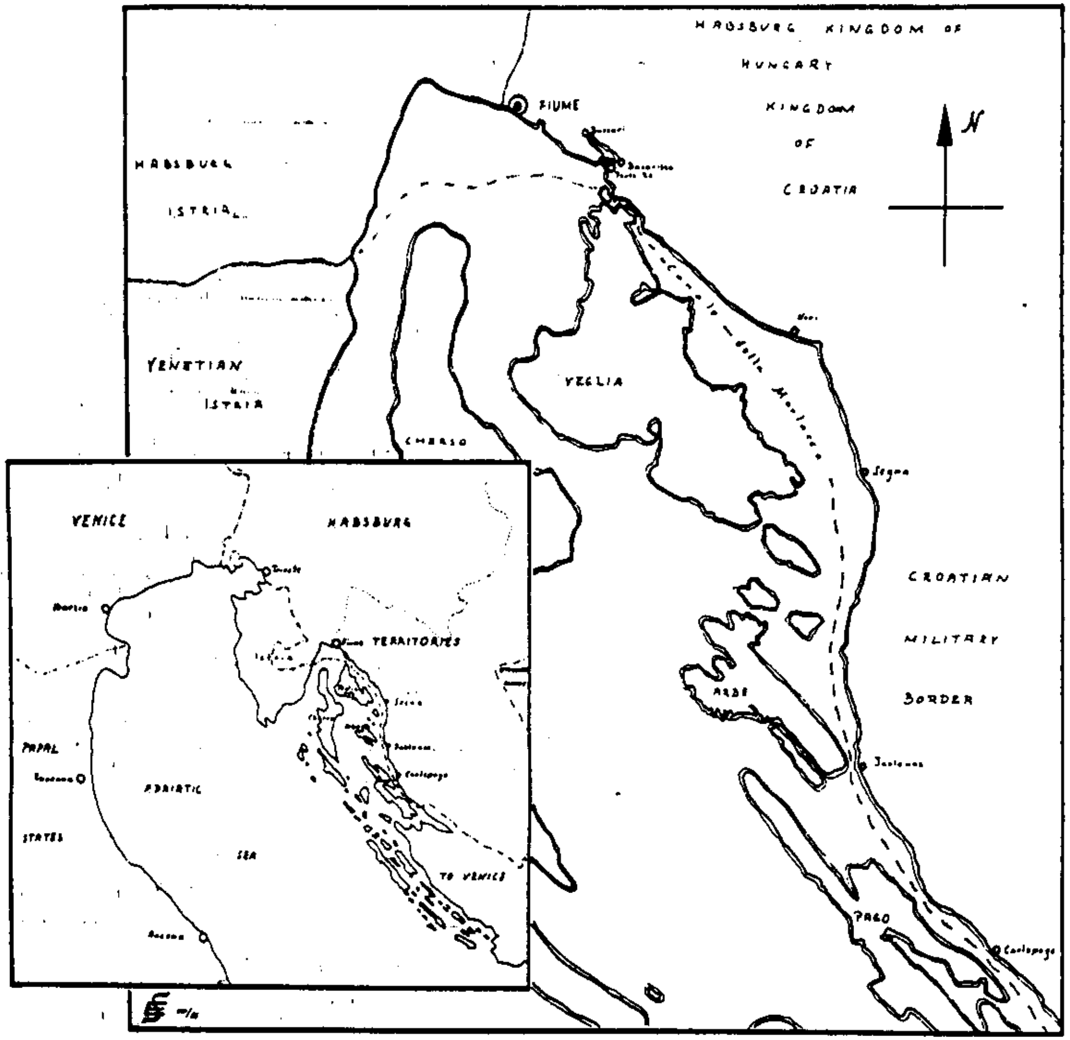

Figure 1: The Austrian Litorale from Fiume to Carlopago

Hochgräffliche Excellenz, der Herr General Feldtwachtmeister Herr Herr Graff von Heister, bis endt Decembris 1702 die Confinen an denen Seekisten, von Trieste an bis Fiume visitiret.

It does not extend so far as Buccari.

Manuscript maps of Istria and the Dalmatian coast are also to be found in collections in Venice, in particular the Archivio di Stato, among the records of such bodies as the *Provveditori dei Fortezze dei Confine*, but they would not have been accessible to Halley in Vienna. The printed maps that Halley would have found in Vienna in 1703 most probably differed considerably among themselves and he was later to comment that they were very inaccurate and that where he could not check them himself, he could often not come to any conclusion.

Halley's survey of the coast and ports was preceded by a survey of the land boundary between Imperial and Venetian territory in Istria made by the Imperial engineer, David Jacob von Rauschendorff [19]). It consists of a main report (undated) with two appendices dated 25 October 1702 and 19 December 1702. The main report is an account of the state of towns and fortifications along the border and is presumably later than the second appendix. The first appendix lists works that are needed to improve the fortifications of Antignana, the present Tinjan, and the second gives similar details for Chersano, the present Krsan (both towns are on the modern road 2 a that runs inland from Parenzo, now Poreč). Although Rauschendorff's report does not refer to anywhere that Halley visited, it is of interest in that it indicates the decayed state of many of the Austrian towns as well as giving an idea of the activities of Rauschendorff, with whom Halley was later to work.

V

English documents show that Halley received his instructions from the Queen at the end of November 1702 and that he arrived at the Hague on 12 December, that he explained his mission to the Grand Pensionary, and that he left for Germany about 16 December, arriving in Vienna on 10 January, 1703. He spent two weeks in Vienna waiting for his passes, and set out for Istria on 24 January, arriving at Trieste on 1 February. He wrote a short account of his survey of Trieste on 4 February and on 10 February he wrote from Fiume. He was at Segna on the 13th, wrote again from Fiume on the 17th, from Graz on the 25th and reached Vienna again on the 27th. There he assembled his material, prepared his maps and wrote a report for the Emperor, who received him in audience on 10 March; Halley left Vienna for London on 17 March [20]).

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[19]) Ibid. fol. 56—61.

[20]) At this time the Gregorian calendar was in general use in the Empire

Upon Halley's arrival in Vienna, the Emperor and his Court Chancellor, Count Julius Buccellini wrote to the Innerösterreichische Hofkammer at Graz to explain the nature of Halley's mission and to ask that he be assisted. The Emperor's letter, over his sign manual in ink, is dated 13 January and the Chancellor's, which is in very similar terms, is dated 17 January. The first letter is reproduced as Document 1 (bundle *HK* 1703-I-53: fol. 15) of Appendix 2. Halley was accompanied in part of his tour by a Sig. Antonio Andreassi who was designated as the Inspector General of the Imperial Fleet, should one be created, and on 27 January (fol. 17) the Emperor wrote to the Hofkammer to introduce him and to say that he would be bringing two thousand guilders, presumably for Halley's expenses. In response to the Emperor's letter of 13 January (fol. 15), the Hofkammer wrote to officials at Trieste, Fiume, Buccari, and Segna, instructing them to assist Halley — the dates of these letters, of which the drafts are conserved in Graz (fol. 1), and that of the first letter from the Emperor, show that the post could not have taken more than two days from Vienna to Graz, which accords with the fact, noted above, that Halley was in Graz on 25 February on his way back to Vienna, and in Vienna on the 27th. The Hofkammer wrote further to the same officials on 1 February (fol. 2) but now included mention of Andreassi, having presumably received the Imperial letter of 27 January. It seems indeed that the Emperor acted quickly upon Halley's arrival, although, in a letter to England, Halley complained about the delays in the Imperial court and that he had to spend two weeks in Vienna (cf. note 20).

Because he did not think Trieste suitable as a winter port, Halley did not send more than a brief account of it to Vienna and London, but a much fuller account of his survey is to be found in the report that the Governor of the City, Conte Vito di Strasoldi, sent to the Hofkammer on 11 February (Document 2 of Appendix 2: fol. 10—12r). The report shows how Strasoldi gave Halley information about the hinterland of Trieste and the provisions that it afforded, and that together with Count Johann Ernst von Herberstein, the military Governor, he provided Halley with ships, introduced him to experienced seamen, and accompanied him in his survey of the port. It also summarizes the results of the survey, and enables some idea of Trieste as it was at that time, to be obtained independently of other sources. The survey is discussed below in Section VIII (p. 141—144).

and letters written from those countries were mostly dated by that calendar. England still used the Julian calendar, which differed by 11 days from the Gregorian, and letters from England are usually dated in the Julian calendar. Halley sometimes gives both dates; English writers sometimes also denoted Julian dates by S. V. (Stilo Vecchio) or O. S. (Old Style) and Gregorian dates by S. N. (Stilo Nuovo) or N. S. (New Style). So far as possible, all dates are given in the text as Gregorian dates. — For the instructions from the Queen see Cook in *The Journal of Navigation* 37 p. 5, for the dates of his journey and his staying in Vienna ibid. pp. 6—8.

Strasoldi tells us that Halley left in haste, and that Andreassi followed him, having apparently arrived later than Halley in Trieste.

No reports of Halley's visits to Fiume and Buccari appear to exist in the archives at Graz, but Halley himself writes that he was in Fiume on 10 February and again on the 17th, having visited Segna and Carlopago in the meantime (Figure 1; cf. note 9). A letter from a priest of the cathedral at Segna, Marc Antonio Orbich, to the Hofkammer dated 15 February, gives us the further detail that Halley arrived in Segna on 13 February, that he left the following day for Carlopago and that he expected to return on the 16th [21]). As will be seen in Section VIII, it is evident that Halley made a thorough survey of the harbour of Buccari, either during the few days between his departure from Trieste and the letter he wrote from Fiume on 10 February or after 17 February.

When Halley returned to Vienna, he prepared his results in the form of a *Memoriall* and three maps. As has already been mentioned in Section II (p. 126), a copy of the *Memoriall* was obtained clandestinely by the Venetian Ambassador in Vienna and now rests in the Archivio di Stato di Venezia; Loredan was unable to obtain copies of the maps, which he tells us were jealously guarded, but he did see them and described them in a despatch to Venice. The *Memoriall* and the relevant parts of the despatches are reproduced as Documents 3, 4 and 5 of Appendix 2. The *Memoriall* contains essentially the same material as Halley sent to London in a less formal way in his letters, but it omits the information about stores and victualling contained in those letters. Thus Halley wrote to the Secretary of State, Daniel Finch, Earl of Nottingham, on 25 February from Graz:

"As to Navall Stores, here are none at present, but very good masts of moderate sizes grow in the mountains near the Sea Side above Zeng [Segna]; Hemp may be raised in what quantity desired in Croatia, from whence and Hungary may be drawn any quantity of Beef and Corn desired, Beef about a penny English per pound, but good wheat delivered at the Seaside will cost about 3s per Bushell, and Pease 3s 6d. Pork is scarce here, and very little butter or cheese and that bad, but in lieu therefore Oyle grows both at Fiume and Trieste, and tis both good and cheap. Oatmeal is not known nor used here, but in lieu thereof they use Rice brought from Lombardy. Wine of the growth of those parts is also reasonable" [22]).

As a result of his general survey of the Imperial coast and of his more detailed surveys of Trieste and Buccari, Halley confirmed the opinion that he had formed from examining maps in Vienna, that the best port for wintering a fleet was Buccari. He so reported in the *Memoriall*, and went on to propose fortifications that should make it defensible against enemy attack. He also states that he had laid out these fortifications on

[21]) *HK* 103-I-53: fol. 5.

[22]) Public Record Office London (henceforth: PRO) *State Papers* (henceforth *SP*) 80/20: fol. 145.

the plan of the harbour of Buccari that he had prepared, and Loredan reports that he saw them marked on the plan. Halley also specified what guns should be placed in the batteries. Although Halley's maps have not come to light, his *Memoriall* and Loredan's report, when taken with accounts of his second visit in which he saw the batteries constructed, enable their sites to be located with some confidence (Section VIII).

VI

It is evident that Halley's proposals for the fortification of the harbour of Buccari were accepted in London, for even before he returned to London Sir Charles Hedges, Nottingham's colleague as Secretary of State, was writing to Stepney on 27 March:

"You must take care to move the Emperor that provision be made for the refreshment of our sea men and stores and necessaryes for the fleet and also that Buccari be fortified for the security of our ships according to Mr. Halley's proposal with all expedition" [23]),

and it was no doubt in response to that letter that on 18 April Stepney and the Ambassador of the States General, Count de Bruyninx, went together to the Emperor, "hand in hand", as Stepney reported to London, and presented to him a memorandum on the conduct of the war including the following passage about the fortification of Buccari:

"Et si come av'è dell'apparenza de la ragione di Guerra unitarsi l'Interesse della Vostra Maestà potrà richiedere ch'una parte della Flotta dovesse operare nel Mare Adriatico il sopra mentionata ministro della Regina d'Inghilterra ha ordine di Sollecitare Vostra Maestà Cesarea ch'Ella commandi di tenere pronti sulli lidi Austriaci le provisione necessarii per fornire rinfreschi ai suoi matelotti e le materiali proprii per racconevare li vascelli; cose bene che di mettere il Porto di Buccari in Stato di riceverli con Sicurezza facendo a tal fine fortificarlo, secondo li dissegni che il Capitano Halley ha havuto l'onore di presentare a Vostra Maestà Ceasarea" [24]).

A problem that was to bedevil the whole project is however already set out in a letter of the Emperor to Count Johann Wenzel Wratislaw, the Imperial ambassador to London, dated the 27th March (Doc. 6 of Appendix 2). Iron foundries for casting cannon did not it seems exist near the Dalmatian coast and it was useless to build batteries if there were no guns to place in them. The guns that Halley specified were much larger and heavier than the field guns that an army would have and it would probably have been impracticable to have brought them in by road from other parts of the Empire. Thus from the first the Innerösterreichische Hofkammer asked that the allied fleet itself should bring with it guns to arm the batteries, but the English government was most reluctant to do that, for the sixty guns that Halley wanted were the armament of a

[23]) BL *Add. Mss.* 7058: 1703 March 16 (O. S.).

[24]) PRO *SP* 105/68: fol. 83.

third rate ship of the line. The letter to Wratislaw is written in the context of the idea, then held in the Imperial court, of building an Adriatic fleet of which Andreassi was to be Inspector General, but problems of supply suggest that idea was never more than fantasy.

The bundle, *HK* 1703-IV-62, of the Graz archives, contains various letters in which the Emperor gives instructions for fortifying Buccari according to Halley's plans, as well as for strengthening the defences of Fiume, and for the supply of provisions for the fleet. The engineering work was to be directed by Rauschendorff, and in a letter of 21 April (fol. 39—42), the Hofkammer reported to the Emperor that they had sent on the Imperial order of the 18th April directly to Rauschendorff and the commandant at Trieste by their Commissioner so that Rauschendorff should lose no time in setting out for Buccari and Porte Re. (The instructions to the Commissioner, Endtres, are reproduced in Doc. 7 of Appendix 2.) The Hofkammer represented that more than one engineer would be needed, but they also argued that the new man should not be subordinate to the Chief Engineer von Hollstein but directly to the Hofkammer which was responsible for Buccari and Porto Re. The Hofkammer itself set out the difficulties of obtaining large guns for Halley's batteries from local sources and asked the Emperor to ask to have them brought with the fleet. The letter goes on to set out what was being done to supply small arms and field artillery to Fiume, Buccari and Porto Re, and also to obtain provisions for the fleet. The supply of long guns, „schlangen" or serpents, to Fiume, as well as the works on the fortifications there, meant even more work for the Hofkammer, who wrote to the Emperor on 14 April (fol. 98) about putting the batteries at the Capucines and S. Lorenzo at Fiume in a better state of defence. The Emperor replied to the Hofkammer's letter of 21 April on the 23rd May (fol. 104—105) and said that Hollstein would soon visit Porto Re to see if an additional engineer was needed, that a request had been put to the Netherlands and England that the fleet should bring the guns for the batteries at Buccari and Porto Re, and also that the Archbishop of Salzburg, Johann Ernst von Thun (1687—1703), had been asked to send foundry workers: Salzburg was the main metalworking region of the Empire.

Much of the correspondence in the archives of the Hofkammer — in this case *HK* 1703-IV-62 — is concerned with the supply of food and other provisions for the fleet, with the preparations of contracts with a merchant, Simone Milesi (fol. 5), and with such instructions as that to the Hauptmann at Buccari on July 24 to have a butcher available (fol. 27—28). The Hofkammer also reported that it was having the roads from Görz (Gorizia) to Trieste and on to Fiume, repaired (fol. 19—21, fol. 22).

Taking the letters of Halley himself with the records in the Hofkammer archives, it appears that the engineering works proposed by Halley were entrusted to Rauschendorff, and that the additional engineer or engineers for whom the Hofkammer had asked never came. The arrangements for the supply of labour seem to have been that unskilled labour came from the forced (corvée) labour of peasants according to the custom of the kingdom of Hungary, and that that was arranged by the Hauptmann at Buccari, while the skilled labour, especially that of masons and carpenters for the upper works of the batteries, was paid for with money brought by the three commissioners, Endtres, Pacher and Cilli. In a letter of 22 September 1703 Halley says that the commissioners were very reluctant to spend money on skilled men [25]).

Meanwhile the government in London was anxious to hear what progress was being made with the fortifications and on April 24 (April 13 O. S.) Hedges wrote to Stepney:

"I desire you will let me know what they are doing at Buccari and whether they are fortifying it as Mr. Halley hath proposed [26]),

and again on May 11 (April 30 O. S.):

"You are directed to sollicite the fortifying of the port of Buccari and to give an account from time to time of their proceedings therein. The Queen will soon send some bodi to see what progress they make and it is believed Mr. Halley will soon be there again" [27]).

In response to these instructions, Stepney made formal enquiries of Count Buccellini and on 19 May he wrote to Hedges that he had asked Buccellini for information in writing about the activities at Buccari and he enclosed a translation of a paper from Buccellini:

"In pursuance to the instances which the English Envoy made, orders have been sent to press the States of Inner Austria, that Porto Re (according to Captain Halley's Project which having been communicated to them) should be forthwith fortifyed preferably to all other places and be provided with Stores of all sorts against the time that a squadron of the Allies Ships can arrive in those Seas. And according to severall advices from thence these orders have in great measure been executed; Engenier Rauschendorff having been dispatch'd to Porto Re with Mr Endres (Counsellor to the Hofkammer) who carry'd a Summ of money for laying in the necessary provisions ... We have notice of their being arrived there the latter end April and that all hands are at work. So there is no doubt, but ye Fleet upon their arrivall there will find all things in a good posture of Defence and quantities of provisions at tolerable rates".

(Note by Stepney?):

"It is the style of ye Chancery to call ye whole Bay of Buccari by ye name of Porto Re which is the entrance into that Bay" [28]).

Stepney wrote again to Hedges on 2nd June after making further enquiries of Buccellini:

[25]) PRO *SP* 80/20: fol. 345.
[26]) BL *Add. Mss.* 7058: fol. 221.
[27]) Ibid.: no folio nos.
[28]) PRO *SP* 80/20: fol. 380.

„I enquired again this morning of Chancellor Buccellini, what further information He had of the preparations making at Buccari; And I have received an answer in writing under his own hand to this purpose; That the Fortifications are now in a perfect state of Defence, or will be so in a little time. That Count Bruenes [Count Carl Weikhardt Breuner], the President of the Chamber in those parts has assured Him a sufficient quantity of victualls are provided and that their loss would be great if it should so happen that the Fleet should not appear in the Gulph" [29]).

On 7 June Stepney wrote further to Nottingham:

"The fortifications about Buccari will be perfected in ten days according to Captain Halley's proposals" [30]).

That was too optimistic.

VII

It is clear that the Secretaries of State in London were not content with the assurances that Stepney had had from Count Buccellini, and as indicated above, Halley was asked to return. On 22 June, Hedges wrote from London to Stepney:

"Mr Halley has received his money and is gone from hence towards Istria" [31]).

Stepney had meanwhile written to Hedges (16 June):

"It will be an ease to me to have Captain Halley in these parts to look after the fortifications and provisions which are things I do not understand and I should have been unwilling to rely on the assurances these Ministers can give me, that all is in readiness, wherein they are apt to deceive both themselves and others" [32]).

No doubt Stepney was glad to hear, on 21 July, that Halley had left the Hague, and indeed, he arrived in Vienna on 23 July with directions from Nottingham for him to be sent on to Buccari to see how the works had progressed. Stepney had an audience of the Emperor at which he presented Halley, and orders were issued for Halley to be assisted in all things [33]).
The orders, of which copies were put in the archives of the English embassy, were from the Emperor to the Hofkammer at Graz, from Count Buccellini to the Hofkammer, and from Prince Eugen to Rauschendorff.

In fact, the Emperor wrote directly to the Hofkammer on 24 July (*HK* 1703-I-12: fol. 19) to say that Halley was coming himself, and the letter in the embassy archives is a copy of one that Halley evidently took with

[29]) PRO *SP* 105/68: fol. 294; Buccellini's holograph letter is at fol. 300—301.
[30]) PRO *SP* 80/21: fol. 31.
[31]) PRO *SP* 105/69: no folio nos. Istria is the Venetian peninsula which Halley in fact never visited. The region that he did visit was called the Austrian Litorale (Litorale Austriaco).
[32]) PRO *SP* 80/21: fol. 40.
[33]) PRO *SP* 80/21: fol. 160, 1703 July 25: Stepney reports Halley's arrival; fol. 168, 1703 July 25: report of Halley.

him, and a further copy is in the archives at Graz in bundle *HK* 1703-VII-89. Buccellini's letter, which is in Italian in the English embassy copy, is to the president of the Hofkammer, Count Breuner, and asks that Halley should be told of all that he had done to prepare Buccari and other ports for the needs of the combined fleet, so that good relations may be maintained with the Queen of England, and he asks that Halley should be shown every courtesy [34]).

The letter from Prince Eugen to Rauschendorff is the only one from the Prince in the correspondence about Halley, and shows that the Prince, who was by now President of the Supreme War Council (Hofkriegsrats-präsident), was concerned himself with the preparation of the Adriatic ports. The letter just asks Rauschendorff to show Halley all that had been done at the ports, especially at Buccari and Porto Re (Doc. 8 of Appendix 2).

The Hofkammer had in the meantime written an account of their actions to the Emperor on 24th July in which they set out what they had done to obtain provisions and how they had ordered the officials at Buccari and in the neighbourhood to look for suitable timber for shipbuilding and masts. They had also instructed their officers or counsellors, Count Johann Ernst von Herberstein (who had helped Halley at Trieste) and Endtres (who had been sent with money to Buccari) to prepare for the arrival of the fleet and to welcome the admiral [35]).

There had thus been considerable administrative activity, but when Halley arrived at Buccari he found it had not resulted in much construction on the ground.

The Venetians had also observed Halley's return. On 28 July, the ambassador, now Daniele Dolfin, reported to the Senate:

„È già arrivato e partito verso Buccari il Capitan Hall percorso da due Ingenieri che vanno a rivider e stabilire l'operazione già disposte per la sicurezza di quel Porto. Stò procurato che parta ben impresso verso le publiche convenienze nè l'espressioni potevano desiderarsi più favorevoli. Resterà assicurato in valida forma quel ricovero perchè si riflette che la flotta non nè ha nel Mediterraneo altro nel quale abbia pronta e sicura la retirata" [36]).

As on his first visit, Halley wrote regularly to Stepney in Vienna and to Nottingham in London to report his findings and activities. On 25 July he wrote that he had arrived in Vienna, that he had been presented to the Emperor and that he had been shown the profile and plan of the works that were supposed to be under way (see n. 33). He arrived in Fiume on the night of August 4th and writing from there on 5 August he says that he had been to Buccari and had found only the battery on the

[34]) PRO *SP* 105/69: 1703 July 25.
[35]) *HK* 1703-IV-62: fol. 126—129.
[36]) Archivio di Stato di Venezia *Senato, Dispacci di Germania* f. 186, c. 186.

left hand side going in partly finished; a fuller account is to wait for a view that they are all to take on the morrow. In the meantime, Halley sends an account of a French attack upon Aquilea:

"As to the account you commanded me to give you of what news I could pick up at Grats or elsewhere, I must humbly beg your pardon, telling you, that at Grats I only met the ill news of Aquilea, then three days old there [and consequently then known at Vienna] which proves too true. It will serve rarely to embellish the Paris Gazette, that 300 Francois should be able to carry by assault, plunder and burn a citty once capable to hould out a siege against the Emperour Maximine [C. J. Verus, 238 A. C.]; but they will hardly tell how little damage they have done in it, that once famous citty being then scarce any other than a heap of rubbish, and a few inconsiderable cottages" [37]).

Halley wrote again to Stepney on August 11th enclosing a letter for the Earl of Nottingham. He found that besides the one battery he had previously mentioned, foundations for a second near Porto Re had been cleared but no stone laid. The commissioners, he said, did not believe that a fleet would come that year so that it was not necessary to hurry, and meanwhile they were drawing substantial daily payments for their time. Halley tried to convince them of the need for haste, and assured Nottingham that they should have no peace until the business is done. He also reported the appearance of two French warships, and smaller vessels, before Fiume. The following week, on August 18th, Halley was able to tell Stepney that good progress had been made on the battery near Porto Re with one hundred and fifty workmen, and also said that unsuccessful attempts to cast iron cannon had been made in the neighbourhood.

Halley continued to press the Imperial commissioners and on September 1st he could report to Nottingham that the framework of the battery on the right going in under Porto Re was complete and ready for planking (on which the guns were to be placed), while foundations had been laid of a second battery on the same side, for 20 guns. He also reported that the French ships had retired from the Gulf on the 19th of August because they were very sickly. Further, on 8th September, Halley could tell Stepney that the third battery was very near finished and the foundations of the fourth, opposite the third across the harbour entrance, had been cleared; defences on the landward side were also being planned. In fact, the works were now close to completion, for on 15 September Halley reported that the fourth battery was well under way and on September 22nd he wrote to Nottingham:

"I have with all my skill, pusht on the Imperial Commissioners here to finish the works in hand, and have at length gotten our Port in the desired state of defence, had we but the Cannon to place on our Batteries, which are so disposed as to defend one another in case of the landing of an Enemy. I have likewise concerted with the Emperours Engineer [Rauschendorff] what may be proper

[37]) PRO *SP* 105/69: no folio nos.

to be done further within land, if the enemy should land at a distance, which will be very difficult for him, both as to the march in a country so full of stones as this is, and to the opposition he will find from the numerous Militia which are kept well disciplined it being scarce possible to do anything here by surprise" [38]).

Halley's last letter is dated October 13th from Vienna, reporting that he left Buccari on September 30th when the batteries were then in a state to receive the cannon, and his final word is, that having intended to speak with the Imperial officers about the cannon, he learns from Stepney that they still hope to have them from the fleet [38a]).

Halley's letters give us a clear and at times sardonic view of how he saw his responsibilities and the obligations of the Imperial officers and their performance of them. How did things appear from the Imperial side?

The archives of the Innerösterreichische Hofkammer contain two reports by Endtres, the first from Porto Re on September 1st [39]) and the second also from Porto Re on September 8th, and a further report from his fellow commissioner, von Herberstein, is written from Fiume on September 29th [40]). Based, it would appear on those letters the Hofkammer sent its own reports to the Emperor on September 17th [41]) and on October 9th [42]). According to Halley's letters referred to above, the state of affairs by September 1st was that the battery "on the left hand side going in" had been effectively finished, that one "under Porto Re" had been completed up to the level of the planking on which the gun carriages would stand, and the foundations for a further battery on the same side as Porto Re had been laid. Halley says that he was told by the engineer, presumably Rauschendorff, that this battery would be finished in eight to ten days. Endtres's letter of September 1st (Doc. 9 of Appendix 2) gives the same information, and taken together the two letters show that the battery on the left hand side going in is the one at "Scherchiza" (now Sršica) the first to be constructed whilst the third to be built, on the same side of the entrance as Porto Re, is the one on the point by Buccarizza; it will be seen in the next section that taken with later accounts of the site, these statements enable the positions of the respective batteries to be established with some certainty. The description of the second battery, "under Porto Re" is less informative, and the site is less certain, as is that of the fourth, "over against" the third. Endtres also mentions a fifth battery, and a note on Halley's letter of September 15th to Stepney, but in a different ink from the main letter, reads:

[38]) PRO *SP* 80/21: fol. 345, 1703 September 22. All the other letters: Cook in *The Journal of Navigation* 37 p. 21—23.
[38a]) PRO *SP* 80/21: fol. 416.
[39]) *HK* 1703-IX-11: fol. 4 (Doc. 9 of Appendix 2).
[40]) *HK* 1703-IX-19: 3—4 and *HK* 1703-X-17: fol. 9—11.
[41]) *HK* 1703-X-11: fol. 7.
[42]) *HK* 1703-X-17: fol. 6—8.

"There are 4 Batteries of Stone for 58 great guns and one of Earth for 8 more in the inner valley on ye Lar bord side going in" [43]).

On 8th September Halley wrote that the stonework of the third battery was nearly finished and that a start had been made on clearing the foundations of the fourth; Endtres's letter of the same date likewise reported further progress with the batteries, but it was more concerned with stores and provisions and the supply of timber.

The letter of the Hofkammer to the Emperor of September 17th follows closely in some of its wording that of Endtres of September 1st.

Count Herberstein's letter of September 29th to the Hofkammer sets out the work that has been done and the report of the Hofkammer to the Emperor dated October 9th is based on that letter and uses some of the phrases. Herberstein wrote his letter at the same time as Halley was about to leave Buccari, satisfied that he had done all that he could, and that the defence of the harbour had been taken as far as was possible without the cannon for his batteries.

The letter of October 9th of the Hofkammer was acknowledged by the Emperor on October 24th, who noted what the commissioners had done at Buccari and went on to discuss the problems of iron guns and whether they might be brought in the allied fleets [44]). By this time it was much too late for a fleet to come into the Adriatic and the allied fleet under the command of Sir Cloudesley Shovell that had entered the Mediterranean in July left it in October.

VIII

Halley himself said little of what he did at Trieste because he considered the harbour too open to shelter a fleet throughout the winter. It should be remembered that in the days of sail, crews and stores would usually be removed from ships in harbour during the winter, so that a fleet in those conditions would be vulnerable to enemy attack upon an undefended harbour as well as to bad weather if it were not protected from winds and waves. Halley accordingly sought an enclosed harbour which would give natural defence from sea and storm and which could easily be fortified against enemy ships. Trieste did not satisfy those conditions, Buccari did. Nonetheless, Halley made quite a careful survey of Trieste and an account of it is given by Count Strasoldi (Doc. 2 of Appendix 2).

Figure 2 shows a plan of the city and port of Trieste as it now is, with the probable features of Halley's day placed upon it. There are extensive relics of the old city still in existence, in particular the castle and the cathedral of S. Giusto which stand together on a steep hill, a Roman theatre (which may have been buried in Halley's time) and some old

[43]) PRO *SP* 105/70: fol. 29.
[44]) *HK* 1703-IX-19: fol. 3—4; *HK* 1703-IX-11: fol. 7; *HK* 1703-X-17: fol. 9—11 fol. 6—8, fol. 13—14.

streets and buildings below the castle hill, but the present aspect of the harbour is very different from that of Halley's day, in three main respects. First, the area to the north of the old city which in the earlier period was salt marshes and salt pans, is now covered by the city built in the reign of Maria Theresa. Secondly, the railway station lies on made ground beyond the former shore line by the Torre S. Pietro, a feature that is recalled by a modern street of that name; and lastly, the whole of the waterfront is lined with quays and moles that were constructed mainly in the nineteenth century when Trieste developed as a port for steamship trade through the Suez canal to the East. The Campo Marzio survives in the name of a street and a district, but the Zucco which was so prominent on early maps has been incorporated into a quay with a small light upon it (Molo Fratelli Bandiere) that now shelters a yacht harbour. For these reasons it is difficult to relate what Strasoldi says of Halley's surveys to the modern topography, and in particular construction and dredging must have changed the depths of the water. The old port also has disappeared under modern roads and buildings and the modern waterfront lies slightly further seaward. Some points can however be fixed, the castle and S. Giusto, the Zuccho, and very probably the old shore line behind the modern railway station, for the present road to Miramare by the station marks the foot of a steep slope that seems to have been a low cliff at the edge of the sea. The registration in Figure 2 depends on these correspondences.

I have already published a plan of the harbour of Trieste — in *The Journal of Navigation* 37 Figure 2 — according to Halley's surveys but I now believe that that was based on a misinterpretation of the distances and depths given by Strasoldi. The issue turns upon two points — the value of the passo used by Strasoldi, and whether Halley used the passo for depths or rather used the English fathom. As to the first point, all references to distances in the correspondence are to the Italian passo and the local one of Trieste seems not to be mentioned. The Italian passo was most likely that of Venice, of 1.74m and not, as I previously supposed, the classical Roman passus of 1.47m which is less than any passo of Halley's day. I give my reasons below for thinking that Halley measured the depths of water in fathoms, but the value of the fathom, 1.83m is not very different from that of the Venetian passo; consequently, it will not be of great significance to convert the figures given by Strasoldi for the depths of water to be equivalent to 1.83m and that is what I have done in giving the depths on Figure 2.

Halley probably determined the positions at sea at which he took the depths of the water by triangulation from known points on the land, as he described in a letter to Southwell [45]). Halley and Strasoldi both point

[45]) Royal Society London *Collectanea Newtoniana* IV (No 4 27), 1701 January

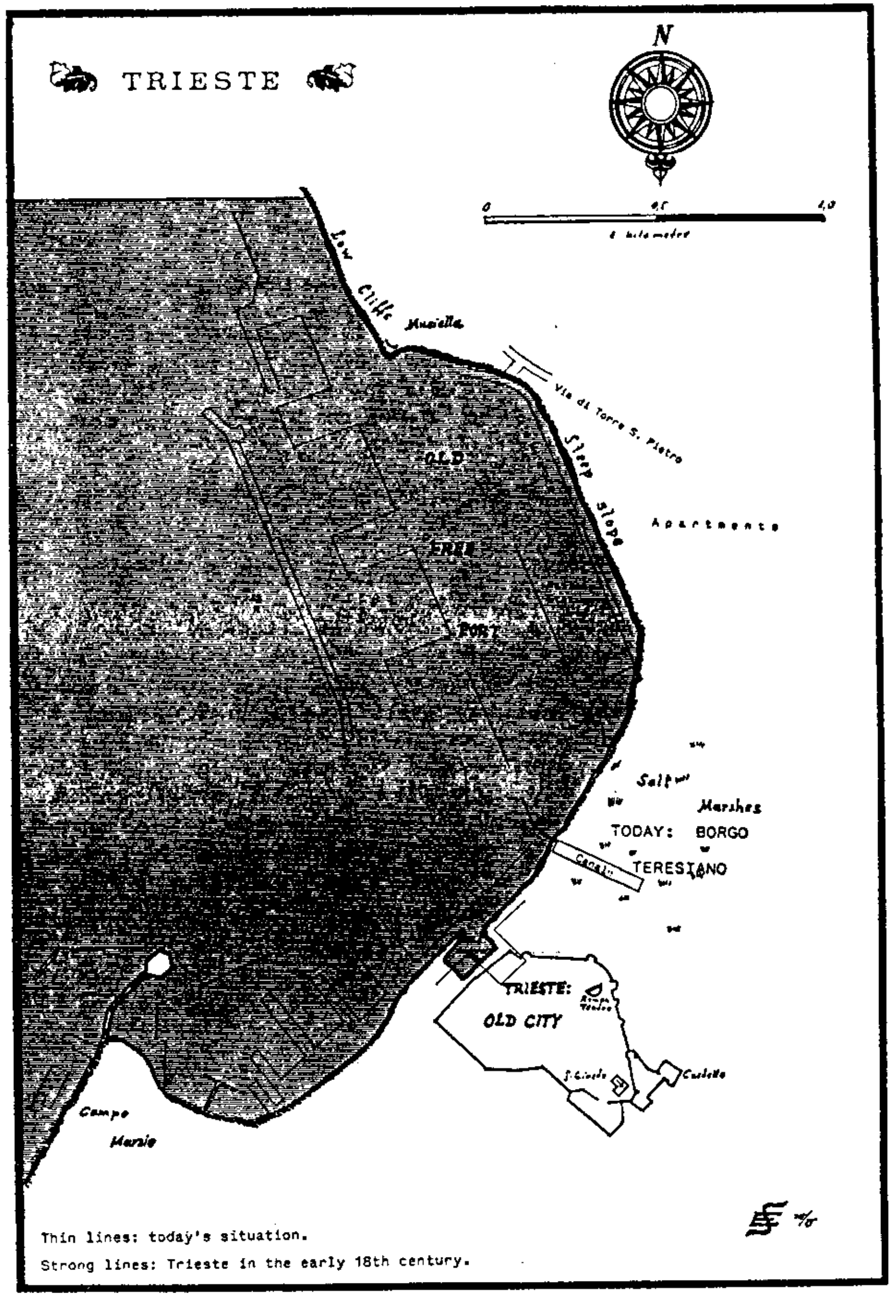

Figure 2: The harbour of Trieste

out that the Zuccho, the small island joined to land by a broken down causeway, could be fortified. They also both reported that the ground in the bay is firm and clear of rocks and that ships at anchor may ride firmly.

Halley tells us little of his surveys at Buccari for the good reason that he made a detailed chart of the harbour which, with his other maps of the head of the Adriatic and of the coast south of Fiume, he brought back to London, as well as leaving copies with the Emperor in Vienna. It is of course frustrating that those maps, which would no doubt tell us much of the state of surveying and of cartography at that time, have not so far come to light, but because they were seen by the Venetian ambassador Loredan, and described by him in his dispatch to the Senate (doc. 5 of Appendix 2), we do have a good idea of the nature of the chart of the harbour of Buccari. A sketch plan based on modern surveys is shown in Figure 3. The harbour is about 4.5 km long and about 1.0 km across at its widest and is entered through a mouth that is some 400 m wide at the narrowest point. Halley in his letters and the ambassador from his sight of the chart agree on some key distances which in the Table are compared with the distances on the modern Admiralty chart (Appendix 3). Evidently Halley's plan agreed reasonably well with modern mapping. It is possible to make more meaningful comparisons between Halley's work and modern maps at Buccari than at Trieste because the harbour of Buccari is surrounded by bare limestone hills and although there are some industrial installations that did not exist in Halley's day, it does not appear that they would have changed the configuration of the land or of the sea bed in any significant way. Thus when Loredan reports that the depth of water in the entrance is 25 (given as a figure without units), we may compare it with depths on the modern chart in that position which are indeed close to 25 fathoms in much of the entrance, and we may compare Loredan's statement, that the depth of water inside the harbour is shown by figures, 20, 18, 16, that diminish in proportion to the distance from the land, with the modern chart where we see depths with almost exactly that range and that behaviour. It is for this reason that I think that Halley measured the depths in the unit with which he would have familiar, the fathom, rather than the local passo, for the difference between 25 fathoms and 25 passi of Venice is about 1.3 fathoms and that seems too large a discrepancy between the figures seen by Loredan and the modern values.

Halley also laid out on his chart of Buccari the locations of the batteries that he proposed for the defence of the harbour. I published previously (cf. note 1) a somewhat speculative sketch of where the sites might be

27/2: "From Captain Halley to Sr. R. Southwell, about taking the survey of a coast".

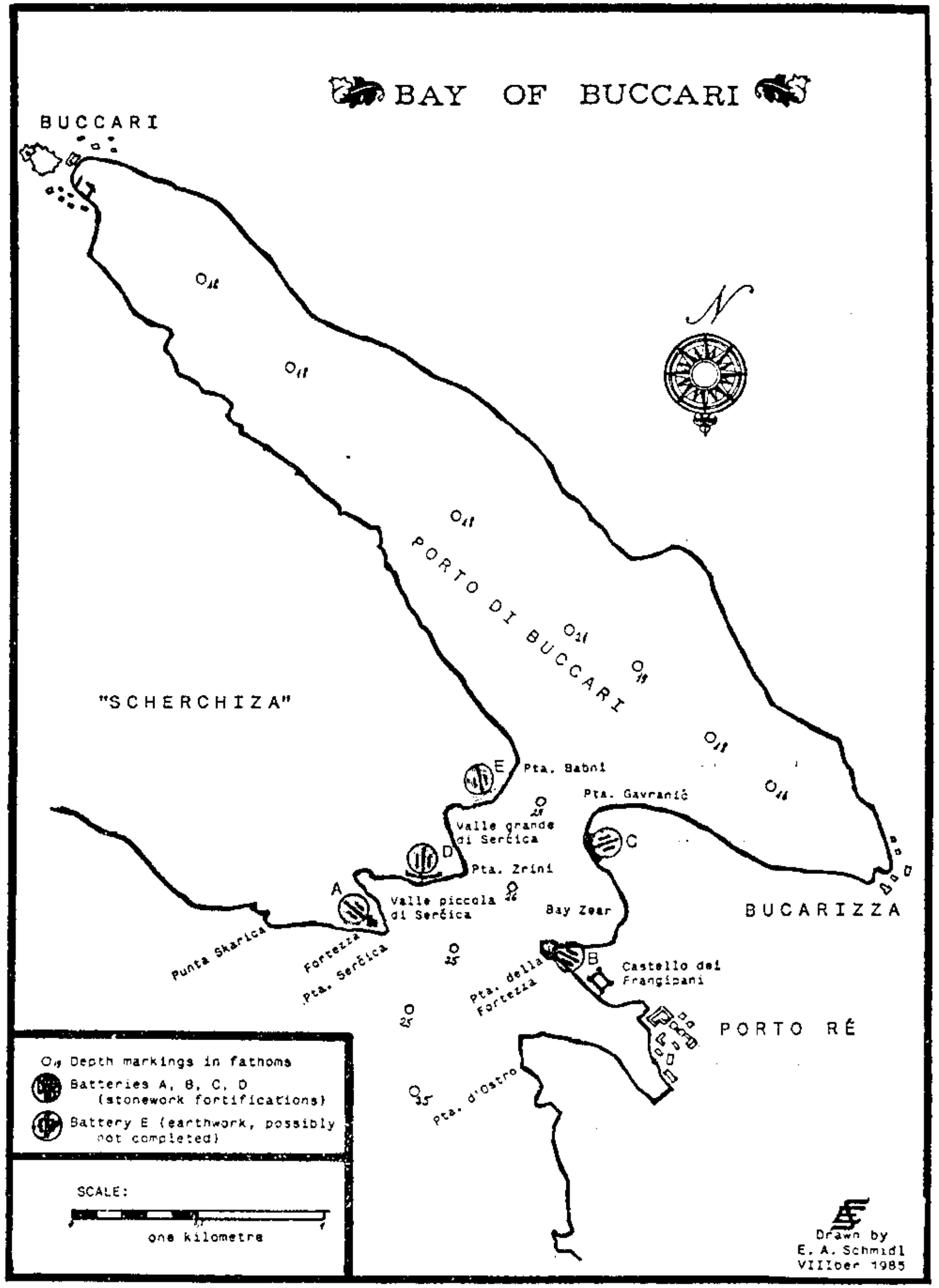

Figure 3: The probable site of Halley's batteries in the bay of Buccari

but further information has now come to my attention that makes the locations more certain.

There exists in the Hofkammerarchiv in Vienna a collection of maps and plans (*Kartensammlung* C 16) that was assembled by Matthia Antonio Weiss in connection with plans for a new road (Via Carolina) from Trieste via Buccari to Carlstadt. Some of the plans were drawn by Weiss himself (for example, one of Trieste) but others were not. A plan of the harbour of Buccari (no. 14, fol. 37—38) is a version of one in the Kriegsarchiv in Vienna (*Kartensammlung* G I h 62), and is associated in the Weiss collection with a more detailed plan of the entrance (no. 15, fol. 39—40) and a pen and wash sketch of Porto Re and other parts of the entrance (no. 16, fol. 41—42).

None of the three documents bears a date, but in the catalogue of the Kriegsarchiv *Kartensammlung* the date of the large map is given as 1726. The plans and view agree in showing batteries at points D, B, and C on Figure 3, but nothing is shown at point A, nor is there any sign of an earthwork battery E. It is said that fortifications were laid out at Porto Re in the reign of Charles VI, about 1729, but if the date of 1726 is correct, the works shown on the plan and view of Hofkammerarchiv *Kartensammlung* C 16 (nos. 14 and 16) must antedate those of Charles VI and can only be Halley's.

There is a further map in the Kriegsarchiv *Kartensammlung*, B IX b 89, drawn by Antonio de Verneda in 1733. It labels batteries at points A, C and D of Figure 3 and has symbols that could indicate a battery at point B but has no legend there. This map was produced in connection with 'new works' at Porto Re (the fortifications of Charles VI?) and it shows the Via Carolina with a branch to Buccarizza which is also to be found in the Weiss plans: Again there is no indication of the earthwork battery E.

In July 1983 I was fortunately able to visit Buccari in company with Professor Munić of Rijeka (the old Fiume), and found that no remains of any battery now exist on the shores of the entrance, but a book published in 1871 by Archduke Louis Salvator of the House of Habsburg—Lothringen(—Toskana) [46]) gives accounts of the ruins of two batteries that may have been Halley's. The book is an account of the topography, flora and fauna of the harbour (or gulf) of Buccari in the form of a guided walk around the harbour from the left hand side of the entrance going in, all the way to Buccari, Buccarizza and Porto Re and so to the right hand side of the entrance, and it includes a rather detailed map of the harbour of Buccari based on Austrian surveys of 1821 to 1867, with depths of water in Wiener Fuß and a scale of Wiener Klafter. Remains of two bat-

[46]) Anon. [Archduke Louis Salvator] *Der Golf von Buccari — Porto Re. Bilder und Skizzen* (Prag 1871).

teries are shown on the map, at the sites marked D and C on Figure 3. Of the battery at site D Louis Salvator writes:

„. . . bemerkt man eine verfallene Strandbatterie (Batteria), welche ehemals dazu diente, den Hafeneingang und Porto Ré, welches sie vollkommen bestreicht, zu vertheidigen. Sie liegt auf einem kleinen Vorsprung von zahnartigen Felsen und hat drei Seiten, wovon die zwei längeren, welche nach Südwesten unter einem stumpfen Winkel zusammenstossen, allein mit Schiessscharten versehen sind. Die Seite, zu der man zuerst gelangt, enthält deren fünf, die zweite, mehr der Hafeneinfahrt zugekehrte, neun" [47]).

A total of 14 gun ports accords with the description given by Halley. There is no proof that the remains that the Archduke saw in 1870 are of Halley's works, for there may have been later fortifications, but they do appear consistent with the accounts of Halley and Endtres. They were not the only remains in that neighbourhood however, for on Point Sršica there was a small fort, now vanished, that the Archduke thought was built in the sixteenth century, but with gun ports and outworks that might have been later [47a]). Though neither Halley nor Endtres suggest that they made use of pre-existing structures, it seems most likely that this is the site of Halley's first battery A.

Leaving the old Zriny castle (on the Porto Re side of the harbour) and walking in a north-east direction to the rocky point of the shore the Archduke noticed an old ruined house with ruined fortifications which might be remains of a battery on site B [47b]), but he did not mention anything at site E which seems to be an obvious place for a battery, perhaps that of earth, being "in the inner valley on ye Lar bord side going in" [48]). There were however, remains of a battery at site C, on the Punta Gavranič, which is "by Buccarizza", although the remains are across the headland from Buccarizza. Of them the Archduke writes:

„Etwas weiterhin liegt eine Strandbatterie (Batteria), welche der Form des Vorsprunges folgt und auf dessen Felsen aufgebaut wurde, welche, wie auf der gegenüberliegenden Seite, die Mesembryanthemum überwuchern. Sie weist noch vierzehn wohl erhaltene Schiessscharten auf, unter welchen ein Cordonsims verläuft; in der Mitte ist sie aber eingestürzt, und die in das Wasser hinabgerollten Mauertrümmer werden nun von den schäumenden Wellen umspült" [49]).

[47]) [Archduke Louis Salvator] *Der Golf von Buccari* p. 10.

[47a]) Ibid. p. 8—9.

[47b]) Ibid. p. 106—107: „. . . Felsenspitze, welche von dem kleinen, darauf gebauten Werke den Namen Punta della Fortezza erhielt. Auf der etwas verflachten Mitte der Punta steht ein verfallenes Haus, die Befestigungen aber nehmen das Ende der Punta ein und bestehen aus einem dreispitzigen, aus geblichen und schwärzlichen Steinquadern erbauten Bollwerke, welches ein Cordon umgürtet . . . Eigenthümlich sind die bei diesem Bau verwendeten, ganz gelben Ziegel. Bis vor wenigen Jahren war das kleine Werk armirt . . .".

[48]) Cf. p. 141 n. 43. Probably nothing was left of the earthworks which would have decayed by then.

[49]) Ibid. p. 97—98.

10*

In my previous article (cf. note 1) I suggested that the batteries would most likely be sited at a height about the same as that of the deck of a ship. The Archduke's description of the battery at site D is consistent with the plan and the view in the Weiss collection for the view shows the battery at some height above the shore, and Salvator speaks of batteries high up on the rocks above the shore. The ruins may however have slipped down the hillside by the time the Archduke saw them. The site at Porto Re is now covered by houses and other buildings, while that at E cannot now be visited because there is a private road leading to the oil installations.

Altogether, according to the note on Halley's letter of 15th September [50]), the masonry batteries were to contain 58 great guns, or fourteen or fifteen each, in accordance with the observations of the Archduke in 1870/71, but in Halley's letter of September 1st, he says:

"We ... have likewise laid the foundations of another on the same side [as Porto Re] which commands the entrance of the Harbour completely, and will be of 20 Guns" [51]).

This is clearly the battery at the site C, on Punta Gavranić, where the Archduke saw 14 well preserved gun ports, but in a somewhat ruined structure, so that originally there may have been more. It is not now possible to say how many guns were provided for in each battery.

The available evidence shows that there is a high probability that Halley built four masonry batteries at the sites A, B, C, and D and that the last three are those shown in Weiss's collection nos. 14 and 16. No signs remain of the earthwork battery E.

If the state of mapping of the Dalmatian coast was rudimentary and inconsistent when Halley set out for Austria, did his work have any effect on subsequent maps?

It might not be expected that it would have, since his maps were kept carefully in Vienna, and it seems that maps for twenty years after Halley's visit were no better than they were before it. The catalogue of an exhibition at Trieste in 1982 [52]) contains reproductions of a number of maps of Trieste from the decades immediately following Halley's visit; that of Bodenehr of 1720 [53]) is clearly unreliable and the first plans of Trieste that seem reasonably accurate are those of Weiss before 1735 [54]) and Pallavicini of 1734 [55]). Neither shows depths of water in the harbour and there is no reason to suppose that they owe anything to Halley.

[50]) PRO *SP* 105/70: fol. 29.

[51]) PRO *SP* 80/21: fol. 302.

[52]) Fulvio Caputo (ed.) *Le Carte del Impero* (Venezia 1982).

[53]) Ibid. p. 86 from Museo Civico di Storia ed Arte Trieste, 11/570.

[54]) Ibid. p. 16 from Hofkammerarchiv Wien *Kartensammlung* C 16.

[55]) Ibid. pp. 38, 39 from Kriegsarchiv Wien *Kartensammlung, Inland* C III, Mappe D; Triest n. 12 (scheda n. 2).

The delineation of the harbour of Buccari on maps of the same period is no more reliable than on those of the decades before Halley's visit and the first printed map that shows the harbour with any accuracy is that of Florjančić [56]). The detailed plan of Bodenehr [57]) shows a few depths of the water in Klafter, as well as what might be batteries on the shore at Sršica, but the plan is altogether erroneous. One manuscript map that may come from the ten years after Halley's visit was included in the archives of the English consulate in Venice. It is one of a set of plans of Dalmatian ports and is among the papers for 1714, although there is no date on the plans. They seem to be a miscellaneous collection with scales in different units and legends in different languages [58]), and a version of the Buccari plan is in the Kriegsarchiv *Kartensammlung* G I a 102, Plan 17. The interest of the plan of Buccari is that it shows fortifications "that might be built" in roughly the places that Halley proposed, so raising the question whether the unknown surveyor (perhaps Oberingenieur Hans Friedrich von Hollstein) had some knowledge of Halley's work.

IX

No allied fleet ever entered the Adriatic nor made use of Halley's surveys and batteries. A fleet under the command of Sir Cloudesley Shovell did enter the Mediterranean in 1703 but it was so delayed by Dutch

[56]) Lago-Rossit *Descriptio* Tav. CXII is a reproduction of *Ducatus Carniolae* by Joannes D. Florjančić de Grienfeld, published „Labaci" 1744; the section with Trieste is reproduced on a larger scale on p. 226, and that of Buccari on p. 230.

[57]) Reproduced in E. Schwarzenberg *La città murata di Fiume e la costa liburnica in una piantina di Gabriel Bodenehr* (Fiume 1976) p. 5—47.

[58]) PRO *Maps and Plans F* (henceforth *MPF*) 352, originally in *SP* 99/60 fol. 419—423. There are altogether five maps in the same style, on sheets of the same size, of Fiume, Buccari and Porto Re, Segna, Jablanac and Carlopago. Two of them are signed by Oberingenieur Hans Friedrich von Hollstein, no doubt the same person as referred to in the letter of 21 April 1703 from the Innerösterreichische Hofkammer to the Emperor: *HK* 1703-IV-62: fol. 39—42. The Buccari map in *MPF* 352 is slightly larger than the version of the Kriegsarchiv *Kartensammlung* G I a 102 Plan 17, its lettering is larger and more regular and elaborate. The words of the description are the same, except for some small differences in spelling; in fact the Kriegsarchiv map shows a more archaic spelling when using „newe", „lavirt" and „gebawt" instead of „neue", „laviert" and „gebauet" as on the map of the English consulate. The Kriegsarchiv *Kartensammlung* not only includes the maps of the four other ports Fiume, Segna, Jablanac and Carlopago, but they are part of a series of about 50 maps of the same style, some signed by Hollstein. — Associated with the five (English) maps there is a description of them in PRO *SP* 99/60, fol. 417—418: „Description of the 5 Imperial Ports in the Gulph of Venice" with brief undated explanations in French. There is nothing to show why the maps and their descriptions were included in the archives of the English consulate at Venice.

reluctance and adverse winds in the English channel that it could spend only a few months there before having to withdraw before the winter. The following year saw the first of major shifts of fortune at sea. Gibraltar was captured by English forces, the French fleet was effectively destroyed in harbour at Toulon, and finally, in 1706, Port Mahon was captured, to serve thereafter as the main English base in the Mediterranean; the French could no longer operate in the Adriatic, and the main English and Dutch land effort in the war was to be in the Low Countries, while the Empire was occupied with the revolt in Hungary. The project of naval action in the Adriatic was briefly raised again by Stepney in 1706 [59]) and thereafter no more was heard of it.

For Halley there was a rather direct consequence — it seems clear that it was his work for the Administration in Austria that led to his election to the Savilian professorship of Geometry in Oxford which had become vacant while he was on his way back to England [60]).

Although the story of Halley's year of 1703 seems to lead nowhere except to his election to the Oxford chair, it does nonetheless extend our knowledge of Halley himself and of aspects of early eighteenth century administration and technology as well as of the difficulties of the allies in the War of Spanish Succession. Halley's ability to manage men, to get things done, and his skill as navigator and surveyor were already known from the accounts of his cruises in the Atlantic and the English Channel of the preceeding years and they receive emphasis in his letters and the accounts that they give of his drive in getting his batteries built. That he was a military engineer is a new aspect of his capacities. Were only his maps to come to light, we would no doubt gain more knowledge of the state of marine survey as he practised it.

At the same time, the story of Halley on the Dalmatian coast reminds us of the difficulties of pursuing any large enterprise in early modern times. It took about a month for a courier to take a letter from England to Vienna or Venice, so that information was often out of date when it arrived, and a great deal of latitude was necessarily left to commanders or diplomats on the spot to act as they thought best in accordance with general directions. Naval operations suffered under many handicaps, of which two are particularly evident in the story of Halley's mission. Sailing ships depend on the winds, and plans could be quite deranged by unfavourable winds as Sir Cloudesley Shovell's fleet was prevented from leaving the English Channel for the Mediterranean in the summer of 1703. Another evident handicap was the inadequate state of many charts and the lack of any general world-wide system of charts such as the

[59]) PRO *SP* 80/28: fol. 120.

[60]) Alan H. Cook *The election of Edmond Halley to the Savilian Professorship of Geometry* in *Journal of the History of Astronomy* 15 (1984) p. 34—36.

British Admiralty charts now supply and that would enable a ship to navigate in any sea. The difficulties with the supply of guns for Halley's batteries remind us that metallurgy was still often unreliable. England, France and Holland could cast the largest guns that could reasonably be carried on board ship, while the guns that were produced in the Ottoman Empire were known to be unsafe. It is curious that while the relief of Vienna from the Ottoman besiegers on 12 September 1683 had come from superior artillery, Austrian founders, at least in Inner Austria, could not produce satisfactory naval cannon.

In retrospect it must seem that the idea of sending a squadron into the Adriatic, however desirable, was not practical. The construction of a fleet of ships of the line was the greatest industrial activity of early modern times, and besides the shipyards themselves, and iron founding for the great guns, it required many other contributory enterprises. Naval stations such as Deptford or Portsmouth or Toulon were not only hives of activity but behind them were regions like the Weald of Kent devoted to metallurgy and forestry. Buccari, Buccarizza and Porto Re were tiny places, as they are still, with only twenty houses at Buccarizza so Halley tells us, and they could never have housed throughout the winter the crew of a squadron of perhaps ten ships of the line that would have amounted to about five thousand men; nor, small ports that they were, had they the rope yards or the timber stores or carpentry-shops, not to speak of the gun foundries that were the cause of so much debate. Hemp and masts might grow in the hinterland, but there cannot have been the same means of working them at Buccari on the scale needed for warships. Victualling also would have been very difficult. The Hofkammer gave orders for supplies to be obtained, but there would have been no warehouses for the stocks of wine and wheat, no yards for the live oxen, no slaughterhouses or butchers' shops to provide for five thousand men.

An air of frustration hangs over Halley's missions, but they are still of great interest, not only for what they tell us about Halley, and about surveying and map making and fortification, but also because they came at a turning point in Mediterranean and naval affairs. The foray of Forbin into the Adriatic, the bombardment of Trieste and the burning of English ships at Malamocco within the lagoon of Venice itself, happened because the dominance of Venice was at an end. Thereafter it was the northern sea powers, and especially England, that were to control the Mediterranean for two hundred and fifty years. It is intriguing that some of our understanding of this crucial period in European sea power should come from the archives of an Empire that was not then a maritime power and indeed was only to become one of significance much later, in the nineteenth century.

APPENDIX 1

List of significant documents relating to Halley in the archives of the Innerösterreichische Hofkammer in the Steiermärkisches Landesarchiv at Graz:

Konvolut HK 1703-I-53

fol. 1: 16 January	Draft letter to Trieste, Fiume, Buccari and Segna, to assist Halley.
fol. 2: 1 February	Similar draft, with mention of Andreassi. Halley is all'incognito.
fol. 3: 3 February	Draft letter about Andreassi.
fol. 5: 15 February	Letter from Marc Antonio Orbich at Segna to Hofkammer reporting assistance given to Halley.
fol. 8: 10 February	Further letter from Fiume requesting assistance given to Halley.
fol. 10—12: 11 February	Count Vito Strasoldi to Hofkammer reporting Halley's surveys at Trieste and that he had gone on to Fiume (Doc. 2 of Appendix 2).
fol. 13: 17 January	Letter from Imperial Privy Council (Geheimer Rat) introducing Halley and asking that he be assisted.
fol. 15: 13 January	Imperial letter that Halley should be assisted (Doc. 1 of Appendix 2).
fol. 17: 27 January	Imperial letter that Andreassi should be assisted.
fol. 19: 24 July	Imperial letter for Halley to be assisted (on his second visit).

Konvolut HK 1703-IV-62

fol. 1—3:	Drafts concerning preparations for the expected allied fleet.
fol. 5: 21 April	Notes for a contract with Simone Milesi.
fol. 31, 35: 11 May	Two latin letters from Segna; the see is vacant but supplies will be provided for the fleet.
fol. 39—42: 21 April	From Hofkammer to Emperor, reporting their actions in preparation for the fleet. Rauschendorff has been despatched to Buccari to construct fortifications as laid down by Halley, but further engineers are needed; small arms are being provided and provisions arranged.
fol. 45—55: 29 December 1702[!]	Long report from Count Hannibal Joseph von Heister with postscript about affairs of Fiume and Istria and reference to Rauschendorff. Protection sought from French incursions.
fol. 56—59: undated	Report from Rauschendorff on the state of defences on the boundary with Venetian territory in Istria, with appendices dated 28 October and 19 December 1702 (fol. 60—61).
fol. 97, 100: 18 April	Imperial Privy Council (Geheimer Rat) to President of the Hofkammer Count Carl Weikhardt Breuner.
ol. 98: 14 April	Hofkammer to Emperor about repairing the batteries at Fiume.
fol. 101: 21 April	From Imperial Privy Council with instructions about Buccari and Porto Re.
fol. 104—105: 23 May	Emperor to Hofkammer concerning fortification of Buccari and Porto Re and preparations for the arrival of the fleet.
fol. 107—108: 18 July	From Emperor about arrival of fleet.
fol. 111: 30 April	From Hofkammer to Commissioner Endtres concerning the contract with Simone Milesi about buying cattle.
fol. 116: 21 April	Hofkammer to Endtres, with his instructions to depart for Porto Re to arrange fortifications and victualling (Doc. 7 of Appendix 2).
fol. 126—129: 24 July	Hofkammer to Emperor reporting actions.
fol. 131: 31 July	Emperor to Hofkammer, concerning Halley's return.
fol. 133:	Map of Istria as of December 1702 by Count Heister, see fol. 45—55, report of 29 December 1702.

Konvolut HK 1703-VII-89

fol. 1—5: 30 July	Drafts of four letters about Halley's second visit.
fol. 8—9: 27 July	Emperor to Hofkammer concerning Halley's return; shorter version — given as a kind of credential to Halley personally — of the Emperor's letter of 24 July (*HK 1703-I-12*, fol. 19).

Konvolut HK 1703-IX-11

fol. 4: 1 September	From Endtres to Hofkammer; progress of fortifications under Halley's urging (Doc. 9 of Appendix 2).
fol. 7: 17 September	Hofkammer to Emperor; report of Endtres's actions.

Konvolut HK 1703-IX-19

fol. 1: 10 October	Draft letter to Commissioners.
fol. 3—4: 8 September	Report to Hofkammer from Endtres at Porto Re.

Konvolut HK 1703-X-17

fol. 1—2: 9 October	Draft of letter at fol. 6—8.
fol. 6—8: 9 October	Letter from Hofkammer to Emperor, reporting actions of Count Johann Ernst von Herberstein.
fol. 9—11: 29 September	Report to Hofkammer from Count Johann Ernst von Herberstein at Fiume about actions at Buccari and Porto Re.
fol. 13—14: 24 October	Letter from Emperor to Hofkammer, concerning iron guns for the batteries at Buccari.

APPENDIX 2

1

1703 January 13, Vienna

Emperor Leopold I to the Innerösterreichische Hofkammer at Graz

Orig.: Steiermärkisches Landesarchiv Graz, Hofkammer 1703-I-53, fol. 15.

Hoch- und Wohlgebohrne, auch Wohlgebohrne Edle, liebe getreue. Wir erindern Euch gnädigist, waßmassen der Königin in Engellandt Liebden Einen Wohlerfahrnen obristen, Edmund Halley genant, zu dem Ende in Unsere Erbländer geschickhet, auf daß Er sambt seinen mithabenden Leuthen Unsere an dem Adriatischen Meer ligende häffen besichtigen, auch deren dieffe und standt Erforschen, und waß etwo sonsten darbey zu thuen währe, an die handt geben, nicht weniger auch, ob in Unsern drinnigen Ländern die Nöthige requisiten zu reparirung der Kriegsschüff und die sonst für dieselbe erforderliche provisionen zu bekhomben seyndt, sich informiren solte; solchemnach Wir Euch hiemit gnädigist befehlen, daß Ihr gedachten obristen sambt seinen Leuthen nicht allein alle Civilitet und Höfflichkheit erweisen, sondern Ihne auch gemelte seine obhabende Commission frey Verrichten, die Verlangende Informationen erthaillen und Ihne mit allen dergestalt an die handt gehen sollet, damit Er in Einem und andern Einige Unzufridenheit zu tragen nicht Ursach haben möge, wie Ihr dann deme schon rechts zu thuen und derentwegen Euren Unterhabenden beambten die Noturfft Ernstlich anzubefehlen wissen werdet. Wir bleiben Euch anbey mit Kayser- und landsfürstlichen gnaden Wohlgewogen.

Geben in Unserer Statt Wienn, den 13ten Januarii im Sibenzehenhundertunddritten, Unserer Reiche des Römischen im fünffundvierzigisten, deß Hungarischen im achtundvierzigisten unnd des Böhaimbischen im Sibenundvierzigisten Jahre.

2

1703 February 11, Trieste

Count Vito Strasoldi to the Innerösterreichische Hofkammer at Graz

Orig. holograph: Steiermärkisches Landesarchiv Graz, Hofkammer 1703-I-53, fol. 10r—12r.

Eccelsa Aulica Camera. Capitato in questa città, il Signore Colonello Edelmondo Halley speditto dalla Maestà della Regina d'Inghilterra a riveder queste riviere Austriache a scandagliar l'acque e prender altre informationi necessarie, io con tutta assiduità e prontezza humile in esecutione del gratioso ordine di catosta [= codesta] Eccelsa Aulica Camera delli 16 spirato Genaro, gli prestai non solo ogni allistenza [= assistenza] et informatione, mà anco con tutta la possibile civiltà e cortesia l'ho tratenuto e riguardato.

Per primo lo fecci restar informato che nelli stati e provincie Austriache non solo si potevano con facilità havere abbondantamente tutti li necessarii materiali per bisognio delli vascelli da guerra, come ferri, legni, telle, cordaggi, pece et altri occorenti, mà anco tutte le necessarie provigioni di carni, vini e farine per proviandarli ogni cosa a prezzi competenti e soportabili, introducendolo in altre dalla facilità, dalle condotte della quantità de nolli che si pagano, e delli paesi de qualli si puono senza molta difficoltà estrahere tutte li sudette robbe.

Per secondo lo fecci restar informato della situatione del paese, del quale ello dilligentamente prese in carte la sua positura con l'annotatione delle sue distanze.

Per terzo lo fecci provedere di barche e chiamati li marinari più vecchi e pratici di questi mari, accompagnandolo io in persona, si portò a far scandagliare l'acque ove si dovevano servire li vascelli di porto in faccia di questa città e fortezza e ritrovò una somena [!] in distanza da terra, cioè 50 in 60 passa geometrici lontano, 4 passa e mezzo d'acqua, in lontananza da terra di 70 in 80 passa, l'acqua si trovò di 5 in 6 passa et in lontananza di passa 100 in circa, l'acqua si trovò alta 6 in 7 passa sino vicino all'Isola del Zucco lontana 700 in 800 passa della città ove si trovò l'acqua alta 8 in 9 passa.

L'Isola poi dal Zucco si trovò haver di circumferenza 50 e più passa geometrici con fondamenti fermi e stabili quasi tutti di scolgio, ove giudicò non solo utile e profitevole mà necessaria l'eretione d'un fortino, e così la ristauratione del molo o sia strada che da detta Isola si congionge con la punta di Campo Marzo in terra forma di lungezza [!] circa 200 passa con che non solo si potrobbe [!] apporre in sicurezza il posto dalli Veneti, mà si assicurarabbe [!] dalli attentati nemici il porto stesso e la città tutta.

La spesa poi per tal erretione non giudicata come nè può esser grande, per esser il fondo dall'Isolletta quasi tutto scolgio e secho e perciò facilissima a fabricar sopra, et la strada o sia molo dall' Isola alla terra ferma di Campo Marzo di simil qualità e già con buona parte de suoi fondamenti, essendo altra volta ab antiquo stata erretta.

Dalla detta Isoletta poi del Zucco si trasportò per dritta linea alla punta [a]) detta di Musiella che li sta incontro, lontano una dell'altra circa mille e 300 passa che formano la boca dal porto, et in questa distanza scandalgiata l'acqua ne trovò per tutto 12 passa sino vicino alla detta punta di Musiella circa 80 passa che si ridusse a 5 passa, qual punta di Musiella pure sta distante dalla città 1000 passa in circa.

In tutto questo circuito di posto che arivera circa tre miglia italiane, o siano 3000 passa, il fondo si è trovato ottimo e sicuro per tener fermi li vascelli sopra l'ancore, oltre che puono avicinarsi volendo in terra a fine di legarsi con le loro so ... [b]) e corde. Questo e quanto posso humilmente informare circa la mia assistenza e l'operationi di detto Signore Collonelo Halley, in resto poi nel mentre che si facevano questo osservationi capitò in una barcha il Signore Conte Comandante d'Herberstein, quale io invitai nella mia barcha ove anco se ne vene, non essendo io mai contrario che tutti unitamente concorino ad assistere ove si trata del bon servitio di Sua Sacra Cesarea Maestà per promovere ... [c]) vicibus di lei avantaggi detto Signore Conte Comandante s'espressò ancho di tenir ordini gratiosi con simili alli miei in questo particolare, quali però io non vidi, si che sarà noto a cotosta Eccelsa Aulica Camera, se gli siano stati transmessi, o no finito poi dal Signore Halley sudetto le sue operationi, si partì verso Fiume a cui ho esebito ogni mia assistenza, anzi l'istella compagnia dal mio secretario, qual esso stimò superflua per essersi introdotte ad accompagnarlo il tenente di questa fortezza Alesandro Cechini, capitò poi più il Signore d'Andreassi con ordine gratioso di cotesta Eccelsa Aulica Camera, a cui participai tutto l'operato, mà per esser già partito il Signore di Halley, il detto Signore di Andreassi lo seguitò, promettendo poi il suo ritorno a Triste [!] al quale in tal cosa non mancherò d'ogni assistenza et informatione col raccomandarmi alla gratia mi inchino.

Triste, lo 11 febraro 1703.

a) *Orig.* quinta. — b) *Orig. destroyed.* — c) *Space left to add a word.*

3

1703 March 3, Vienna

Francesco Loredan, Venetian ambassador in Vienna, to the Senate of Venice

Orig.: Archivio di Stato di Venezia, Senato, Dispacci di Germania, filza 185, cc. 287v, 288r. — Cop.: HHStA Wien, Staatenabteilungen Venedig, Dispacci di Germania, vol. 185, pp. 330 f., de anno 1880.

Hieri è ritornato dalla sua espeditione il Capitan Hall. Applica presentemente a prodduire le sue informationi e diligense a questa Corte per poi passare personalmente a spiegarle alla sua Regina. Io non ho havuto tempo nè occasione di vederlo, nè d'internarmi con esettezza nelle notitie che desidero, al qual fine certo non mancarò d'ogni studio per tutto rassegnare a publico lume. Ciò che mi è sortito rittrarre da breve e passaggiero discorsso dell'inviato Brittanico è: che ha esaminato tutti li porti e le spiaggie Austriache da Trieste fino Carlobago, scandagliando il fondo de' canali e de' porti, misurando la loro capacità, rillevando i confini con lo Stato Veneto e tutto riducendo in pontuale disegno. Io non dispero di vederlo, mà non spero di haverne copia. Confermo poi che sopra tutti esaltava il porto di Buccari, che disse trovar più comodo, più capace e sicuro di Tolon medesimo e di molti altri porti più famosi; haver l'imboccatura assai stretta e che erretti sopra le due punte di terra della medesima due piccioli forti, sarebbe da qualunque forza nemica diffeso l'ingresso, così che potrebbe trattenervisi una squadra anche nell'inverno senza l'apprenssione d'alcun pericolo nè da venti nè da nemici. Mi fu osservabile questo ultimo tocco di supposta permanenza anche nell'inverno, benché per lo più tutti li discorssi non habbiano fondamento, nè tutte le idee sempre l'effetto. Intanto tra i raccordi che saranno suggerriti da questo perito non è quasi a dubitarsi, sarà quello di promovere le sudette fortifficationi. Chi rifflette alla solita incuria, tardità e penuria di denaro di questa Corte, dovrebbe credere che, quando anche non havessero luogo altri riguardi, facilmente potesse trascurrarsi o almeno non esser si pronta e fervorosa l'essecutione. Pure in questo caso potrebbe apprendersi che la Camera di Gratz avidissima di simili novità, e che non manca di mezi, fosse per dar contanti e calore all'operatione.

4

s. d.

Captain Edmond Halley's „Memoriall" to Emperor Leopold I

Cop.: Archivio di Stato di Venezia, Senato, Dispacci di Germania, filza 185, cc. 317r—318r (obtained by Francesco Loredan). — Public Record Office London, State Papers 105/67, fol. 418r—419v (from the archives of the English embassy in Vienna, slightly differing from Loredan's copy). — HHStA Wien, Staatenabteilungen Venedig, Dispacci di Germania, vol. 185, pp. 360—363, de anno 1880.

Sacra Cesarea e Real Maestà. Essendosi compiacciuta la Maestà Vostra Cesarea non solamente di concedermi la libertà di visitare le costiere maritime e suoi porti nell'Adriatico per riconoscer in essi qual fosse la speranza de' comodi, secondo mi era stato comandato dalla Serenissima Regina d'Inghilterra mia padrona, mà ancora essersi compiaccuita clementissimamente di far dare gl'ordini più proprii perché mi venisse somministrato ogni aiuto acciò potessi dar effetto all'opra et in primo luogo per la navigatione e sicurrezza in essi mari de' vascelli da guerra che vi potessero pervenire; havendo dunque principiato a riveder le carte, che da diverssi auttori sono state messe alle stampe, e trovatele molto fallaci nel vero in prattica: mi son dato l'ardire di formare una delle medesime di tutte le costiere della Maestà Vostra e dell'isole convicine che ho potuto riconoscere la quale mi rendo ardito di presentare alla Maestà Vostra.

Doppo di che mi sono trovato in obligo di osservare qual sicurrezza vi fosse contro le fortune de' venti che spesse volte si sentono in essi mari, particolarmente l'inverno, et ho riconosciuto che per tutto il Canale di Morlacchia correndo le coste di ferra ferma d'ubidienza della Maestà Vostra Cesarea all'opposto dell'Isole di Veglia, Arbe e Pago li vascelli possono ben star sull'ancore, essendo il mare netto e privo di segatori, mà la gran profondità dell'aque rende un pocco incomodo il darvi fondo.

Venendo poi alli porti di dominio di Vostra Maestà Cesarea ne' quali possa esservi sicurrezza da una poderosa armata nemica, non ho saputo ritrovar altro che quello di Buccari, essendo buonissimo e capace di numerose nave da guerra, dilatandosi nella lunghezza per lo spazio di circa di tre miglia italiani e la bocca non più larga di passi duecento, di modo che si può facilmente assicurare con batterie di cannoni, rendendosi in tal modo impropio il cimento di volerne tentar l'entrata, ogni volta venga con simil maniera fortifficata, essendomi preso l'ardire d'annotare le battarie ne' luoghi proprii sopra il dissegno dello stesso porto che unitamente alla carta geographica ardisco presentare alla Maestà Vostra Cesarea, giudicando neccessario per la guarniggione delle mede[si]me battarie sessanta pezzi di cannone, cioè quaranta da diciotto e venti da dodeci, dovendosi ripartire i medesimi alla dovuta ripartizione, convenendosi la grossezza della palla, perché dalle picciole non molto patiscono le navi grosse, et il numero de' cannoni, perché tentandosi l'entrata dalle navi nemiche con vento

fresco, si renderà quasi impossibile il far più d'un sparro; et circa la provista d'essa artigliaria potrà la Maestà Vostra Cesarea degnarsi dare a suoi ministri gl'ordini più solleciti perché vi sia condotta in tempo, tanto più che basterà esser di ferro, della quale o ne' proprii stati della Maestà Vostra Cesarea o altrove non mancarà modo di prontamente provederla.
La fabrica poi delle predette battarie la stimo di non rillevante spesa, ritrovandosi sopra il luogo tutto il necessario e solo la rena dovrà condursi da Fiume che si riduce al solo camino di due ore. In oltre stimo neccessario che clementissimamente si degni ordinare che si riconoschino ne' proprii boschi le qualità degl'arbori per navi acciò che ad ogni bisogno possa sapersi ove trovarli. Così che resti pronta ogni più regolata dispositione per la provista sollecita di tutta quella provianda che sarà stimata propria alla neccessità d'un mantenimento delle navi che potessero passare nell'Adriatico.
Con che sospirando d'haver la consolatione che con questo mio viaggio oltre l'obedienza prestata alli comandi della mia Serenissima Regina d'havere incontrato le fortune di servire a vantaggi della Augustissima Sua Casa e Persona humilmente prostrato al Suo Imperial Trono m'inchino.

5

1703 March 17, Vienna

Francesco Loredan, Venetian ambassador in Vienna, to the Senate of Venice

Orig.: Archivio di Stato di Venezia, Senato, Dispacci di Germania, filza 185, cc. 30rv—311r. — Cop.: HHStA Wien, Staatenabteilungen Venedig, Dispacci di Germania, vol. 185, pp. 353—356, de anno 1880.

Allo studio delle mie fervide e caute diligenze è in fine riuscito haver copia della relatione del Capitan Hall presentata a Sua Maestà Cesarea doppo le osservationi del Littorale Austriaco. Viene rassegnata a publico lume come haverei desiderato poter fare anche de' dissegni che hebbi occasion di vedere, mà non fin hora d'haverne copia. Li medesimi però non contengono osservationi di essentiale novità o rifflesso, oltre quelle più distinte del Porto di Buccari. Occupa questo un dissegno particolare in cui si vede distintamente dellineato l'ingresso o l'imboccatura larga incirca 200 passi. È segnata la profondità dell'acqua nella medesima di 25 e comparriscono abbozzate due battarie per parte per diffenderla. Nella parte interna si stende poi il maggior seno versso Buccari e sarà incirca di due miglia italiane, continuando l'altro alla parte opposta versso Bucarizza di un miglio, con li numeri in ogni sitto dell'altezza del fondo di 20, 18 e 16 passi che vanno diminuendo a proportione che si avvicinano a terra. L'altro dissegno è generico di tutto il Littorale cominciando dalle sboccature del Po fino a Carlobago, distinguendo con diversità di colori li possessi di Cesare da quelli della Republica. In questo punto osservabile mi è parito rillevar molta pontualità senza alcun publico pregiuditio perchè alla

Morlacca, dove cade l'occasion del maggior rifflesso, doppo il territorio di Carlobago segue subito il color che marca il dominio Veneto. Può cader alcun dubbio di disturbo circa il Canale della mede[si]ma per quello addita la relatione. Nel resto è denominato parte di Dalmatia quel sitto che confina con l'Istria, notando sopra la Licca e la Corbavia, et in situatione più alta la Croatia, il che tutto è utile a comprobare nella nota differenza di Zvonigrado e questione insorta sopra gl'acquisti publici in quella provincia che anche per il sentimento di questo soggetto molto verssato la Dalmatia arriva fino all'Istria. Non havendo però lo stesso occularmente esaminato se non il Littorale Austriaco, tutto il resto è tratto da carte et osservationi degl'altri auttori. Quanto alla di lui relatione, che veramente pare non esca dalle sole inspetioni che riguardano il ricovero e sicurrezza della flotta in occasione che dovesse penetrare nell'Adriatico, non devo tacer la mia gelosia che in voce o in altro foglio più custodito possa esser corsso alcun racordo o propositione più pericolosa e di pregiuditio più permanente. Ho mottivo di dubitare che secondando le suggestioni di quei confinanti e la vaghezza di farsi merito, habbia esagerato le facilità et i proffitti di applicare alla struttura et armamento de' legni proprii, additando il comodo de' boschi vicini, delle telle, ferramenta et altri requisiti de' quali abondano li Stati Imperiali, producendo anche le eshibitioni de' sudditti con gl'oggetti non solo d'una diffesa perpetua, mà d'un continuato proffitto nel corsso d'un ricco traffico. Procurarò maggiormente internarmi per verifficar li miei sospetti, de' quali traspirerà sempre alcun confronto, anche dalle voci e diligenze che si dilatassero in quelle parti. Circa la prontezza o difficoltà poi che si potesse supporre nella essecutione di tali idee, non posso che conformarmi a quanto ho humilliato in anteriori dispacci. Adempite le sue incombenze doppo haver conferrito con ministri et esser stato admesso all'audienza di Cesare, in nome di cui fu regallato d'una gioia di qualche prezzo; hoggi è poi partito questo soggetto per Londra.

6

1703 March 27, Vienna

Emperor Leopold I to Count Johann Wenzel Wratislaw von Mitrowitz, his ambassador in London

Orig.: Haus-, Hof- und Staatsarchiv Wien, Staatenabteilungen England, Korrespondenz 32, fol. 68.

Hoch- und wohlgebohrner, Lieber Gethreuer. Wür Erindern Dich hiemit gnädigist, waßmaßen Wür resolviert, Einige armierte Schüff in Unsern Meer Porthen bauen und außrissten zu laßen und derentwegen die Notturfft an Unsere Innerösterreichische Camer gnädigist rescribiert haben, diße aber darauf berichtet, wie daß Es Ihro an Einigen wohl Erfahrnen Schüffbauleüthen, wie auch an einen guetten Eißenen Stuckhgießer Ermanglen thette, und Unß dahero gehorsambst eingerathen, Wür möchten

Unsere Allyerte See Potenzen ersuechen laßen, daß Sye mit Gelegenheit der in das Mediterraneum und Adriaticum khombenden Flotta nicht allein Etliche von gemelten wohl Erfahrnen Bau- und Gießleuthen, sondern auch eine Quantitet unmontierter eißenen Stuckh, so für die Schüff tauglich seint, mitbringen und in Unßern Meer Porthen, gegen Bezahlung des billichen Werths, außschüffen laßen wolten.

Wie Wür nun kheinesweegs zweifflen, daß sowohl dergleichen Bau- und Gießleüth, als auch eißene Stuckh aldorthen genuegsamb vorhandten und nach der alhier von dem Englischen Obristen Hallay gegebenen Vertröstung leichtlich zu bekhomben seyn werden, alß wollest Du derentwegen gehöriger Orthen Instanz machen und darob seyn, damit gemelte Leüth und Stuckh mit der Allyerten Flotta in Unsere Meer Porthen überbracht werden, deme Du schon rechts zu thuen waist, und Wür verbleiben Dir mit Kayserlichen und königlichen Gnaden wohlgewogen.

Geben in Unserer Statt Wienn, den 27ten Martii im 1703ten, Unserer Reiche des Römischen im 45ten, des Hungarischen im 48ten und des Böhaimbischen im 47ten Jahre.

7

1703 April 21 (Graz)

Innerösterreichische Hofkammer at Graz to Johann Andreas Endtres

Contemporary copy: Steiermärkisches Landesarchiv Graz, Hofkammer 1703-IV-62, fol. 116.

Hoffcammer dero Mitlsrath Herrn Endrees.

Auß hiebeyliegenden abschrifften hat derselbe mit mehrern zu ersechen, was Ihre Kayserliche Mayestet in puncto alsobaltiger anleg- und Verfertigung der Nöthigen fortificationswerkch zu Porto Rè und Buccari durch den Ingegniur von Rausendorff [!] unterm 18ten dits allergnädigst anbefolchen. Und weillen Eine Löbliche Hoffcammer Einen Löblichen Hoffkriegsrath Mündtlichen requirieren lassen, derentwillen die weithere Verordnung an den Herrn Commendanten zu Triest und Berührten von Raußendorff in originali und Copia herüber zu geben, alß werden Ihme Herrn solche nicht allein zu gehoriger Bestellung, sondern auch beyligende Landtcarthen, damit Er mit Ihme von Raußendorff sich alsobaldt von Triest nacher Porto Rè begeben und Ihre Kayserliche Majestet in sachen Ergangnen gnädigsten befelch gehorsamst volziechen und die von dem Obristen Hallay an die handt gegebene fortificationes also gleich anfangen und Verfertigen lassen solle, gleichfahls beygeschlossen. Sovill aber die Verschaffung Einer guetten provision von allerhandt victualien für die ankombende Englische Flotta anbetrifft, da hat Eine Löbliche Stöll in Ihme das Gnädige Vertrauen sezen und denselben dise Commission gnädigst auftragen wollen, Sich ditsfahls mit dem Herrn Haubtman zu underröden und solche anstalten machen, damit ein zuelänglicher Vorrath von allerhandt victualien für gedachte Flotta verschafft werde, auff welches Sich Eine Löbliche Stöll genzlichen verlasset, derentwillen dieselbe Ein gleichmessiges und was dem anhängig Berührten Haubtman zu Buccari, Herrn Baron von Kerzn[?], unterm heutigen däto lauth besonderer Verordnung anbefolchen und von solcher Ihme gleichfahls hiebeyligende abschrifft zu seiner Nachricht Mithaillet. In ybrigen: weillen aus angeregter Kayserlicher allergnädigster resolution zu Ersechen, wie Praemuros und Sorgföltig Ihre Kayserliche Mayestet dises werckh Einer Löblichen Stöll allergnädist anbefolchen, zur Folge dessen, weillen dises in loco am Ersten geschechen kan, so hat Eine Löbliche Hoffcammer Ihme Herrn dises werckh auch übergeben wollen, der wirdet das weithere alda zu veranstalten und den Einfolg, au[c]h waß Sonsten vorbey gehet, zu berichten wissen.

Datum [?] den 21. April 1703.

8

1703 July 26

Prince Eugene, President of the Imperial War Council (Hofkriegsrat) to the military engineer David Jakob von Rauschendorff

Contemporary copy: Public Record Office London, State Papers 105/69, no folio numbers.

Unsern grus zuvor, Sonders freundtlicher, Lieber Herr Haubtman.

Demnach Ihrer Königlichen Mayestet zu Grossbrittanien bestelter Schiffcapitain Herr Hallay nach denen Keyserlichen Innerösterreichischen Meerporten in obhabender sehr wichtiger Comission abraiset und solchem nach nöthig seyn will, das demselben alle Information gegeben werde, also wird Er, Herr Haubtman, gedachten Herrn Schiffcapitain alle in Erwehnten Seeporten gemacht und angelegte absonderlich zu Buccari und Portorè zeigen und sehen Lassen, auch denselben allerdings an die hand gehen, was zur sicherheit bedeuter Porten noch anzulegen und zu machen ubrig oder besagter Herr Schiffcapitain für nottig urtheilen wird, wie deme der Herr recht zu thun schon wohl weiss, demselben benebens gottlicher bewahrung Empfohlen.

Wienn, den 26 July 1703.

9

1703 September 1, Porto Re

Johann Andreas Endtres to President and Councillors of the Innerösterreiche Hofkammer at Graz

Orig.: Steiermärkisches Landesarchiv Graz, Hofkammer 1703-IX-11, fol. 4.

Hochlöbliche Innerösterreichische Hoffcammer. Hoch- und Wollgebohrner Herr, Herr Praesident, auch andere Hoch- undt wollgebohrne, wollgebohrne, woll, Edl Gebohrne, gnädig undt Hochgebiettige Herrn Herrn. In Crafft der Erhaltenen gnädigen Verordnung, daß ich Bey anhaltendter schwerer Unpäslichkeit des Herrn Graffen von Herberstain ein und andere bericht allein Erstatten solle, hab ich zu gehöriger nachlebung dessen unterthänig berichten wollen, daß Herr Obrist Halay zu schlainiger Verferttigung der anlegente Batterien negst Porto Re unglaublich insistiert, da doch bis däto aller miglichster Fleiß angewendt undt die zu Scherchiza alß die principal orth beraith verferttiget worden. Morgen wierdet auch die vor Porto Re bis auf die legung deß Podens zuer perfection gebracht werden. Innerhalb 8 oder lengist 10 Tagen solle auch die an der punta gegen Buccariza anlegendte unndt meo judicio beste Batteria nach Verlang des Herrn Obristen Halay in standt gebracht, nebst deme auch die vierte von Porto Re über vollendet, mithin vier Batterien perfectionirt, undt nach disem auch die fünffte in wenig Tagen gemacht werden; welliches Ihme Herrn Obrist Halay hegstens Consoliert, dahero nicht ursach haben wierdet, na[c]her hoff ein widriges zu erinern, wie dan zu wintschen, das nach vollendten Batterien die Englische undt Hollendische Flotta alhier zu sehen wär: weliches ich Einer Hochlöblichen Stell gehörig berichten, mich aber anbey zu hohen gnaden empfel[c]hen wollen.

Porto Re, den Ersten Septembris 1703.

APPENDIX 3

Table of some distances in the Harbour of Buccari

Distances are in metres, using the equivalence, 1 passo = 1,74 m.

	Halley	Admiralty Chart
Total length	5220	4600
Width of entrance	350	400
From Entrance to Buccari	3500	3200
From Entrance to Buccarizza	1700	1400
Greatest width of harbour	580	1000

Impact of Science on Society No. 141, 3-14

SCIENCE AND TECHNOLOGY: THE THIRD WORLD'S DILEMMA

Akhtar Mahmud Faruqui
Pakistan Atomic Energy Commission, Karachi, Pakistan.

Big science and high technology today are the almost exclusive domains of the developed countries, while the developing world lags far behind. What are the prospects for change? A Pakastani author gives his view, which serves as an introduction to this issue on research, high technology and the multinationals.

'It is indeed possible that the psychological factors working against science development will become more intense in the ACs (advanced countries) but will lessen in the LDCs (less-developed countries). If so, the LDCs would have an exciting opportunity indeed . . . From a historical point of view, there is precedent for a reversal of roles. Civilizations rise and fall . . . the opportunity is so momentous and exciting that this task deserves the primary attention of the whole scientific community of LDCs.' *Science Development: The Building of Science in Less-Developed Countries*, by Michael J. Moravcsik[1].

Present world conditions hardly allow one to share Moravcsik's euphoria about the prospects of science development in the developing countries. That the developed world would largely fall behind the Third World seems so preposterous a suggestion that one might readily discard it as improbable.

The colossal investment of the developed world renders the Third World's expenditure on research and development (R&D) ignominiously miniscule. In 1984, the United States earmarked $30·5 billion for defence-oriented research alone[2]. Another $400 million was set aside to meet 'a long-standing complaint from university researchers to upgrade research tools'. In the 1960s, America was spending more on research and development 'than [what] President Roosevelt had at his disposal for all purposes before Pearl Harbour'[3]. The effort paid rich dividends. In 1966, the United States' Gross National Product increased by an amount that exceeded the combined GNP of all countries in the African continent! The trend continues.

Science and the Third World

Yet Moravcsik's buoyant optimism about the future of science in the Third World is not wholly misplaced. Viewed from an historical perspective, his observation is justified. The world's four earliest civilizations—Mesopotamia, the Nile Valley, the

Indus Valley, and the Yellow River Valley—sprang up and flourished outside the geographical boundaries of Europe and America. They nurtured scientific enquiry and sustained the creative impulse. According to Thomas, 'The citizens of the towns of what is now Iraq were responsible for [the] fundamental innovations... They reached a mathematical level of achievement not touched elsewhere until the Renaissance'[4]. Much later, before 200 AD, according to Thomas, Alexandria 'had made almost all discoveries necessary for the achievement of modern Western civilization'. Throughout the early ages, the march of science in the regions now forming parts of the Third World was religiously sustained. The universities of Cordova and Toledo in Spain formed the hub of scientific activity where scholars from the *rich East*—Syria, Egypt, Iraq and Afghanistan to name a few—dabbled in science, and prospective researchers from the *poor West* looked askance when told to go back to clipping sheep because their teachers 'doubted the wisdom and value of training them for advanced scientific research'[5]. By the time North America was opened up, 'much of North Africa, South and East Asia were both densely populated and highly organized politically, culturally, and time, technologically'[6]. China appeared decidely more innovative than Mediaeval Europe, and better poised to stage a renaissance in Asia than was Italy in Europe. It is not surprising that the chronicles of scientific achievements, including George Sarton's *History of Science*, make only a brief mention of the West's earlier contributions to science.

Big science and early failings

The Renaissance marked a critical development in modern history. As Cordova and Toledo faded into oblivion and a civil war inhibited China from diffusing science anew in the Asian continent, scientific enquiry came to be identified with Europe and Anglo-America.

But the going was difficult. Early inventors were an unwelcome lot. Universities appeared indifferent to the application of research findings. Rutherford, for example, poured scorn on the idea that his great discoveries would ever be of any commercial use. Social assimilation of the mass-production concept posed problems. The demographic pattern—a 4% birth rate in the 18th century—severely taxed limited resources. Technology's role was decried as well as appreciated in such diverse works as Edward Bellamy's *Looking Backward*, Aldous Huxley's *Brave New World*, Dickens' *Hard Times*, and as late as 1954, Jacques Ellul's *La Technique*.

The first full-time professor of chemistry at Cambridge University, Richard Watson, aspired to be a professor of divinity and took pride that he knew nothing of chemistry! 'His greatest scientific achievement was to persuade the university to pay him £100 a year'[3]. The Clarendon Physics Laboratory in Oxford was modelled on the kitchens in Glastonbury Abbey on the grounds that physics and chemistry were much the same and that chemistry was indistinguishable from cooking. The budget of Cambridge's Cavendish laboratories in 1895 was £1000, plus the salary of Professor J. J. Thompson. Lord Rutherford, in the 1920s, never had more than £2500 a year to spend on science. And some argued that experimental skill was an art that could not be taught and that experimental physics could have no place in a university.

R&D and GNP correlated

What are the motivations for R&D today? Christopher Freeman identifies five principal catalysts: war, prestige, economic growth or competitiveness, welfare, and science for its own sake—'one of the supreme achievements of the human intellect'. Military motivation, with war acting as the mother of science, has precipitated many scientific developments. Today, quite a few developed countries attribute considerable importance to military research and invest heavily. In 1980, nearly one-fourth of the world's expenditure on R&D was consumed by military research, and more than half a million scientists were engaged in the development of new weapons and defence systems. Simon Ramo, founder of TRW, a major defence contractor in the United States, has argued that 'had the total dollars we spent on military R&D over the last 30 years been expended instead in those areas of science and technology promising the most economic progress, we probably would be today where we are going to find ourselves arriving technologically in the year 2000...'[7]. Ironically, some Third World countries whose progress is seriously jeopardized due to denial of technology, contribute to the military research of developed countries through arms importation.

But while military research takes precedence over civilian research in a few countries, economic growth remains the prime motivation for science in all countries—both the haves and the have-nots. The scientific size of a country is significantly correlated with its GNP—the more productive a country is in the sciences, the larger its GNP tends to be. A unified concept of R&D forms an integral part of economic planning in the United States, Europe and Japan and largely explains their burgeoning GNPs and enviable state of economic well-being, which act as an impetus for emerging nations to take to science and technology.

Western science's constraints and the Third World's dilemma

The spectacular 'big science' achievements, a consummate fusion of science and technology, bear a distinct Western imprint. Moravcsik's observation seems relevant:

> The origins of science may be traced back to civilizations in Northern Africa and elsewhere but in a functional sense, modern science is the product of Western civilization. Hence, scientific assistance has primarily emanated from Europe and North America.

Regrettably, the flow of scientific assistance from the West has remained at a low ebb. 'The ever-widening gap', the title of the address of Professor P. M. S. Blackett, then president of the Royal Society, London, to the American Association for the Advancement of Science in December 1967, stated that science's world-wide supra-national evolution could be sustained through heavy financial investment, loans, and gifts from the developed to the developing nations. That did not come about. The Pearson Report, a laudable effort undertaken at the behest of the World Bank in 1969, noted that technical assistance from the developed world had failed to adapt to the requirements of the developing countries. Western science certainly had created manifold opportunities for man, but sadly its beneficiaries had been a chosen few. Why?

Science is no longer the gentlemanly enquiry of yesteryear—independent, disinterested, and without frontiers. (Sir Humphry Davy lectured at Paris in the middle of the Napoleonic wars and Captain Cook continued his exploitation, unhindered and unharmed, in the Caribbean during the American War of Independence.) The present trend is seriously disconcerting, particularly, as Alexander King succinctly put it, 'the traditions of science and its nature are essentially and intrinsically international'[3]. The individualistic tendency of each country, attempting to break new ground on its own and containing newly-gained expertise/knowledge within its borders, tends to cripple scientific enquiry, which thrives when unrestrained efforts are unleashed and research remains a collective effort. It particularly hurts activity in sciences relating to the earth and sea (climatology, geophysics, biology, and medicine), which require pooled resources and knowhow. The same is true for research in high energy physics, a costly proposition made lighter through multinational undertakings and the sharing of expenses. If scientific co-operation is perpetually discouraged for gaining political leverage or safeguarding corporate interests, science's cause will suffer irreparably, particularly in countries where its framework is frail. In such a situation, the Third World's dilemma can easily be imagined. Isolation at the critical formative phase can be very damaging. Moravcsik maintains that 'No country has yet managed to develop its own science without assistance'. A UN study confirms that 'there is a great doubt that the growth of an indigenous scientific community can be effected without active participation by the international scientific community'[8].

Frail science versus strong

The world's scientific and technical manpower resources are shared in an uneven way by developed and developing states. Gross inequalities draw an invisible line between the haves and the have-nots. Salam vividly spotlights the alarming disparity between developed and developing countries—the former, generating an income of $5 trillion, spend $100 billion (2% of the earnings) on non-military science and research, while the latter, with an income of $1 trillion, spend a niggardly $2 billion when they should actually be spending $20 billion, according to the percentage norms of the richer nations. 'A world so divided between the haves and have-nots cannot endure', Salam comments[5].

Roughly 92% of the world's scientists are engaged in R&D in the developed regions and account for about 98% of the world's total expenditure for these activities. The developing countries, according to a 1971 UN study, contain a dismal 8% of the global technical corps and spend a nominal 0·2% of their GNP on R&D. In recent years, a healthy trend has been witnessed in some developing countries, which invest more. Nevertheless, the per capita expenditure on R&D in the Third World is about 300 times less than that in developed countries.

The number* of researchers per million population illustrates the same discrepancies between the developed and developing world: in the United States, 2500, the developed world as a whole between 500 and 2000, France/United Kingdom 1000, FR Germany 900, Japan 1400, Canada 900, India/China 200, Africa 20, Argentina 194, Chile 246, and Brazil 70. The manpower requirements for a self-sustaining functional research infra-structure are rated by A. B. Zahlan at 1000 research-active persons in science and 3000 research-active persons in technology per million population.

The same disconcerting trend seems to manifest itself in the schools. Students of science and technology per million population number 180 in Africa, 445 in Asia, 550 in Latin America and 1170 in Western Europe according to a 1971 UN study. The position

* In recent years the number has gone up, particularly in the developed countries.

has certainly improved in more recent years, but so have populations. To further compound the situation, enrolment in social sciences and humanities in some developing countries accounts for 50–70%. Adjusting production activities in such countries to research results carried out elsewhere is an onerous task, not to speak of the problems encountered in assimilating the technologies they import.

The academic scene, often plagued with poor laboratory equipment and misdirected goals, is also beset with an outstanding and chronic problem—a serious shortage of scientific books. Books, in fact, are generally in short supply in developing countries. A recent study suggests the availability of only half a book per reader in 1981!

A general perspective of Third World science

The developing countries are a heterogeneous assemblage of nations with many cultural, ethnic and historic backgrounds. But most share 'a concept of emergence and characterize themselves as being developed socially and culturally and as being underdeveloped economically and technically'[9]. Their patterns of scientific growth are anything but uniform. Some are extremely backward, their amorphous science presenting a picture of what has been called a 'research desert', and neither progress nor retrogress; others have made a beginning and have marginally assimilated science; while a few have covered considerable ground and spark a glimmer of hope. All demonstrate an urge to assimilate change and to draw science and technology into their production lines. Their common failings include:

(1) *Implentation failures and bureaucratic highhandedness*

The most common and disturbing feature of Third World science is that it remains in a perpetual state of planning. Concern is often voiced for upgrading the status of science and technology: plans are enthusiastically drawn up, priorities exuberantly defined, reappraisals eagerly made, commissions frequently formed. But at the critical stage of implementation, the urgency and enthusiasm disappear and the task is entrusted to the next generation of planners. And astute science planners, a rare breed in the developed world, are even rarer in the developing countries.

Bureaucracy has always stultified scientific enquiry. Much to the chagrin of the researcher, bureaucrats and economists act in conjunction to seriously distort the priorities of a research programme. They adopt an even more high-handed approach in some parts of the Third World where democracy, a friend of science, makes only an elusive appearance and bureaucracy enjoys a freed hand. The problem is often compounded when older élitist groups of scientists, having severed links with research, turn into full-time science planners.

(2) *Faulty career-patterns*

Research in developing countries is mostly undertaken in government-run laboratories which often, if not always, are rendered inert partly because of an odious career system which catapults a senior unimaginative scientist into the director's seat and leaves a younger, enterprising researcher at his mercy. Mediocrity is thus perpetuated.

(3) *Educational weaknesses*

University research in most developing countries is still in a stage of infancy, and in quite a few countries even basic research is sadly ignored. But this is not true for all. In some developing countries university research has taken firm root and plays a useful supportive role in strengthening laboratory research, both in the public and private sectors.

The educational scene in the Third World must soon be transformed. The schools, nurseries of science, should speedily inculcate a spirit of enquiry. The colleges should promote science learning—not at the expense of, but in conjunction with, the humanities—and groom potential researchers. The universities should have a fresh infusion of science, recast their curricula, refurbish their laboratories, and produce a new breed of researchers whose functional orientation can contribute to scientific productivity.

(4) *Industrial research inadequacies*

Industrial research in the developing countries has a low priority: in Asia it represents only 3% of total research activity. The reasons are not difficult to find. Most industrial concerns are subsidiaries of big multinational firms and depend on the R&D effort undertaken in the home country. Indigenous research is considered superfluous and a drain on company profits. Even the local firms with no foreign links often shy away from investing in R&D as they are little conscious of the benefits.

(5) *Inadequacies in the basic/applied research connection*

A redeeming feature of Third World science is that despite a pronounced emphasis on applied research, the important role of basic science is not altogether neglected. The proportional investment in the two conforms to what is generally considered an ideal ratio, with basic science claiming a 10–20% slice of the whole. 'UNESCO statistical studies on R&D show that the lower the per capita GNP in countries, the higher tends to be the amount of fundamental research', says a UNESCO report. It applauds this trend and claims that it 'corresponds to the actual needs of developing countries at the present juncture'[8]. Moravcsik tends to concur: 'the ratio between basic and applied research is the desired one' but contends, and rightly so, that the connection between the two remains underdeveloped. Hence the effectiveness of both, particularly applied research, is considerably lessened. 'It is the improvement of quality in applied research and the establishment of links between basic and applied which should be the primary targets of attention, not the redressing of numerical ratios between the two'.

(6) *The brain drain*

According to Robin Clarke's 1971 estimate, the developing countries had then lost 40 000 scientists to the developed world. Other studies suggested that while the situation in Africa and Latin America may not have been alarming, that in Asia was cause for serious concern. In 1972, between one-half and two-thirds of all Arab PHD scientists and two-thirds of engineers lived outside the Arab world. In Turkey, the number of PHDs in natural sciences who had emigrated was seven times the annual production of PHDs. During the 1960s, it was estimated that only 10% of the students

from Taiwan, Hong Kong, Korea and Greece returned home and 60% of the students who went from Iran to American universities stayed in the United States. At a seminar in 1967 Lord Bowden complained about the losses of Britain to the United States: 198 PHDs in 1961, 415 in 1965, and one PHD physicist out of every three who graduated in 1966. 'If we capitalize the value of those who have left the British Isles for America since the war, we have very much more than paid back the whole of the Marshall Aid', he plaintively observed[3]. No computations have been made to work out the Third World losses on this count, but the brain drain has a more poignant aspect in the context of the developing world. It reminds one of the Biblical adage: 'To him that hath shall more be given and from him that hath not shall be taken even that which he hath'.

(7) *Lack of international support*

Science's commercialization and its newly-acquired initiating role in technological innovation have seriously impeded the international promotion of 'science for science's sake'. Only 600 American scientists, comprising 0·1% of the total strength of the US research community, participated in international conferences, symposia, and meetings during the last decade. Capitol Hill finds little appeal in international science, and technical assistance occupies a 'less-distinguished-position' in the American Congress. What is true for the United States is, by and large, also true for most of the European countries.

The United Nations has shown sincere concern for international science and has promoted R&D effort on a global scale in order to live up to its world-body image. In the absence of a universal science policy, the United Nations perception of some global problem-areas has not been entirely without gains. It has helped to define a strategy and to frame well-meaning long-term programmes. Some of the UN's successes have won accolades, and deservedly so. But its programmes contribute only in a feeble way to the elephantine science needs of the Third World and have serious limitations. First, the paucity of funds restricts the scope of the United Nations operation. In 1968 its budget for this purpose, as Victor A. Kovda perceptively observed, was a meagre 100 million dollars or 5 cents for each citizen of LDCs. The United Nations science budget today must be far greater—but then so is the population of the Third World. Secondly, 'emphasis in United Nations programmes is primarily on planning activities; achievements in implementation are less pronounced', says Moravcsik. Quoting Zahlan, he mentions that at the 1966 UNESCO meeting in Algiers (dealing with science policy in the countries of Northern Africa and the Middle East) 21 recommendations were adopted, but 'Six years later none had been implemented, not even the eight which should have been implemented by UN agencies themselves'. Finally, the science programmes of UN agencies are often too highly specialized in nature.

Despite these limitations, UN agencies have done much for science in developing countries. An outstanding example is the International Centre for Theoretical Physics at Trieste, an institution with considerable international stature enhanced by the personal reputation of its Director Abdus Salam. This Centre, run by the International Atomic Energy Agency and UNESCO, has made an immense contribution to the fostering of science in LDCs. But such bright spots are more the exception than the rule.

One may conclude that neither bilateralism, nor international assistance nor UN agencies can resolve the overwhelming problems of Third World science unless the developing countries also act on their own. Some have already done so, others should follow their example. There is not much time to lose.

A changing scene?

The Third World's increased investment in R&D is a good omen. In China, it rose from 0·01% of the GNP in 1950 to 1·54% in 1960. Between 1962 and 1965, China's R&D expenditure registered an impressive 100% increase. The upward trend continues. Happily, China has also shown serious concern about its burgeoning population. In 1980, its population growth rate fell to 1·3% compared to 2·1% for Third World countries as a whole and the 1·7% world average. The Beijing Declaration, drawn up at the Asian Conference of Parliamentarians on Population and Development, has called for a 1% population growth rate by the year 2000.

Egypt's R&D expenditure between 1961 and 1967 experienced a 23-fold absolute increase, or a four-fold increase as a percentage of GNP. In India, a five-fold absolute increase—a two-fold in percentage of GNP—took place between 1958 and 1969.

The number of Third World students in foreign universities had been steadily mounting. In the United States, their number increased from 3200 in 1938 to 70 000 in 1968 and to 110 000 in 1972. The upward trend continues. Simultaneously, the number of educational institutions and research centres in the developing countries themselves has visibly increased. In addition to this educational ferment, 'talented individuals are becoming increasingly involved in the important and exciting activities of institution-building' to transform 'alarming situations into surprising opportunities'[10]. A particularly heartening feature of these developments is that the curricula, eagerly and hastily copied from the West in the 1960s, are being imaginatively revised: in the 1970s a healthy trend to build national curricula based on local experience was much in evidence.

Thus, while large-scale rejuvenation of science in the Third World may not be in the offing, hints of a change in parts of it at least, persist. One sanguinely hopes that the advent of the Third World into the science-oriented technological era will be achieved with minimal friction with the West.

The West has a moral obligation to erase some of the present technological imbalances, which are largely its own doing. It is hard to deny that 'for most of the sovereign states of the world, the length of time and the degree of intensity to which they have been subjected to European influence has much to do with their present political, economic, material and technological levels and systems of organization'[6]. The scars of colonialism are still visible in many parts of the battered developing world. Sadly, science was left to suffer and languish during the colonial period.

At the same time, the Third World must act on its own to adapt itself to the world of science. History provides many instructive lessons. The Industrial Revolution in Britain, and the later industrialization of Europe and America, were financed by private savings and profits from the Great Trade Triangle. German industries grew in one generation between 1840 and 1875: in this short span of 35 years Germany passed from the Middle Ages to modern times. The vast sums that brought about the transformation of Europe and America are more than matched by a contemporary Third World entity, the OPEC consortium. Here is food for thought for the oil-rich countries, particularly the Arab states, which were the torchbearers of international scientific research in the 8th to the 11th centuries and who are ordained by Islam to pursue knowledge and learning.

The UN could also help. More international research institutes on the ICTP pattern are needed by Third World scientists for studying disciplines other than physics.

High technology

High technology has recently dominated the science-based business world. R&D inputs in high technology in the United States account for 60% of industrial investment in R&D. The returns are on a similar scale. High technology products form a key element of US foreign trade today: their share of the country's total exports has risen from less than 40% in 1967 to more than 44% in 1980.

Commercial stakes being high, the field is fiercely contested, with the United States and Japan labouring to retain their ascendancy and the developed countries striving to catch up. Recently, the European Community launched a $1·2 billion plan 'to achieve parity, if not superiority, over American and Japanese competitors within the next ten years'[12]. Within the United States, there is anxiety over the growing technological onslaught from the competitors.

The United States lead could be maintained both by consistent R&D operations and by denying technological gains to others—even to allies and friends, a method that recently had generated bitterness and resentment. Norman Tebbit, Britain's Secretary of State for Trade and Industry, told the US Chamber of Commerce in February 1984, that the 'most persistent cause of tension between the US and Britain is Washington's attempts to impose [its] laws on people in other countries, inside their homes, and their business'[13]. The attitude smacks of the multinationals' indifference to the diffusion of their technical know-how among the developing states where they operate.

Lately, commercial motivations have prompted a fairly large-scale interaction between the United States and many developing countries in the high-tech field. 'At a time when many US high-technology firms have taken to waiving the flag and sounding the cry "buy American" to counter the threat of growing competition from the Japanese and other foreign-rivals', says a writer in *Datamation*, 'a number of these firms are "buying foreign" when it comes to the labour market'[14]. These corporations are offering jobs 'to non-US workers in countries where wages are often a fraction of those paid here and corporate taxes minimal or non-existent'. The offshore development had grown at a fast pace and major American corporations now have as large a share of their operations outside the United States as in it. 'Half our business is outside the US', explains Richard Love, director of international marketing for Hewlett-Packard which has major facilities in Mexico, Singapore and a number of other countries. Today, more than 70 countries are vying to attract US facilities including Korea, Singapore, Taiwan, Sri Lanka, Scotland, Mexico, Jamaica, India, The Philippines and Malaysia; Eire alone has successfully drawn as much as $1 billion in fixed-asset investment from about 350 US firms, including IBM, Apple, Cado, Digital Equipment, Storage Technology, Prime, Modular Computer, Wang Labs, General Electric and Four-Phase. A few other developing countries, including Singapore, Barbados, The Philippines, and Mexico (where 650 American plants employ 140 000 workers), have also benefitted from the overseas operations of American high-tech corporations. More recently, some American companies have been 'scouting around for engineering and data processing assistance overseas': National Semiconductor had its 32-bit microprocessor developed in a Third World country. If the present trend is any indication, the hubs of American technology—Route 128, Silicon Valley etc.—will become progressively less labour-intensive and more automated, providing a grim picture for those who have been unfortunate enough to tie their careers to a high-tech assembly line.

Thus, commercial interests act as a constraint against the diffusion of high-tech knowledge in the developed world, and as a catalyst for the overseas expansion of high-tech American assembly lines in parts of the Third World. Commercial interests may or may not restrict the flow of technology in one part to its slow diffusion in another.

The emergence of Third World multinationals

Applauded by some as an economic link between the disparate segments of our world and as an agent of development, and castigated by others as exploitative business houses, the multinationals are trading republics operating on a massive global scale as a commercial manifestation of the West's technological supremacy. Their turnovers exceed the gross domestic products (GDP) of some of European countries. General Motors' sales, for instance, can be favourably compared with the GDP of Austria or FR Germany, while British Petroleum's turnover roughly approximates the GDP of Portugal. 'The whole of tropical Africa (excluding the northern group of countries and South Africa) does not greatly exceed the sales of the largest US company', according to Cole. The political influence of the multinationals, too, is by no means small. 'Instances such as the alleged involvement of International Telephone and Telegraph in persuading the American government to undermine the government of Chile's Allende, have put the leaders of the Third World under an increased sense of insecurity in their dealings with the multinationals', one study suggests[15].

Viewed earlier as partners in development—the Third World contributing labour and raw materials, and the developed countries providing the technological nutrient—the multinationals' role is little appreciated in developing countries today. And for obvious reasons. Commerce between developed and developing countries has gone on for centuries on an even keel, but with the infusion of technology into commercial ventures, the West's 18th- and 19th-century industrialization and 20th century technological innovations acting as a catalyst, the trade pattern drastically altered to the advantage of Europe and Anglo-America. The trading of cheap labour and raw materials for Western technology meant that the major portion of value added was credited to the advanced countries[15]. Trade between the developing and developed world grew into a whopping $277 billion by the mid-1970s, making up about 39% of the world total, but the major share of the benefits went to the developed world. Indeed increased trade between the haves and have-nots today, as James McGuinnis vividly described in *Bread and Justice*, actually 'reinforce the privileged position of the few on the top at the expense of the many at the bottom. Increasing the interaction between parties of unequal bargaining power only perpetuates the inequities of the current economic system'.

Partnership in multinational trade has provided neither technology nor economic gains to the Third World. This agent of change hardly generates any, yet accumulates profits. Today, the hapless developing world is unable to market technical goods and helplessly relies on the exportation of cheap primary products. (The total exports of $9 billion in technical products by the developing countries contrast sharply with the $219·5 billion by the developed regions[15].)

Pressing for new legislation

Contemporary imbalances of international trade have raised a clamour for legislation for an international code of conduct on the transfer of technology and a revision of the international patent system, but to little avail. The developed world steadfastly clings to

its technological secrets and obstructs the diffusion of knowhow, since 'free diffusion preempts markets that the creator might have served, and may thus remove the incentive to innovate... Control over the supply [of technology], plus the buyer's ignorance regarding the true value of technology can lead to excessively high prices'[16]. This pro-business atmosphere has been characteristic of European and American dominance of the world throughout most of the 20th century.

Disenchantment with Western business houses spurred the Third World to establish its own breed of multinationals, and with commendable rapidity. The scale of their overseas investment is fairly impressive, especially considering the small size of most developing economies and their number has soared from six to 23 in the past decade. There are 1300 foreign manufacturing and trading subsidiaries among 15 developing countries, according to Professor Louis T. Wells of the Harvard Business School. Brazil's Petrobras and Kuwait Petroleum already rank among the world's top manufacturing companies, while Hyundai (Republic of Korea) has grown bigger than France's Michelin and Britain's Rio Tinto-Zinc, and Taiwan's Walsin Lihwa outranks Distillers of Britain, Atlas Copco of Sweden and DeBeers of South Africa. But the Third World multinationals have little to offer in terms of technology and have yet to acquire the high sophistication levels of their Western counterparts.

Rapport between the Western and Third World multinationals has already begun. And there are sane and timely suggestions that host governments may allow Western-based multinational operations into their markets if the multinationals will help the host countries develop indigeneous technology and R&D capabilities. The Western multinationals would be well advised to heed such suggestions rather than solicit the opinions of highly-paid political scientists and former foreign service officers about the political and economic risks of investing abroad. After all, R&D operations in developing countries require little financial outlay.

Will the science scene alter with the emergence of the Third World multinationals? The prospects appear remote. Nevertheless, corporate interests and increased interaction between the old multinationals and the new just might bring about some changes. We shall have to wait and see. ■

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YUGOSLAVIAN EXPERIENCE IN DEVELOPING NUCLEAR POWER

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WAY OF PRESENTATION:

- THROUGH THE DEVELOPMENT OF NUCLEAR POWER RESEARCH IN THE J. STEFAN INSTITUTE

CONTENTS:

FACTS ABOUT YUGOSLAVIA IN 1985

STATISTICS

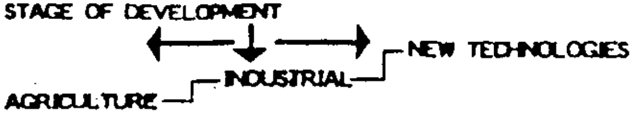
- POPULATION 22 MILLION
- AREA 256.000 km^2
- NGP 2000 - 2500 $ PER CAPITA

CONSTITUTION

- FEDERATION
- 6 REPUBLICS + 2 AUTONOM REGIONS
- FEDERAL RESPONSIBILITIES
  - ARMY
  - FOREIGN POLICY
  - OTHERS BASED ON CASE BY CASE CONSENSUS OF 6R + 2A
- REPUBLICS RESPONSIBILITIES
  - BASICALLY ALL OTHERS

CHARACTERISTICS

- BIG DIFFERENCES - AVERY ASPECTS
- DIFFERENT CONFLICTING INTERESTS
- STAGE OF DEVELOPMENT



ECONOMY

- IN PRINCIP - FREE MARKET
- IN PRACTICE - LOT OF REGULATION AND ADMINISTRATION
- BIG FOREIGH DEBTS - 20 BILLION $
- FOREIGN EXCHANGE - 15 BILLION $

FOREIGN POLICY

- MEMBER OF NONALLIED COUNTRIES

FACTS - J. STEFAN INSTITUTE

STATUS

- INDEPENDENT RESEARCH INSTITUTE
- NATIONAL RESEARCH INST. OF THE REPUBLIC OF SLOVENIA (10 %)

PERSONNEL

- PhD	130
- MSc + DIPL. ENG.	350
- TECHNITIANS	170
- OTHERS	100
- TOTAL	750

ACTIVITIES

- BASIC RESEARCH — 30 %
- APPLIED RESEARCH, CONSULTING, PRODUCTION — 70 %
- EDUCATION AND TRAINING
  - LJUBLJANA NUCLEAR TRAINING CENTRE
  - POST DOC., PhD, MSc, DiplEng.

DISCIPLINES

- BASIC
  - PHYSICS
  - CHEMISTRY
  - BIOCHEMISTRY
  - ELECTRONICS, INFORMATICS
- MULTIDISCIPLINARY
  - NUCLEAR POWER
  - ENVIRONMENTAL PROTECTION
  - AUTOMATION + PROCESS CONTROL
  - CYBERNETICS

COOPERATION

- DOMESTIC
  - UNIVERSITIES
    - UNIV. PROF. WORKING AT JSI — 80
    - JSI MEMBERS TEACHING AT U — 30
  - RESEARCH INSTITUTES
  - INDUSTRY
- FOREIGN
  - IAEA
  - UNIVERSITIES
  - RESEARCH INSTITUTES

FINANCING

~~FUNDING~~

- 30 % NATIONAL RESEARCH FUNDS
- 70 % OTHERS - INDUSTRY

OUTPUTS (1984)

- SCIENTIFIC JOURNALS	420
- MEETINGS	270
- INTERNAL	600
- PATENTS	20

HISTORICAL BACKGROUND

1945 - 1950 NO NUCLEAR PROGRAM

RECOVERY FROM THE 2^{nd} WW

1950 - 1965 GROWTH OF NUCLEAR PROGRAM

- YU - CENTRALIZED
  - FEDERAL ATOMIC ENERGY COMMISSION
  - ESTABLISHED NUCLEAR INSTITUTES
  - BUILT 3 RESEARCH REACTORS

NUCLEAR POWER

- DESIGN OF YU REACTOR
- FUEL TECHNOLOGY
  - FLUORINE CHEMISTRY
  - CERAMICS
- REACTOR PHYSICS

GENERAL

- BASIC NATURAL SCIENCES
- SCIENTIFIC APPROACH

JOINING SCIENTIFIC COMMUNITY

1965 - 1973 DECREASE OF NUCLEAR PROGRAM

YU - CONSTITUTIONAL CHANGES

- REPUBLICS AUTONOMY INCREASED
- FED-ATOMIC ENERG. COM. DISMISSED
- NO FEDERAL FUNDS
- NO YU NUCLEAR PROGRAM

REDUCED NUCLEAR PROGRAM

- JSI - REACTOR PHYSICS
  - NUCLEAR SAFETY

1973 - 1985 EXPANSION OF NUCLEAR POWER

- START CONSTRUCTION 1st NPP IN KRŠKO
  - PURE COMMERCIAL PROJECT
  - NO SYSTEMATIC TECHNOLOGY TRANSFER
  - TURN KEY PROJECT
  - DOMESTIC PARTICIPATION

    CIVIL AND ERRECTION WORK
    START-UP TESTING
    SAFETY ANALYSIS
    SOME EQUIPMENT
    BASIC TRAINING
    OPERATION
  - PROBLEMS IN DOMESTIC PARTICIPATION
    - LITTLE TIME FOR PREPARATION
    - ACCOMODATION TO FOREIGN STANDARDS
    - QA/QC

NUCLEAR POWER IN YUGOSLAVIA - 1985

1. INDUSTRIAL

- KRŠKO NUCLEAR POWER PLANT
  - IN OPERATION SINCE 1985
  - PWR, 2 LOOPS
  - 662 MWe
  - DOMESTIC OPERATION, MAINTENANCE, INSPECTION
  - AVAILABILITY 1984 - MORE THAN 70 %
  - DOMESTIC TRAINING - EXCEPT SIMULATOR

- URANIUM MINE ŽIROVSKI VRH
  - IN OPERATION SINCE 1985
  - DOMESTIC TECHNOLOGY / PROTECTION OF ENVIRONMENT
  - PRODUCTION 120 ton/year - U_3O_8

- INDUSTRY
  - PRODUCTION OF SOME COMPONENTS

2. REGULATORY

- LAW ON RADIATION PROTECTION
  - INCLUDES NUCLEAR POWER

- REGULATIONS
  - NATIONAL - GENERAL
  - IAEA SAFETY GUIDES
  - VENDOR'S REGULATIONS

- REGULATORY BODIES
  - INSPECTORS ENFORCEMENT
  - EVALUATIONS AUTHORIZED ORGANIZATIONS

RESEARCH AND DEVELOPMENT

- NUCLEAR FUEL CYCLE

NUKLIN - 8 INSTITUTES

main: B. Kidrič Inst. - Beograd
R. Bošković Inst. - Zagreb
J. Stefan Inst. - Ljubljana

- FRONT END OF NFC
  - ORE PROCESSING - DOMESTIC TECHNOLOGY
  - FUEL FABRICATION - LABORATORY SCALE
  - CORE DESIGN CALC. - JUST COMPLETED

FUTURE OF NUCLEAR POWER

- NATIONAL PROGRAM AGREED
  - SERIES OF 4 NPPs IN 1000 MWe
    2 until y. 2000
    2 until y. 2010
  - 1st PREVLAKA NPP
  - EQUAL NFC
  - GRADUAL INDEPENDENCE IN THE WHOLE NFC
  - STRONG DOMESTIC DEVELOPMENT + TECHNOLOGY TRANSFER
  - BID INVITATION - OCTOBER 1985
    - NFC
    - SERIES
    - PREVLAKA NPP
    - SPLIT PACKAGE APPROACH
  - CONTRACT FOR THE 1st PLANT - 1987

- NUCLEAR FUEL CYCLE
  - START: LABORATORY SCALE: NUKLIN
  - SEMIINDUSTRIAL } INDUSTRY + NUKLIN
  - COMMERCIAL }

Concluding remarks

1. Beginning: unrealistic goal YU reactor

Failure?

- yes: - no YU reactor
  - end of YU nuclear program

NO: - 3 strong research institutes
  - established research programs
  - later: expansion of non NP discipl.
    basic NP research remaind

why NO? - NP is multidisciplinary
  - 15 years of constant expansion

2. Construction of the 1st NPP

100% turn key, BAD?

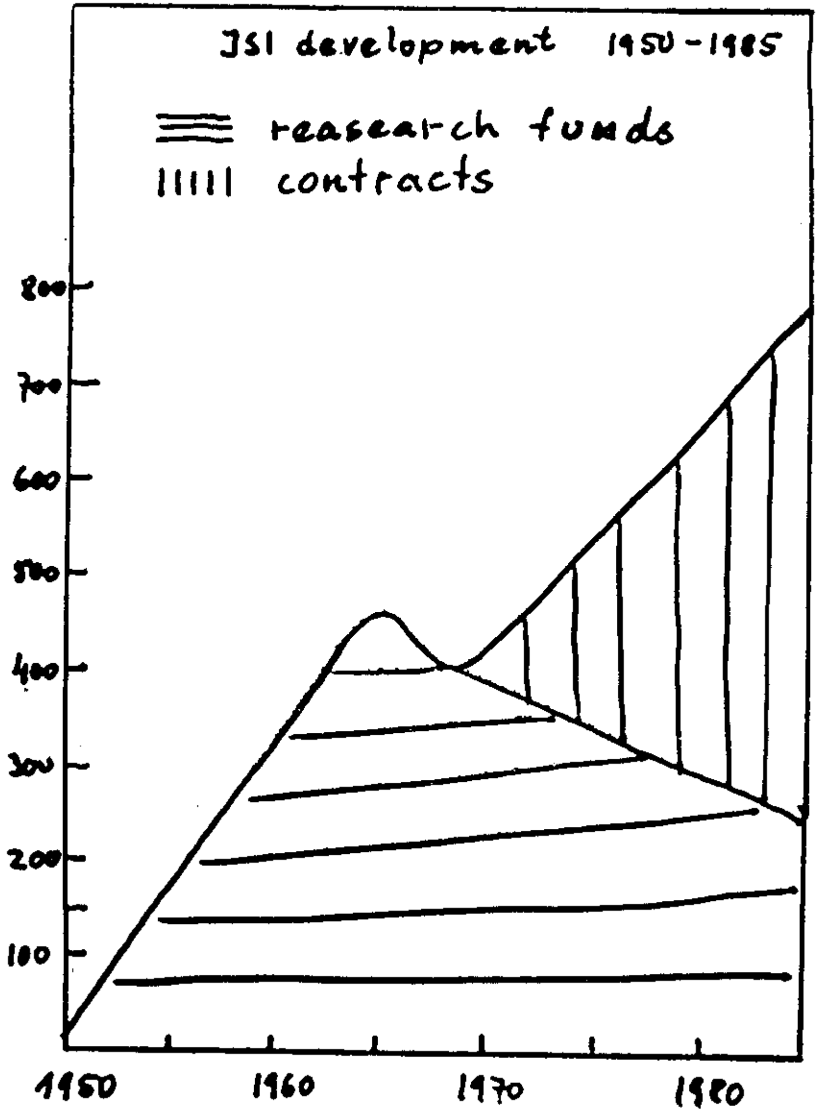
yes: - no domestic design & engineering
  - little eqipment manufacturing
  - little utilization of on-the-job training possibilities at vendor
  - no cooperation agreement

no: - reasonable price

achievements: - operation & maintenance
  - uranium concentrate
  - in-core fuel management
  - nuclear safety analisys
  - environmental control
  - training

failures: - saveing on domestic pers.
  - little direct support to domestic R&D

- RESEARCH REACTORS
  - RA 6,5 MW, HWR, BEOGRAD - VINČA
  - RB 1 KW, CRITICAL FACILITY - VINČA
  - TRIGA 250 KW, LWR, LJUBLJANA
- POWER PLANTS
  - JEK 662 MWe, PWR, KRŠKO
  - NEP Planned, 1st in the series
- * URANIUM MINE, ŽIROVSKI VRH



THE USE OF PERSONAL COMPUTERS IN APPLIED RESEARCH

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INTRODUCTION

The purpose of this lecture is to point out that at the present time personal computers are powerful enough (in terms of speed and core size) and at the same time inexpensive enough to be used in applied research in even small institutes and laboratories. In particular the current low cost of personal computers can allow institutes that cannot afford larger computers to now have significant computer power available for their use.

BRIEF HISTORY

In order to examine the direction that computer development has taken over the last few decades. I would like to briefly review the history of computers.

The earliest electronic computers used fixed programs, essentially plug boards with many wires to allow a fixed set of operations to be performed on data. The birth of the modern computer may be considered to begin with the idea of J. Van Neumann to store not only data, but also the computer program within the computer. Storing the program within the computer allowed programs to be handled like dots, e.g. the programs could be written in higher level languages and then compiled and checked for errors. More important is the fact that programs could be modified during execution and could be designed to make decisions based on computed results.

Once computer programs were stored within computers it was possible to consider solving much more complicated problems. Fortunately the possibility of solving more complicated problems due to stored programs was accompanied by a tremendous increase in the speed and reliability of computers.

Forty years ago the most advanced computers were composed of thousands of vacuum tubes and for the first time in history it was possible to perform arithmetic operations in milliseconds. However, these computers were not very reliable, since vacuum tubes failed too often. Roughly thirty years ago the introduction of the transistor allowed operations to be performed in micro-seconds and greatly improved the reliability of computers. About twenty-five years ago IBM introduced their 7090/7094 computer - the first "big" scientific computers with 32K words of memory and a 2 microsecond cycle time. At that time this computer cost roughly $1,000.000.

Over the last twenty-five years the increase in computer speed and size has been absolutely incredible, to give but a few examples:

20 years ago - CDC - 6600 - 200 nanoseconds
15 years ago - CDC - 7600 - 50 nanoseconds
10 years ago - CRAY-1 - ~ nanoseconds (parallel processing)
tomorrow - CRAY -3 - picoseconds!!!

To summarize this brief history, in only thirty years there has been a tremendous increase in the speed of computers as we went from operations in milliseconds to microseconds to nanoseconds and in the near future picoseconds. This increase in speed has been accompanied by a tremendous reduction in the cost per operation and today we can perform 10-100,000 operations for the same cost as one operation in 1960.

PROBLEM

The problem is that with all the advances in computers large computers today still cost roughly that they cost in 1960; roughly $1,000,000 or more. This means that even with all of our advances in computer technology we are still not moving in the direction of allowing everyone to use large computers; this is particularly true for developing countries which simply cannot afford large computers.

SOLUTION

Fortunately during the last few years there appears that there may yet be hope for the common man. The introduction of personal computers and their rapid increase in speed and size and at the same time reduction in cost now makes it possible for even small institutes to afford computers that can be used for practical applications.

As an example of currently available personal computer consider the IBM-AT which has,

- 254-512 K (up to 4 megabytes)
- 40 megabytes of fixed disk
- math co-processor (floating point hardware)
- excellent and very up to date software

When this personal computer was announced in mid 1984 it cost approximately $12,000, but the cost for IBM-AT compatible computers is now under $5,000.

The efficient use of this computer for applied research depends very much on the availability of the co-processor and software to utilize the co-processor. With the co-processor floating point operations can be performed 10 to 20 times faster and very accurately (to 80 bits precision). Fortunately the Ryan-McFarland FORTRAN compiler and the INLINE/8087 BASIC compiler both use the co-processor very efficiently resulting in application programs which can execute very quickly.

RUNNING TIME

In order to illustrate the power of personal computers the ENDF/B pre-processing codes have been converted for use on an IBM-AT. There was an immediate

gain in the sense that the diagnostics from the Ryan-McFarland FORTRAN compiler were found to be much superior to the diagnostics on an IBM-3083 central computer using either the H or VS compiler. This led to improvements in the codes. Once operational the same codes were run on both the IBM-3083 central computer and an IBM-AT. The surprising result was that the codes only ran 6 to 8 time longer on the IBM-AT (this seems amazing since we are comparing a multi-million dollar mainframe computer to a $5,000 personal computer).

AVAILABLE PROGRAMS

The ability to use these personal computers in applied research naturally depends on the availability of application programs. Fortunately code centres are now beginning to distribute programs on diskettes for use on personal computers. The Radiation Shielding Information Center (RSIC), Oak Ridge National Laboratory has already announced that they will distribute programs on diskettes and the NEA/Data bank will probably soon make a similar announcement.

CONCLUSIONS

Personal computers are now available with sufficient core memory and processing speed to be used in applied research. In addition personal computers are now inexpensive enough to be affordable by even small institutes. As such personal computers should be seriously considered for use in scientific application as either an alternative or a complement to large mainframe computers.

THE NATURE OF ENVIRONMENTAL PROBLEMS FACING DEVELOPING COUNTRIES WITH GHANA AS AN EXAMPLE

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DISTINGUISHED PROFESSORS, FELLOW SCIENTISTS;

I feel highly honoured to have been allowed to talk on the nature of environmental problems facing developing countries with examples from Ghana. I feel honoured because I cannot claim to to be an expert on the complex problems of the environment in a formalistic sense. The science of the environment has become a specialized discipline in itself, applying as it were, very sophisticated techniques both in theory and practical observations; some of the practical techniques involve remote sensing reaching out to space via satellites - to study vegetation and soils, rocks and mineral deposits, atmosphere and waters as well as organisms which characterize life in the biosphere and the interactions between all these subsystems.

INTERDISCIPLINARY APPROACH TO STUDYING THE PROBLEMS OF THE ENVIRONMENT

The approach to understanding, handling and possibly controlling the problems of the environment is typically interdisciplinary involving not only the basic sciences like physics, biology and chemistry, but also engineering as well as social sciences, national economy, national legislation and international relations involving politics, economics and sometimes even military power.

My aim is to attempt in a modest way, to bring to the notice of all of us present here, some of the problems of environmental pollution and destruction facing our countries in their peculiar situation as developing countries struggling to free themselves from scientific, technical and economic backwardness. Through this, it is hoped to stimulate some interest in, and discussion of, this complex problem.

RELEVANCE TO SCIENCE AND DEVELOPMENT

The relevance of the problems of environmental pollution and control to science and development is immediately obvious:

Understanding air pollution in order to combat it demands understanding of a combination of physical, chemical, meteorological and biological aspects of air pollution - things like nucleation of particles, movement of air masses, spectroscopy of atmospheric constituents such as carbon dioxide; photo dissociation, harmful effects of pollutants on living organisms, and the like.

If we want to know whether a nuclear explosion, be it in the Nevada, or the Pacific, the Sahara or in Australia affects us in our own countries, we must be able to establish the level of background radiation and determine increases.

If we want to know whether the observed increases of the incidence of some types of cancer in our countries are only apparent or due to specific factors, we must be able to establish baseline values and follow trends. What role does the consumption of chemically treated grains - which was not the case with our grandfathers and grandmothers - play? What about food dyes and sweeteners, skin bleachers and cosmetics; or drugs which probably find their way to us without having been well tested in the industrialized countries? Or the habit of packing food in all sorts of papers? Does possible over-exposure to ionizing radiation in our X-ray units as result of defective equipment contribute in any way? How significant is the pollution from the way-side industries, or the fitting workshops?

What kinds of pollutants do we have in our waters, soils, vegetation? How far are we destroying the very basis of our existence by continued large scale exportation of the natural resources of our environment?

GLOBAL ENVIRONMENTAL PROBLEMS

POLLUTION AS BY-PRODUCT OF INDUSTRIALIZATION

In man's endeavour to use resources in his environment to promote economic growth and social harmony, to acquire scientific knowledge and technical excellence and reduce the constraints of time and space, he has passed from the stage when he used primitive tools to produce food, clothing and shelter to the stage involving large scale manufacturing and construction with sophisticated technology.

In this process, he has created global environmental problems. The developing countries today are no exceptions, even if the benefits of scientific knowledge and technical progress to them remain relatively modest, small or to some, even insignificant.

Today, developing countries have their economies closely tied to those of industrialized countries. Third World countries not only export raw materials; many also import raw materials usually in their desperate efforts to keep import - substitution industries running. In this endeavour, they are bound by relations on which they cannot exert much influence.

I am trying to suggest that the environmental problems of developing countries cannot be seen completely in isolation from the general economic, technical and even political forces determining their relations with the industrialized nations and states.

SOME EXAMPLES OF ENVIRONMENTAL PROBLEMS WITH INTERNATIONAL IMPLICATIONS:

SMOG ALARM

In the 1960s and early seventies, it was fashionable to talk of 'smog' alarm over London, or Ruhr area of West Germany etc., smog being a combination of smoke and fog, resulting from reaction of pollutants from exhaust gases of traffic and industry - cabon monoxide, sulphour dioxide, oxides of nitrogen, hydrocarbons, etc. Today, in industrialized countries, efforts are on way to produce automobiles which would be more "friendly" to the environment; and industries are being forced by legislation to observe "minimum emission" standards for atmospheric pollutants. With regard to developing countries, even if the density of traffic may not be as high as in a typical European city, pollution resulting from traffic in urban areas

cannot be overlooked. This is the case especially if one takes into account the technical defects of vehicles plying our roads. Industries as sources of pollution in developing countries are no exceptions even if the degree of industrial pollution may not be as widespread as in the industrialized ones.

ACID RAIN

Years of industrial pollution has led subsequently to precipitation of what is now called acid rain over parts of Europe, for example, Scandinavian countries and parts of Eastern USA and Canada. The extent of damage caused by acid rain to forests, fish in lakes and rivers, crops and historical buildings is currently in the news in Europe.

GREEN HOUSE EFFECT

An environmental problem of significant global character is the so called Greenhouse effect, whereby the atmosphere generally acts as a window for sunlight but as a blanket for thermal radiation reflected from the earth's surface. This results from the fact that while both carbon dioxide and water in the atmosphere are essentially transparent to visible light, carbon dioxide is a good absorber of infrared light. Thus, the increasing concentration of CO_2 in the atmosphere as a result of anthropogenic factors - mainly the burning of coal and oil - is causing global concern. This is because the increase of carbon dioxide in the atmosphere would invariably lead to the increase in the value of the average temperature on the earth's surface. Estimates suggest an increase of about $2^oC - 5^oC$ by the year 2050 with projected carbon dioxide increase. Interested readers would recall that measurements of the concentration of atmospheric carbon dioxide have been carried out since 1957 at the MAUNA LOA OBSERVATORY in HILO, HAWAII[1, 2] .

OZONE DEPLETION IN THE STRATOSPHERE

Concern has also been expressed about the global effects of the reduction of ozone in the stratosphere by the action of chemicals

such as:
chlorfluoromethan, CFM(CCl_3F, CCl_2F_2) through catalytic reaction cycles[1], or eventually by supersonic flights. The concern surrounds the probable increase in the incidence of skin cancer as a result of increased Ultra-violet radiation(UV) which would reach the earth.

POLLUTION OF THE OCEANS

The problem of pollution of the oceans by crude oil - whether at an off-shore drilling site, or from a Liberian or Panamenian tanker which "breaks apart" or sinks on the high seas, or through military conflicts as is happening in the GULF war, should not be a matter of concern to Insurance companies and Oil Multinationals only; it has global environmental implications.

NUCLEAR WINTER/NUCLEAR HAZARD

The latest fashionable enviro-word is "Nuclear Winter" which scientific studies suggest would result,should there be a full scale nuclear war between the nuclear powers; this state would be characterized by prolonged darkness, abnormally low temperatures, violent windstorms, toxic smog and persistent radioactive fallout on the planet "earth"[3].

It should not be forgotten that in the absence of such a nuclear conflagration, there is still a hazard from nuclear accidents: There are military bases with formidable nuclear weapons spread all around the world; nuclearsubmarines are constantly patrolling under the oceans; nuclear armed planes and other nuclear warheads delivery systems are ever ready to be set into action; and the probability of acting on false alarms cannot be ruled out. A nuclear accident, whereever, and in whichever form it may occur, has serious environmental repercussions not only for the nuclear power states, but for the whole of mankind. This is valid, naturally also for chemical and biological weaponry or warfare.

Nuclear Reactors/Nuclear waste management:

Concerning the peaceful uses of nuclear energy, it has been noted that despite the growth of strong anti-nuclear opposition in a

number of industrialized countries, and the slowing down of the development of power reactors in others, the development of nuclear power reactors world-wide will continue. In his statement to the 27th Regular Session of the General Conference of the International Atomic Energy Agency in Vienna on 10th October 1983, the Director General, Hans Blix, gave the number of nuclear power reactors operating in the world by 1982 as 297 **, accounting for about 10% of the world's electricity production[4]. He mentioned as one of the obstacles to increasing the use of nuclear power in developing countries the fact that existing electricity grids were not suited to accept generation capacity increments of 600 Megawatts(electric), or more, associated with large nuclear reactors commercially available today. He indicated that steps had however been taken in cooperation with interested IAEA members to initiate a study of the general case for Small and Medium Size Power Reactors which might satisfy the needs of developing countries.

It is clear that if more developing countries should opt for the acquisition of nuclear power reactors, they should take into account, the environmental problems involved. The questions of safety, nuclear waste management - how to trear them, store them and dispose of them - must be clearly answered.

Today, the matter of safe disposal of radioactive waste is posing a formidable problem even for the technically advanced countries. Thus, it is not uncommon to hear or read from time to time of approaches made to some developing countries to accept the dumping of nuclear waste in these countries. The disposal of nuclear waste in the oceans also has global environmental implications and is coming more and more under criticism.

From the foregoing, one may assert that the scientific, technical and safety aspects of nuclear power and their short and long term environmental implications are relevant not only to the nuclear power states but also to developing countries generally.

**[Latest number quoted by the Director General is 313 for 1983]

ENVIRONMENTAL PROBLEMS OF THIRD WORLD COUNTRIES

Against the foregoing background of global environmental problems, we may now turn to the situation of developing countries with specific examples. In this regard, it is remarked that although particular examples of environmental problems may be attributed to natural or man-mediated(anthropogenic) causes, these causes cannot always be fully separated. They may overlap and reinforce each other as the case may be. Especially some causes which may seem to be natural today may have had some athropogenic origin in the distant past.

DEFORESTATION

The clearing of tropical forests continues unabated. Estimates of the Food and Agricultural Organization(FAO) suggest that 11.3×10^6 ha or more of tropical forests are cleared annually world-wide[1 ha = 10^4 m^2]. Naturally my country Ghana is not an exception. Ghana has some of the hardest tropical woods such as Emiri, Dahoma, Odum and the like; these types of species require tens, if not,hundreds of years to grow to commercial size. Like other tropical countries such as Brazil, Burma and others, Ghana has exported tropical hard wood since ages. The country's tropical virgin forest has almost completely disappeared. Some really very valuable species such as ebony face the threat of complete disappearance. In the most intensive periods of exploiting these natural resources, commercial logging was never accompanied by replanting.

The example of Brazil's Amazona - an area of about 350 million ha with about 12 % of the world's forest reserves illustrates the deforestation problem even more dramatically. Evaluation of satellite photographs indicate that between 1975 and 1980, the logged area of the Amazona forest rose from 2.8 to 12.4 million ha [5]. And apparently as a way to solving the economic problems of drought-stricken North-Eastern Brazil, a project was launched in 1979 - with the blessing of the World Bank - to resettle millions of Brazilians in the Amazons. A 5200 Km transamazonian highway - "Transamazonica",

the highway of the century - was to be built from the Atlantic Coast to the border with Peru. With this project never having been realized, it left behind a ruthless destruction of virgin forests and displacement of Indios.

Naturally it is not only commercial logging for export which is destroying tropical forests. Firewood and charcoal have been the main source of fuel in Ghana - like many other African countries - especially for domestic use. This has remained so even in the urban communities, although electricity and gas have become available to a very small section of the urban population for boiling and cooking purposes. There is no doubt that the demand for wood as fuel will continue to increase in Ghana .

It is also noteworthy that Ghana has depended for many decades - almost a century - on cocoa as the main export item(monoculture cash cropping). This has necessitated the conversion of large forest areas into cocoa plantations over the decades. With the aging of cocoa trees and drop in soil fertility, farmers have had to start new plantations. This takes us to shifting cultivation which accompanies not only cocoa farming, but is characteristic of traditional agricultural practice. This practice and seasonal bushfires in the dry season have also contributed to the reduction of forest zones and their transformation into savannah-grassland.

One serious result of the extended clearing of forests near sources of streams and small rivers is the drying up of such aquatic systems which in the past served as sources of water for domestic use in many rural areas in forest zones.

THREAT TO SAVANNAH AND TROPICAL GRASSLAND- DESERTIFICATION

The Savannah and Grassland areas constitute important farming areas not only for tubers but also for grains and vegetables. They are also the main grazing land as well as important sources of wood for fuel. Although forest areas do suffer seasonal bush-fires, it is the Savannah and Grasslands which suffer most.

Subjected to annual bushfires, overgrazing, drought and soil deterioration, these areas which have the greatest potential for a reasonable degree of **agricultural** mechanization are the ones most threatened by desertification.

It is estimated that about 4% of the area of Ghana which borders on the Sahelian zone to the north is threatened by the Sahara desert which is advancing southwards. Although dams have been built in the Northern and Upper Regions for domestic and agricultural purposes, extended periods of drought, siltation, erosion and seepage have resulted in **reduced** life expectancy of such dams [6a]. This kind of situation means great uncertainties in agricultural activity in an area where farmers depend mainly on rainfall !

GHANA'S ENERGY CRISIS

Extended periods of drought since the 1970s have seriously affected the largest man-made lake in the world. The Akosombo dam water level has fallen below the 248 feet(74.4m) minimum level of operation designed by the engineers, having fallen below 236 feet in June 1984. Hence, for some time now, only **two, and sometimes one,** out of the six generators are put into operation. Thus, environmental influences have **incapacitated** the 768 MW Akosombo **hydroelectric dam** and the 140 MW Kpong dam 24 Km down stream. This has led to electricity rationing for both industrial and domestic consumersas well as neighbouring countries like Togo which get electricity supply from Ghana.

It is noted that with the coming of the major rainy season this year(1984), the lake level at Akosombo has begun to rise gradually. With the continuation of this trend, one can look forward into the future with hope for the resumption of full generation of electricity.

Notwithstanding the **expected return to full scale generation of electricity at Akosombo, it should be emphasized that**

the experience with the Akosombo hydroelectric dam has been very instructing:
First, it was the significant impact of the dam and lake on the environment - on flora and fauna involving the disappearance of large vegetation areas and large numbers of wild life and the appearance of new flora. Now, the influence of environmental factors on such a gigantic hydro electric **dam** with the probable consequences have been dramatically **indicated** ! Furthermore, with the damming of the Volta River, **Ghana** has exhausted the largest percentage of her hydroelectric power potential. In the case of greater demand for energy, what alternatives does the country have?

In the absence of any spectacular advances in the harnessing of solar energy world-wide and in developing countries in particular, one may think of the following:

a. building of smaller hydro-plants on the country's smaller rivers, whereby the criticalities of environmental factors experienced with the Akosombo dam remain to be considered;

b. going back to conventional generators whereby the country's demand for petroleum products would increase with inherent foreign exchange reserve problems;

c. importation of nuclear power reactors (as a remote possibility), whereby **a situation of** great dependence on the supplier and foreign technology would be created;

d. the harnessing of tidal waves to generate electric power. Ghana's atlantic coast is supposed to be among the areas in the world, where cosmic influences on the oceans of the earth could profitably harnessed for electric energy production, based on the use of temperature gradient [7]. The constraint would be the scientific and technical knowledge necessary to realize such a project.

MINING, INDUSTRIALIZATION AND THE ENVIRONMENT

A. MINING

The principal mineral deposits mined in Ghana are gold, diamond, manganese and bauxite. Among these, one may mention the gold mines where the ore contains arsenic and sulphur as sources of environmental pollutants; for example, in two mining areas - Obuasi and Prestea where arsenic poisoning, water pollution and destruction of vegetation are known to occur.

B. ALUMINIUM SMELTER IN TEMA

The Aluminium Smelter in Tema, Ghana, VALCO (Volta Aluminium Company) owned by Kaiser Aluminium and Chemical Company, USA, processes Jamaican Alumina into Aluminium using electricity from the Akosombo dam. This involves the reduction by carbon anodes of Alumina(Al_2O_3) in a melt of Sodium fluoride and aluminium fluoride approximately the composition of cryolite(Na_3AlF_6). Air pollution is associated with the emission of gaseous and particulate fluoride compounds. Pollutants other than flouride compounds include tar aerosols and sulphur dioxide [8]. Studies carried out in Norway in forest areas within 32 km from aluminium smelters showed pollution effects attributed to the above mentioned pollutants. Animals which consumed herbage and polluted water in such areas were also known to suffer fluorosis, a state which could lead to reduced food intake, less production of milk and reduced reproductive capacity [8].

I am not aware of any systematic investigation in this direction with respect to the production of Aluminium in Ghana.

C. A SMALL ASBESTOS INDUSTRY IN GHANA

Generally, asbestos is used in insulation, in friction products, for example as brake linings of automobiles and as roofing material. Asbestos which occurs in fibrous form

gives off fibres which can exist in air as solid particles. The material is known to be carcinogenic and produces occupational health hazard known as asbestosis, associated with chronic lung disease, lung cancer and heart disorder [9].

In Ghana, two firms - Fulgrit and Ketane - operate asbestos industries mainly for producing roofing material and water pipes. The socalled "wet-processing" technique is employed; risk to health is supposed to be associated only with the pouring of asbestos material into a pulverizer. However, the fact that the firms use as raw material blue asbestos - alleged to be most toxic - is alarming, especially when one takes into account the use of the end product in water supply or sewerage systems. Since this raw material is imported, it is obvious that the blue one is selected because it may be the cheapest. It is relevant to note that because of its carcinogenicity, the use of asbestos in industrialized countries is coming more and more under critism. For example in Great Britain, suggestions were made to remove asbestos as insulation material in schools.

D. OIL REFINERY

Pollutants usually associated with oil refineries are hydrocarbons, nitrogen oxides, sulphur dioxide, carbon monoxide and particulates. Ghana has an oil refinery located in the industrial township of Tema. It was built in the 1960's at a time when even in the industrialized countries, control on emission limits of pollutants was not very stringent. The case of the oil refinery is mentioned in order to illustrate the fact while legislation on emission limits of pollutant from industrial plants in industrialized countries is becoming more stringent these days, many developing countries imported and installed plants in the past, which today probably donot measure up to the environmental standards being demanded by legislation in the countries of origin. Current economic constraints would not permit many of these developing countries to effect desired technical innovations on such plants.

Ingredients for Industrial Pollution do Exist

With the above few examples, it is possible to demonstrate that with the beginning of industrialization, all the ingrediants for industrial environmental pollution do exist in a developing country like Ghana. The concentration of the country's most important industries in only a few urban areas, particularly in Tema and Accra, due to energy availability and infrastructural problems, is indicative of the trend in many developing countries.

AGRO-BASED ENVIRONMENTAL POLLUTANTS:

Herbicides, Pesticides, Fertilizers

The best known insecticide to us when we were at school was DDT (Dichloro diphenyl trichloroethane). It was used mainly against mosquitos. There were campaigns to irradicate the maleria vectors with World Health Organization sponsored spraying programmes using DDT.

Since DDT was widely used in many countries, it is adverse effects eventually became known. The consequence was the banning of the application of DDT in many industrialized countries with the Scandinavians taking the lead.

However, DDT continued to be exported to and used in most developing countries, especially in the tropics. The results of mosquito irradication programmes have remained questionable and reports of the successful application of the chemical was sometimes accompanied by other side effects. In Bolivia St. Joaquin [9] the anti mosquito spraying campaign was supposed to have had the side effect of killing cats in the village. An invasion of mouse-like mammals which carried the black typhus virus was the consequence, leading to the death of 300 villagers. Some success against tsetseflies in parts of Northern Nigeria through use of DDT and against the African migratory locust which inhabit parts of Mali and a valley in Tansania and seasonally migrate, devouring everything green on their way—through the use of organo chloride insecticides was reported in the 1970's [10]. But in no way has the tsetsefly in Nigeria or elsewhere in Africa been irradicated. The side effects of these insecticides like herbicides are considerable. It is now widely known that insecticides donot only destroy target insects but also useful ones and birds. Animals and humans are no exemption. In 1979, there were reports in West German newspapers on the insecticide Hexachlorcyclohexan, HCH, which was applied in forestry in Hessen. The chemical was supposed to have passed onto grazing

land and traces were found in the milk of the cattle and thus passed over to humans, causing injury, specially to children. Other insecticides are known to cause cancer in experimental animals, for example, Ethylene Diobromide (EDB) used for treating grains. The chemical has been found in food products such as wheat flour and popcorn made from EDB treated grains. Tests have also proved that it is carried through the soil into underground water. Hence the Environmental Protection Council of the USA has decided to ban the use of Ethylene Dibromide in treating stored grain.

The problem with developing countries lies in the fact that there are usually no systematic studies to document long term environmental and health hazards of the chemicals before being used. They depend on information supplied by the marketing or importing agents.

Ghana, for example, imports about 8 different types of insecticides cymbush (cypermethrine), actellic, agrothion (fenetrothion), dieldrin, phosdrin, bidrin, ripcord, phostoxin and about 5 different types of herbicides atrazine, saturmate, trifluralin N46, gramoxone, stam F34-T, [11]. The environmental effects of these chemicals remain yet to be studied and documented.

Naturally, also fertilizers must be mentioned. The main pollution aspects of fertilizers is due to the fact that excessive use or in-appropriate application can negatively affect aquatic ecosystems and ground water resources [12]. This is of particular importance to farming communities of developing countries which may depend at one time or another on ground water for domestic use. Excessive use of nitrate fertilizer leads to nitrite formation in soil and water. Phosphate fertilizers do contain small quantities of naturally occuring Radio Nuclides- Uranium, Radium, Thorium and Potassium [13]; therefore, it is important that farmers be educated to handle them with care.

In order that afro-based chemicals would be applied to enhance productivity with a minimum of adverse side effects, UNESCO has made proposals for a thorough ecological study of the problems of pest control involving the use of herbicides and fertilizers [12]. However, it remains questionable whether manufacturers of these chemicals in their desire to conquer markets in 3rd world countries have any real concern for the pollution which their products may cause. Many 3rd world countries also seem to take such products for granted even if their effectiveness and side effects are not well known.

THE HERBICIDAL WAR IN VIETNAM

It would be a serious omission not to mention the terrible effects of the herbicidal chemical war fare of the USA against the people of Vietnam and their god-given environment between 1961 and 1971. In question is the herbicide with the chemical formular 2,4-D and 2,4,5-T nick-named Agent Orange containing the highly poisonous Dioxin (TCDD) which came to be known world wide as Seveso poison. About 91 million kg of the herbicide were used by the USA to destroy in Vietnam (South), about 44% of the tropical rain forest, 60% of the rubber plantations, 1500 000 ha mangrove swamps in a large scale defoliation campaign. The extent of ecological and genetic effect on flora, fauna and man have been unknown in human history [14]. The incidence of cancer and birth defects are abnormally high in the areas sprayed. The gentic effects are reminescent of those of the nuclear bomb victims of Hiroshima and Nagasaki. Children are born without brains or even heads or sometimes with only the lower extremities.

A scientific conference held in the Ho-Chi-Minh City from 14th-20th January 1983 has documented the long term ecological and human consequencies of herbicidal war fare. The Stockholm International Peace Research Institute has just released a book (this September 1984) entitled "HERBICIDES IN WAR" edited by an American Professor of Ecology at Hampshire College, Amherst, Massachusettes, Dr. Arthur Westing, who was co-president of the conference in Ho-Chi-Minh City. The conference was attended by 72 foreigners and 56 Vietnamese scientists.

A picture is shown of an abnormal child, born with cyclopen eye with a penis on top of it [14]. This was in an area sprayed with the chemical.

A picture of Ecological Conscience- A Picture of our 20th Century!

WHAT IS TO BE DONE ?

Having said all that, the question arises, what is to be done?

First and foremost, awareness must be created on national and regional levels on the nature of the problems of the environment . Developing countries should initiate programmes to do what is in their power to arrest further deterioration or destruction of the environmental basis for a secured and meaningful existence of their people. Such programmes, modest as they may be, could incorporate afforestation, nation wide tree planting, selective logging,

regulation of tree felling for fuel etcetera, and the protection of lakes, rivers and streams. Systematic studies of available natural resources should be undertaken with the view to achieving a balance between optimal utilization and conservation. This is essential because future prosperity depends on their availability.

Difficult Choices

As mentioned earlier on, pollution as we have come to find it today, has accompanied industrialization. In their desire to achieve better living conditions for their people, developing countries cannot discard the idea of industrialization. They must create the necessary material and economic basis for old age care, for production of sufficient food and adequate housing, for better transport and communication, for social harmony and cultural fulfillment, and all the other things which define the quality of life in our times.

In this exercise, most developing countries are often placed face-to-face with difficult choices, since they donot contribute much to the scientific and technological innovations underlying the development of industry in our days. In order to attract foreign investment, they are supposed to make the investment climate favourable - cheap labour, taxation concesssions, guarantee of repatrition of capital and profits and available cheap sources of energy ; and among those factors which create a favourable climate, the would-be-investors in developing countries may not count stringent legislation on environmental pollution which may demand extra capital expenditures to start with. (In fact lack of stringent laws on industrial pollution in many developing countries has become an attractive factor for some investors). Should a government close down a factory which produces asbestos sheets or other items considered to pose health or environmental hazards, then it may not only be creating a few more unemployed hands and losing some sources of revenue, but may not be able to initiate quick action for alternative materials.

In this sort of situation, there is urgent need to create in international forums a better understanding of the environmental problems facing developing countries and their revelance to the general economic relations between the developed and the developing countries. A more critical approach may be adopted to the issue of investment, taking account of existing scientific understanding of environmental pollution in industrialized countries and expanding development of technical devices to control it. The environmental problems of developing countries today, if left unheeded, can become also part of the economic problems of the industrialized countries tomorrow.

With regard to agro chemicals it is clear that many developing countries spend huge amounts of money importing and using herbicides, pesticides and fertilizers in efforts to increase food production and agricultural raw materials. However, existing scientific knowledge on their short and long term effects, especially herbicides and pesticides, does not justify their indiscriminate and improper application. In Ghana for example, a major factor contributing to food shortage is the problem of storage. Using herbicides which may have adverse effects on flora and fauna in order to reduce cost of labour in farm maintenance cannot be justified if the food produced cannot be effectively stored, any way. Thus, it may be necessary to restrain the widespread use of herbicides while systematic studies and efforts are made to promote an optimal application of fertilizers and insecticides.

With regard to fertilizers research efforts can also be directed towards the use of organic manures. It is known, for example, that the soil under the ACACIA ALBIDA tree in the Savannah areas of West Africa has more organic matter and minerals and is thus more fertile than the soil further away. The tree is even said to act as a herbicide; various crops are observed to grow under it better [15,16]. Thus, the systematic planting of such a tree and the use of its good agro properties in the region could be developed similar to the traditional use of the AZOLLA weed in China and Vietnam to aid Nitrogen fixation in rice growing areas.

Whatever positive is to be done, demands naturally not only well organized national efforts, but also regional understanding and cooperation among the developing countries concerned beyond conference tables.

The Environmental Protection Council of Ghana

In Ghana, an Environmental Protection Council (EPC) was created in 1973 [17] and charged with the responsibilities for

1) Coming to grips with the complex problems relating to the environment
2) Striking a balance between the demands of rapid economic development and the need to protect the country's natural heritage and resources.
3) Safe guarding the health and welfare of the people by providing them with a whole-some environment.

Formidable tasks indeed ! Recently, however,

the EPC has embarked on educational programmes to create awareness of the serious nature of the ecological problems facing Ghana [6a,b] and possible contributions which the people can make towards improving the environmental conditions. Such steps are positive in situations where there are no specific laws regarding environmental pollution through mining and industrial activities and the like.

UNANSWERED QUESTIONS

Many questions have been left untouched, for example, the population problem. Which countries are over populated and which are under populated or normally populated? Of what relevance are population growth and urbanization to economic development and environmental problems?

There may be widely divergent views on this - traditional perspectives and demands of modern society. Naturally a talk of this nature cannot exhaust all problems. For some discussions of the urbanization and other questions relating to economic development and the environment, see for example [18,19]

CONCLUSIONS

Development of Awareness on the National and Global Environmental Problems Facing Industrialized and Developing Nations and States.

The Greens in Europe did not come overnight.

Naturally, awareness of the problems of the environment in Europe, America and other industrialized countries as it is in these 1980's did not come overnight or as a matter of course. In Western Europe, it has been activist groups especially in the Scandinavian and German speaking countries usually in the minority and sometimes even the apparent outcasts in the society of the affluent north-who initiated actions which ultimately made a significant percentage of their people aware of the vulnerability of man's environment.

They questioned the theory of unlimited growth in the free market economy, they opposed uncompromisingly the use of chemicals by the USA in Vietnam in defence of the "free world". They discussed actively in seminars how exploitative economic systems and multinational companies contributed to the destruction of the environment in third world countries, in search of gold and uranium. hardwood and other forest products; through the creation of large monoculture plantations; through uncontrolled mining activities which left behind barren land-scapes. They pointed out how this process uprooted original inhabitatants of these areas be it the slaves from Africa, the Incas of Peru in the 16th century, the Aborigines of Australia, the Eskimos of Canada, the West Indians of the USA or the Indios of Brazil.

They pointed fingers at the unacceptable pollution of rivers and destruction of forests and landscapes in their own countries through the activities of firms which showed little or no concern beyond their own profits.

They criticized their own societies which threw away old paper, glass, bottles, tins and many more while making more and more demand on the raw materials of third world countries.

They questioned the export of large technologies and nuclear reactors to third world countries and the massive settlement of industries in their urban areas without regard for the environmental hazards.

Even if today, one may not agree entirely with every way in which these groups initially had seen the problems, they have succeeded, all in all, in awakening an environmental conscience. They have awakened awareness on the limits to which man can disturb the natural equilibrium in the world around him in this our technological age.

Creating Awareness in Third World Countries

Today, the educational activities of the UNESCO through the United Nations Environmental Programme [19] is helping to awaken consciousness among certain sections of the societies of third world countries. National Environmental Protection Authorities may also be making efforts in their own ways on national levels. But the mass of the people, usually illiterate and unable to attribute the sum total of the effects of environmental destructions to the original causes, remains yet to be reached. They should be brought to the awareness to appreciate:

- the dangers in seasonal setting of bush fires for hunting and other purposes and in-discriminate cutting of trees for fuel,
- the advantages of afforestation and tree planting programmes,
- the dangers of using chemicals like dynamite in fishing in their own rivers and lakes, and many other actions which probably though the result of frantic struggle for material existence and survival cannot be allowed indefinitely unchecked.

Possibly also, many national governments in developing countries are yet to become aware of the dangers involved in entering certain economic relations or promoting some types of economic development projects which ultimately will bring little material returns to their people but destroy their very basis of existence.

And probably, the idea should appreciated deeper in the industrialized North, that the globe has finite dimensions with finite resources, resources which cannot be wasted indefinitely. The solutions of the problems of the environment demand international understanding and cooperation, scientific knowledge and technical skills, coordinated efforts of various disciplines- physical, chemical, biological and medical sciences, engineering and technical designs , legislation and effective administration and many others which act together to make development meaningful, with an eye on the future and on humanity as a whole.

Thanks for listening.

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