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Conversion of military research and development: Realism or wishful thinking?

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The acceleration of the arms race since the beginning of the 1980s has significantly heightened international tension and increased the dangers of war. But it is not only that the new scale and characteristics of the arms race make it a time bomb for the future existence of mankind: it is already devouring enormous material, financial and human resources, to ruinous effect, and has thus become the greatest political and economic challenge now facing the world. As a United Nations study puts it: "The arms race represents a waste of resources, a diversion of the economy away from its humanitarian purposes, a hindrance to national development efforts and a threat to democratic processes."[1]

The same study goes on to argue that it is not increased armament but disarmament that will give the peoples of the world greater security. Conversion could help considerably to foster stable and peaceful development and to accelerate social progress. It could contribute to the creation of a firm political, economic and social "infrastructure" ensuring détente and peace. But what we are currently witnessing is a significant conversion not from the military to the civilian sphere but in the opposite direction. In discussing here the problems involved in converting to civilian purposes the scientific and technical resources serving military ends, we are mindful of the fact that the growing economic and social burden of arms expenditure has become so unbearable for the world at large that alternatives must be investigated without delay if mankind is to be saved from a future catastrophe.

1. Military use of science and technology

The massive waste of scientific and technical resources is more and more at cross-purposes with the urgent economic and social problems facing the world today, such as underdevelopment, the depletion of energy and raw material supplies and the growing dangers to the ecological balance of

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nature. Such problems are becoming critical in many countries and can only be effectively tackled and solved if the scientific and technical means devoted to military purposes are progressively made available for civilian ends. There can be no doubt that, with all the differences in the world's social systems, assured economic growth is an essential prerequisite for solving the economic and social problems of mankind. Economic growth depends largely on the extent to which scientific and technical resources are mobilised, and for what purposes.

The Minister of Science and Technology of the German Democratic Republic, Herbert Weiz, has declared: "More than ever must the development of the productive forces of our country receive decisive impulses from science and technology, from the purposeful application of scientific and technical advances in all fields of public production."[2] Indeed, scientific and technological advances in the German Democratic Republic have for over a decade made possible increases in national income averaging 4.6 per cent a year – achieved almost entirely through improved labour productivity.[3] In its 1977 Annual Report the National Science Board in the United States found that "the contribution of R and D to economic growth and productivity is positive, significant and high, and that such innovation is an important factor – perhaps the most important factor – in the economic growth of the United States in this century".[4] This very important finding doubtless holds true throughout much of the world, implying that a decisive factor for progress everywhere is the harnessing and use of science and technology for civilian purposes.

The escalating expenditures on research and development for military purposes run completely counter to this. The previously mentioned United Nations study estimated the proportion of human and material R and D resources devoted to military purposes at 20 to 25 per cent. With the accelerated arms race of the 1980s the upper limit probably has been passed already and is approaching 30 per cent.

It can be said generally that countries with a large modern armaments industry account at present for a particularly high proportion of the world's total military R and D expenditure. The unequal distribution of this expenditure among Western industrial nations is shown in table 1. The socialist States also spend considerable sums on military R and D. The nuclear powers in particular, but also the countries with a high level of conventional armaments, have a special responsibility for putting forward disarmament proposals with a view to curbing the qualitative arms race and banning the development and production of new kinds of weapons systems, initiating talks and setting an example for effective disarmament measures.

For the conversion of scientific and technical resources from military to peaceful purposes the role attributed to military technology in the scientific and technological revolution is of prime importance. In a number of countries it is widely held that military technology acts as a pace-setter and thereby accelerates scientific and technical progress in other fields as well. If such a role is ascribed to military technology one obviously cannot expect any

Table 1. State-financed military R and D expenditures of Western industrialised countries, 1983

Country	US$ million[1]	%
United States	22 041	72.5
United Kingdom	3 472	11.4
France	3 091	10.2
Federal Republic of Germany	863	2.8
All others[2]	ca 950	3.1

[1] Provisional figures; 1980 prices and exchange rates. [2] Australia,* Belgium, Canada, Denmark, Finland, Greece,* Italy, Japan,* Netherlands, Norway, Spain,* Sweden,* Switzerland * (* estimated by the author).
Source: Calculated from Stockholm International Peace Research Institute: *World armaments and disarmament*, SIPRI Yearbook 1984 (London, Taylor and Francis, 1984), pp. 168-169.

serious interest to be shown in conversion for peaceful purposes. Conversion of scientific and technical resources is therefore not simply an economic and organisational problem but even more a question of national conceptions of technology and the economy. If this aspect is ignored any concrete conversion proposals – however soundly thought out and detailed – will stand little chance of being put into practice.

But what is this "pace-setting" function in fact worth?

To begin with, any military R and D consumes part of a country's total scientific and technical potential. There is widespread agreement among many scientific experts in countries with different social systems about the negative economic and social consequences of devoting R and D to military purposes, particularly the restrictions it imposes on economic growth, labour productivity and the number of jobs that could be created in civilian growth industries with the aid of new technology. If state expenditures on military R and D were diverted to civilian purposes instead, it would also be possible to invest far greater amounts in those sectors where private risk capital is not forthcoming. Giving priority to armaments leads to a distortion of the overall R and D potential since long-standing economic and social issues requiring urgent attention are neglected. It reduces a country's flexibility in reacting quickly to new peaceful challenges in the scientific and technical fields as the energy, raw materials, infrastructural and ecological problems encountered by many countries conspicuously show. There are no practical or theoretical grounds – nor any really convincing empirical evidence – for believing that concentration on military R and D can be an effective way of achieving results in the completely different conditions found in civilian life. The roundabout route to civilian progress via military R and D is not only risky but also, because of the high degree of specialisation of modern weapons technology, much more costly. Japanese science and technology offer an example of how a country without a large armaments burden can attain remarkable levels of scientific and technological achievement in a relatively short span of time.

Moreover, each increase in armaments production deprives the national economy of *proportionally much more* of its scientific and technical potential. This is mainly because military goods are extremely R and D-intensive, so that any alternative use of this potential would have a greater, and in some cases a much greater, direct impact on employment and growth as well as extensive multiplier effects. The calculations of the Stockholm International Peace Research Institute (SIPRI) shown in table 2, which are in complete agreement with my own findings, indicate that the R and D input per unit of output value is some 20 times higher for military than for civilian goods, and the disparity is doubtless growing with the increased sophistication of weapons systems. In a number of countries military R and D expenditure has considerably increased while civilian expenditures have been curtailed. Because of this the continuing development of arms technology may be said to constitute an extreme perversion of human creativity and inventiveness.

Secondly, armaments technology has so far produced few direct scientific and technical results that were of fundamental importance for progress in the civilian sphere. As a rule, most basic scientific and technical discoveries were made first in the field of civilian research, and that includes nuclear fission, micro-electronics, laser technology, etc. For example, the basic mathematical problems involved in the development and construction of the atom bomb had already been solved by the end of the 1920s as a result of research in astrophysics. The basic work on the digitalisation of terrain surfaces necessary for the functioning of the cruise missile had already been done in the late 1950s by civil engineers dealing with road building problems.[5]

Micro-electronics was also first developed in the civilian field. In some countries it is directed primarily towards military goals and the development of this sector has been accelerated with the aid of armaments financing. This has given a tremendous impetus to the military as well as the civilian application of micro-electronics. However, the extremely demanding specifications for micro-electronic components and equipment for military purposes – insensitivity to variations in pressure and temperature, resistance to radiation, etc. – were extremely costly and totally useless for civilian purposes. In Japan, on the other hand, "it was the demand for integrated circuits stemming from consumer electronics that stimulated the new technology",[6] and produced significant civilian growth and employment effects.

In other words, the much vaunted spin-off effect, i.e. the transfer of technology from the military to the civilian sphere, has no serious foundation in fact. The United Nations experts' report fully agrees when it states that "military spin-offs from civilian research have been incomparably larger than civilian spin-offs from military research. The truly remarkable fact is how

Table 2. R and D input per unit of output: civilian and military sectors compared

Country	Year	Military R and D expenditures as % of value of production of military equipment	R and D expenditures as % of value of manufacturing output
Federal Republic of Germany	1975-76	32	1.9
United Kingdom	1975-76	34	1.3
United States	FY 1975	43	2.3
Japan	1975	5	1.2

Source: Stockholm International Peace Research Institute: *World armaments and disarmament*, SIPRI Yearbook 1981 (London, Taylor and Francis, 1981), p. 7.

little that is new, not how much, has come to the civilian sector from military R and D efforts."[7]

Military R and D certainly has a pace-setting function for enterprises whose economic expansion is assured by the large profits they make from these activities. But it results in an irretrievable loss for national economies and society in general, for it is the greatest obstacle to the solution of the scientific, technical and social problems confronting the world today. This leads us to conclude that nations' attitudes to science and technology help to determine whether the necessary conditions are created for the conversion of military R and D to civilian purposes.

2. Conversion of scientific and technical resources used for military purposes

Conversion in the broadest sense is nothing new. While little research has apparently been done on the subject and its effects are supposedly unknown, conversion is in fact a daily occurrence in the national economies of the highly industrialised nations. In the general sense it is synonymous with material, financial and human structural changes in the economy. No economic system would be capable of surviving, developing or competing without constant structural change. This applies not only to the structures of the national economy but also to branches of industry and scientific, technical and labour resources. As the scientific and technological revolution proceeds, there is a growing trend for employees in the scientific and technical fields to change their jobs and specialisations during the course of their working lives. This trend is apparent in all countries and is bound to become even more marked in the future. The conversion of scientific and technical resources from military to civilian purposes therefore constitutes only one form of structural change, of which abundant examples exist in all civilian spheres.

The main difference is that the military R and D sector is not subordinated to civilian national economic interests but to military priorities.

As regards armaments conversion in the narrow sense, and particularly in the scientific and technical sphere, there is on the whole little practical experience. Owing to the prolonged high level of arms spending that has lasted for more than 35 years – approximately 6 per cent of the world's gross national product is currently spent on armaments, whereas in the 1920s the figure was less than 1 per cent – there have been no significant "test" cases of arms industries being converted to civilian ones. However, a number of noteworthy studies have been carried out to develop alternative models for armaments industries, including their R and D component. The models generally assume that conversion to civilian production will have to be achieved by these industries through their own efforts and using their own resources, yet this is only one side of the coin. If effective disarmament measures were launched as a result of international or multilateral agreements, additional financial and material resources would be released which could first and foremost be used in the highly specialised armaments field to overcome temporary conversion difficulties. This raises two sets of problems which we shall now go on to discuss.

Conversion at the works level

By far the greatest part of the total military R and D input is invested directly or indirectly in armaments factories. Hence the conversion of scientific and technical resources is inextricably linked to the switch-over from armaments to peaceful production. In the field of military R and D personnel, a number of informative analyses already exist.

An instructive example from the Federal Republic of Germany was the study made by a working group set up by the Metalworkers' Union (IG Metall) in the VFW aircraft works in Bremen, which built the Tornado multi-role combat aircraft. The group's investigation of alternative manufacturing possibilities made a noteworthy contribution to the conversion debate from both a methodological and a practical standpoint. Since 42 per cent of the employees of the Bremen works are graduates of universities or technical colleges (50 per cent if master craftsmen and engineers are included), any switch in production would clearly involve the large-scale conversion of scientific and technical personnel. The overall purpose of the study, according to the group's spokesman, was to investigate the possibilities of conversion "using existing plant and without causing any financial loss or drop in turnover". The general conclusion arrived at was that "a switch-over from armaments to civilian production can be made quickly and at any time in VFW".[8]

In their analyses the members of the study group kept certain realistic considerations in mind:

- they investigated not only complete conversion but also partial conversion to cover the case of gradual disarmament;
- in view of the precarious state of the civilian aircraft market throughout the world they did not investigate the relatively simple switch-over from military to civilian aircraft but developed a conversion model for non-aeronautical products that are socially useful and in short supply;
- the new products were also selected with a view to using the existing scientific and technical resources. As alternative products, which the group members stressed were only some of many possible options, they proposed and investigated wind power plant, solar water heating equipment, oceanics, low-noise engines and an air quality sampling system.

"In view of the company's overall development in recent years, and on the basis of its research, development and production capacities," the study group concluded, "there is evidence that alternatives to armaments production could be oriented towards ecologically beneficial energy systems."[9]

A partial conversion was successfully carried out at the works in Varel near Bremen in 1977-78. Over a period of "only eight weeks, thanks to the training of specialist teams, the plant was able to develop and manufacture precision measuring instruments, test benches and special-purpose machines".[9] The products proved to be competitive and marketable and hence will continue to figure in the regular production programme. This example and the detailed calculations for the above-mentioned alternative products led to the conclusion that conversion is possible at any time without causing financial loss or affecting the employment of scientific and technical personnel.

In another highly enlightening conversion project, a study group set up in the United States also took as its point of departure the idea that resources devoted to armaments should be diverted to tackling energy problems: "As a renewable resource, solar energy can contribute significantly to our economic well-being by fostering energy self-sufficiency and expanding job opportunities through community growth."[10] As regards the employment effects, the study group arrived at the conclusion that government spending for solar energy development would create more jobs than a comparable expenditure on military production. For example, in 1977 Lockheed Missiles and Space Company in Sunnyvale, California, which employs 16,000 people, received prime contracts from the Department of Defence worth $918 million. "An equivalent commitment of $918 million per year for 30 years to solar energy technologies would provide from 446,000 to 840,000 job years, compared to 480,000 in military systems over the same period of time."[10] This confirms the findings of other studies carried out by experts in both Western and socialist countries that resources released from military production could create up to double the number of jobs in civilian fields.

This study group also devoted special attention to the employment opportunities for scientific and technical personnel. "Technicians, many of whose skills are highly specific to defence work, will have difficulty matching their exact jobs in solar work, but minimal retraining will fit them for solar jobs."[11] In other conversion projects, too, it was found that a certain period of retraining is necessary to allow scientists, engineers and technicians to switch from armaments technology to the civilian field. But these highly skilled personnel in the armaments sector have at the same time the best qualifications for systems analysis of the new technological problems of today:

> In terms of type of work, defence engineers were found to be best suited to designing integrated systems, advanced engineering and analytical design. At the time of the study, systems approaches to engineering problems were being pursued only in certain sectors of civilian industry, and to an even lesser degree in non-defence government programmes. Since that time, however, the systems approach is being used more in commercial industry and by state and local government as well as by major federal programmes such as the Environmental Protection Agency, the Department of Transportation, and the Department of Energy. It is here that the greatest potential for use of engineers in civilian work lies.[12]

These are precisely the fields in which there is currently the greatest technological shortfall in most countries.

The conversion project worked out by engineers, scientists, technicians and workers for the Lucas Aerospace company in the United Kingdom is well known internationally. Two basic principles were adhered to: the alternative products should be useful to society as a whole, and the skills and qualifications of the employees as well as the existing equipment and machinery should continue to be utilised.[13] In all, the working party set up for this project came up with 150 feasible alternative products which were analysed in detail in a 1,500-page plan. Some of these were developed with the help of scientists, engineers and technicians to the prototype stage.

That these projects involve a substantial investment of R and D is clear from the following examples. In the field of alternative energy sources or energy-saving systems, a wide range of proposals was made – for example, a natural gas-fired heat pump that attains an efficiency ratio (energy produced to energy used) of 2.8, and wind-powered generators based on experience in the field of aerodynamics that provide, thanks to a new type of control system, constant energy generation at different wind speeds. Another idea, in the area of new transport systems, was for a hybrid power pack – combining a small internal combustion engine and a battery-driven electric motor – that can be incorporated into road and rail vehicles and reduces fuel consumption by 50 per cent and toxic emissions by 80 per cent. Finally, attention was drawn to the importance of deep-sea equipment and oceanics. The shortage of raw materials calls for more intensive exploitation of the oceans. New underwater vehicles that could be used for "marine agriculture" or raw materials retrieval not only would be a meaningful alternative to arms production but also would call for extensive scientific and technical groundwork, which in this instance would be very similar to that done in the military R and D field.

A disarmament study group in Bremen headed by Professor Jörg Huffschmid has investigated the conversion of warship construction to civilian marine technology. "Oceanics is primarily a field for high-grade technology. . . . The branches particularly concerned would be the iron and steel industry, mechanical engineering, shipbuilding, electrical engineering, data processing, machine building and the construction industry." [14] According to the Federal Ministry of Research and Technology, too, oceanics is assuming "a key role for the future development of these sectors".[15] Work in this area could be significantly expanded with additional expenditure on scientific and technical research and turned into a commercial proposition. Conversion would be made even easier by the fact that the big shipyards in the Federal Republic of Germany have already had some experience in civilian oceanics. As regards the employment effects, the study finds that "in view of the skills the workers possess, there should not be any great problems in the shipyards".[16]

A survey of the aeronautics industry carried out by the California Department of Employment found that of a total of 127 trades, 97 could be converted to civilian production without retraining. Conversion of the other 30 would entail retraining lasting from six to 17 months at most.

In the light of the various studies we have briefly outlined it can be concluded that *(a)* if the proposed alternatives mainly used similar technologies, military R and D personnel could be reintegrated without problems within the same enterprise; *(b)* a small proportion of engineers and technicians would require training lasting six months, or in some cases one year, and in exceptional cases up to two years; this would be the case only of those who have specialised in military technology for many years and for whom there is no civilian counterpart; and *(c)* R and D personnel can therefore be integrated into civilian activities largely without altering the existing skill structure and with more or less the same high pay scale. (It should not be forgotten that in the armaments industry a differential is sometimes earned not because of skill but for reasons of military security.)

Research on military conversion should pay much greater attention to the restructuring that is going on in the civilian fields of the economy, science and technology. This would have the advantage of enabling conversion projects in the armaments field to be compared with real processes constantly occurring in the economy. For example, in the conversion of bituminous coal mining in the German Democratic Republic to building, metalworking and vehicle construction the conditions were much more complicated than in many areas of armaments conversion. Three general features of that conversion, however, would apply to any armaments conversion. First, state agencies along with trade unions and local bodies assumed responsibility for the overall conversion process. Second, the management of the enterprises that were to be shut down had to secure for each employee a new job in line with his skills and qualifications. Third, the successor enterprises were chosen, following prior studies, with an eye to ensuring economic efficiency. As regards the amount of retraining required,[17] a third of the workforce voluntarily accepted employment in other industrial branches for which they already had suitable training; a third could be employed directly in the successor enterprises because their primary or secondary skills matched the new requirements; and a third had to be retrained for new trades. Most skilled workers required an average of five months' training and engineers and technicians up to one year or even two years in some exceptional cases.

During the period of retraining workers were paid their former average wages by the State. Additional compensation was paid to those who faced a temporary loss of earnings. Many similar examples could be cited from the German Democratic Republic.

State and trade union support for conversion measures

The conversion from military to civilian production immediately after the Second World War demonstrates that countries with different social systems were able to overcome this problem to the benefit of their people and their economies. Naturally, conditions at that time differed. As a result of the war there was an enormous demand in most countries both for production resources for civilian purposes and for consumer goods. Also, science and technology did not yet play the role they do today in the armaments industry. For this reason, the problems of conversion are more complex now than they were then. But in terms of scale and organisation the process would be much easier today than in the case of an economy that was completely subordinated to the conduct of a war.

In the Soviet Union 8.5 million servicemen were demobilised by the beginning of 1948. Vocational retraining and upgrading courses were arranged for them throughout the country. Preparations for proper planning and management of the conversion process had already been made by state bodies even before the end of the war. This process has been fully described by Soviet researchers in a publication put out by the Vienna Peace Institute.[18]

Conversion in the United States was on a similar scale. The armed forces were comparably reduced and between 1945 and 1948 the arms budgets were cut from 81,200 to 11,800 million dollars. The fears expressed at the time that unemployment in the United States might spiral to the order of 8 million proved unfounded. Despite the enormous scale on which employees of the military and armaments sectors had to be reintegrated into the civilian economy, unemployment during the first post-war years stayed below pre-war figures. In the United Kingdom, post-war developments were very similar.

The problems at the end of the Second World War were successfully solved because, among other reasons, States with different social systems supported and accelerated conversion through measures that were aimed at controlling or directing the economy. Today, too, it is important that States should assist conversion with the aid of budgetary savings on arms spending. This applies particularly to highly specialised weapons production and above all to the scientific and technical resources employed therein. It was only with massive state support that such important R and D resources were shifted from the civilian to the military technology sphere. One cannot therefore take the view – unless disarmament is rejected on principle – that reconversion from military to civilian technology should be achieved solely by the armament industry's own efforts.

Furthermore, the trade unions in market economy countries are calling ever more clearly for a voice in armaments conversion. The chairman of the Aerospace Committee of the British Confederation of Shipbuilding and Engineering Unions, Ken Gill, declared that his colleagues were insisting that "the total community be involved in the planning of a regional industrial investment strategy which would ensure the smooth rundown of the arms industry".[19] In the Federal Republic of Germany a proposal has been made to form industrial conversion committees composed of equal numbers of worker and management representatives.[20] In the socialist economies it is both a statutory requirement and established practice that those affected by conversion should take an active part in planning and implementing the process. Since a number of complex and longer-term conversion problems do arise for engineering, technical and scientific personnel in various undertakings and sectors their co-operation is essential.

All in all, a drastic reduction in military R and D resources and their allocation to civilian projects instead would be a gain for the national economy, the world economy and all mankind. The very fact that modern weapons are far more R and D-intensive than civilian goods (table 2) clearly shows that disarmament could have a manifold effect on the civilian development of science and technology.

3. Conclusion

Our priority task at present must be to halt the increasing use of scientific and technical resources for military purposes: otherwise conversion to civilian uses can only take longer and prove more difficult to realise in the end. Judging from past experience of disarmament negotiations and arms reduction agreements, effective results will probably be achieved only step by step, though a quicker breakthrough would be desirable.

Conversion will of course mean a gradual redeployment of scientific and technical personnel to the civilian sector. But even if far-reaching disarmament measures are adopted, the difficulties of reintegrating such personnel will be slight compared with the medium- and long-term advantages. As regards their retraining, it is false to think that the complex nature of weapons systems necessitates equally complex skills and training that are peculiar to the military field. With relatively few exceptions, the training required can be broken down into individual activities that are identical, or at least very similar, to civilian ones.

Conversion of scientific and technical resources, both material and human, is by its very nature more complicated than the general process of armaments conversion. But all in all, the problems of conversion – provided certain conditions outlined above are met – are less difficult than is generally believed. In organisational, scientific and technical terms these problems can be overcome, but they cannot be unless the political signal for disarmament is given.

Notes

[1] United Nations: *Economic and social consequences of the arms race and of military expenditures*, Study Series 11 (New York, 1983), p. 2.

[2] H. Weiz: "Wissenschaft und Technik für Gegenwart und Zukunft unseres Landes", in *Einheit* (Berlin), 1984, Vol. 3, p. 199.

[3] ibid., p. 200.

[4] Cited in L.-J. Dumas (ed.): *The political economy of arms reduction* (Boulder, Colorado, Westview Press, 1982), p. 17.

[5] United Nations, op. cit., p. 40.

[6] H. Eglau: *Der Kampf der Giganten: Europa, USA und Japan im Wirtschaftsstreit* (Düsseldorf and Vienna, Econ Verlag, 1982), p. 122.

[7] United Nations Centre for Disarmament: *Economic and social consequences of the arms race and of military expenditures*, Updated report of the Secretary-General, doc. A/32/88/Rev. 1 (New York, United Nations, 1978), p. 47.

[8] G. Bouwer: *Vom MRCA-Tornado zur zivilen Alternative* (Baden-Baden, Nomos Verlagsgesellschaft, 1983), p. 7.

[9] ibid., p. 149.

[10] R. DeGrasse, Jr., et al.: *Creating solar jobs: Options for military workers and communities*, A report of the Mid-Peninsula Conversion Project (Mountain View, California, 1978), p. 1.

[11] ibid., p. 23.

[12] ibid., p. 30.

[13] Lucas Aerospace Combine Shop Stewards Committee: *Corporate plan* (Solihull, West Midlands, 1976).

[14] J. Huffschmid (ed.): *Für den Frieden produzieren – Alternativen zur Kriegsproduktion* (Cologne, Pahl-Rugenstein Verlag, 1981), p. 52.

[15] Cited in Huffschmid, loc. cit.

[16] ibid., p. 58.

[17] K. Engelhardt et al.: *Effects of the arms race and disarmament on the labour situation in countries of different social systems*, Contribution to a United Nations study on the relationship between disarmament and development (Berlin, Institute of International Politics and Economics of the GDR, 1980; mimeographed).

[18] Vienna Peace Institute: *Socio-economics of disarmament* (Vienna, 1979).

[19] K. Gill: "Alternative to arms production is feasible and necessary", in *New Perspectives* (Helsinki, World Peace Council), 1979, No. 2, p. 7.

[20] Bouwer, op. cit., p. 139.