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MILITARY FUNDED RESEARCH: THE INSTITUTION OF SCIENCE AND THE MILITARY*

by

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Abstract: I shall discuss how tne growing practice of shifting much of research funding (both basic and applied) from civil to military agencies makes the prompt organisation and exploitation by the military of a network of friendly scientists both possible and efficient. I shall contend that the control of all kinds of research, not only those directly related to weapons systems, is relevant to the scope of the military throughout the world.

1. Introduction

Reagan is asking the Europen NATO allies to participate in "star wars" research (1): 26 billion dollars are at stake, fatty research contracts loom at the horizon, the scientific community seems interested and ready to serve. This seems therefore the right time to say a few unpleasant things to our scientific colleagues and ask a few questions. How is it that they are so ready to serve? what shaped the institution of science and made it so sensitive to the demands of the military?

I shall offer here a few considerations on this theme, based on the following theses:

- there is no inherent madness in the military (2), there is no inherent perversity in the institution of science (3)

- economical, political, military and scientific institutions all cooperate (4) (allowing for a few contradictions and tensions (5)) in a well-knit network, whose clear-cut rationale is power (not necessarily military power: control rather than war)

- the real partner of the military is the institution of science, not science (a rather mythical espression that I shall avoid and that implies a sort of neutral "body of knowledges")

2. How things are perceived (or made to be perceived)

In the present, hectic arms race, the politicians and the military have some interest in appearing as not responsible for it in front of public opinion. A few models help them: the scientists as hustlers; the technology as an imperative. See the following.

2.1 A "rich menu"

> "There seems to be widespread consensus among qualified observers that a rich technological menu has been offered to the military by the scientists and engineers." (6)
>
> "...(during World War II) the scientists, in part, defined their own problems and took the responsibility for selling not only new techniques but also strategies to go with them to the

> military service. Scientists appeared on the battlefield zones as civilians, flying with bombing missions to observe the operations for new developments." (7)

This is a fact: scientists, within the institution of science, are more and more enriching the menu that they periodically propose to the military. They feel personally concerned with development, production and deployment of new weapons systems. They like to be on the spot, briefed by generals, treated as honored guests.

The recent history of the development of the neutron bomb is unambiguous: scientists wanting the bomb, scientists lobbying for the bomb, scientists proving that the bomb would solve most military problems. The survival of a research laboratory and the prestige of a small group of scientists lead to the development of a new instrument of mass destruction. A (heavily censored) transcript of a 1973 hearing of the US Congressional Joint Atomic Energy Commission is illuminating. H. Agnew, director of the military laboratories at Los Alamos, stated:

> "It may be that people like to see tanks rolled over rather than just killing the occupants. It is quite clear there is rethinking going on... I know we at Los Alamos have a small but very elite group that meets with outside people in the defence community and in the various think-tanks. They are working very aggressively, trying to influence the Department of Defense to consider using these (deleted) weapons." (8)

Scientists take the initiative. They did so particularly well during World War II. They were at the root of the program leading to the atomic bomb, as is clear from the famous letter signed by Einstein and addressed to F.D.Roosevelt (August 2nd, 1939):

> "This new phenomenon (the nuclear chain reaction in Uranium) would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type, carried by boat and exploded in a port, might well destroy the whole port together with some of the surrounding territory... In view of this situation you might think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America." (9)

But the collaboration operated at all levels, in all fields. Here is a chilling example from a memorandum sent by a scientist (H.Ewell) to V.Bush and transmitted to the Army Air Forces:

> "Advance estimates of forces required and the damage to Japanese war potential expected from incendiary bombing of Japanese cities indicate that this mode

> of attack may be the golden opportunity of strategic bombardment in this war - and possibly one of the outstanding opportunities in all history to do the greatest damage to the enemy for a minimum of effort." (10)

I have given two examples from two outstanding successes by scientists; atom bombs were, as a matter of fact, produced and used on Hiroshima and Nagasaki; incediary bombs accounted, at the end of the war, for more than 3,500,000 dwelling units destroyed or heavily damaged, more than 5,500,000 Japanese people rendered homeless, more than 300,000 dead, more than 750,000 wounded. (11)

I could give many more examples. But I want to emphasize that this is only part of the story: I shall link, in what follows, the rich menu model with the technological inevitability model. They both contain, of course, quite a lage amount of truth but they contribute building up an image of the military as tied to the initiative of scientists and the progress of technology. This is a very useful image (to the military), one that hides responsibilities and complicities. It has been already expressed by Eisenhower in his well known "farewell address":

> "Yet in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite." (12)

But it is clear that the most important question is: What has created these scientists that insist in offering a rich technological menu to the reluctant military? Were they born by spontaneous generation?

2.2 A "technological imperative"

> "Since military technology as a whole is the most rapidly developing aspect of contemporary military affairs, one can assume beyond doubt that it is the development of armaments which, in the last analysis, determines the development of the whole of military affairs. This is a fundamental proposition on which the entire present chapter is based... At the present time the rapid development of military technology has affected a still greater influence on the development of military affairs... Soviet science and culture form a mighty rock on which to base the solution for any problem of military affairs or of military technology." (13)

It seems to me that the old and discredited use/abuse model of science

in our society is being replaced smoothly by a more subtle model, that enlarges the rich menu model already presented ("the fault, it is the scientists' ") to a new one, the technological inevitability model ("the fault, it is scientific and technological progress") exemplified by the quotation above.

The use/abuse model is too well known and worn too thin by age to deserve much analysis. More or less, it goes as follows: scientists are in quest for truth (being somewhat convinced that any truth about nature is of general interest to humanity); the institution of science (through civil or military agencies) provides them with funds and tools for their search; the results are the common patrimony of humanity. If someone decides to use them for evil, it is none of the scientist's business: the scientist accepts no blame.

You might think that this is a caricature of a serious model. But listen:

> "If I produced butcher's knives, I would feel totally at peace with my conscience, even if those knives were sometimes used to kill people; all said, people need butcher's knives, and it is not the producer of knives that has to concern himself with the criminal use that someone could make of them." (14)

It is a Nobel Prize for physics that is speaking; a long term collaborator with the French military. The caricature is therefore not in my presentation of the model, but rather in the use/abuse model itself.

The tehnological imperative model is much subtler. We are all sensitive to the incredible impetus of scientific research in our world; we feel that there is an internal logic in it (hard to define, even for those who work inside the institution of science) and that this logic leads to technological development, production, application, consumption of newer and newer industrial goods. We feel the thrust of this impetus in all aspects of our life: we have not asked for color television, supersonic aircraft, electronic printing, teaching by computer, etc. We have been given presents (in the form of continuous technological progress) but we have no way to refuse or discuss them. The same seems to go with bombs and other new weapons systems.

Capitalistic production believes in the inevitability of technology: all that can be made, should be made. Otherwise, a competitor will make it and destroy you. The military seem to share the same belief: all weapons system that can be made, should be made. Otherwise, an enemy will make it and destroy you (15).

At this point, one's natural curiosity arises: what made the present institution of science such as to be able and eager to offer more and more technological enjoyment to our everyday life, to industrial production, to the military? Did it develop according to some internal logic of scientific and technological thought and methodology?

3. How things are

It is perhaps arrogant on my part to speak of "how things are" (a correct appreciation of all relevant power relations is so hard to dig out of the apparent social relations). At least, I can try and present a few ideas that are, in general, quite clear to all those involved in decision making but are often obscured by scientific and military propaganda.

3.1 The military establishment

Any analysis of the relation between the military and the institution of science should start from a comprehensive survey of the complex role and power of the military establishment. However, such an analysis would be out of place in this brief paper. I shall quote here Leger Sivard (16) for a comprehensive review of world military and social expenditures (an annual report); Yarmolinsky (7) for the US military establishment; Smith (17) for the Soviet military establishment (a bibliography).

A few simple but significant data (18):

- "20 million people were killed in some 150 wars since 1945, more than the soldiers killed in World War II"

- "world military expenditures doubled between 1960 and 1983 to reach 800 billion dollars per year" (at constant 1981 dollar)

- "international arms trade and transfers increased threefold between 1968 and 1982" (from 10 to 34 billion dollars, at constant 1981 dollars)

- "for every 100,000 people in the world there are 556 soldiers and 85 doctors"

- "for every soldier the average world military expenditure is $20,000, for every school-age child the average public expenditure is $300"

- "1 billion dollars = 28,000 jobs in military goods and service
  = 57,000 jobs in personal consumption industries
  = 71,000 jobs in education"

One could say: these data speak by themselves. It is not really so, as they can be differently judged according to personal political choices and values (by the way, I disagree with the underlying dogma that "the more doctors" and "the more teachers" implies necessarily a significant progress for humanity). But I think that one can fairly

state that these data show the weight, the relevance, the impact on our life and future of the military establishment (19),(20).

3.2 The institution of science

Again, a careful estimation of the role and power of the institution of science would be out of place here; a few data will however help in placing it in a correct perspective with respect to society as a whole.

Again, I shall list here only a few simple, significant data:

- resources devoted to R&D in 1975 (21):

	France	Italy	Japan	Switzerland	USA
total (billion $)	6.0	1.7	8.8	1.2	36.7
% GNP	1.8	.9	1.7	2.2	2.4
R&D/person (dollars)	113	30	79	195	172
nr.scientists (x 1000)	62	31	260	16	533
nr.(scient.+ engin.)/workers	2.8	1.6	4.9	5.3	5.6

(for Soviet Union, an estimation of nr.scientific workers (x 1000) - averaged over the years 1966-1969 - is given by Gvishiani et al (22): 270)

Well, this institution of science is a huge thing indeed! And it is clear that contemporary science and technology have been shaped by the ruling interests of our society in such a way as to be ready to serve them. It is in this context that I prefer to talk about the institution of science rather than about science and/or technology. "Science" sounds atemporal, a growing body of knowledge about natural phenomena, an increasionlgy complex kit of tools for the control of nature. You can talk about Greek science, Chinese science, etc. and you will forget the interests that shaped them. In the same way, "technology" sounds homely, new gadgets for our everyday life, new hopes for a longer life expectancy, etc.

The institution of science is the whole body of the present practice on the control of nature and man: scientists, scientific/academic institutions, funding agencies, scientific journals and associations, administrative personnel (including the famous girl who "typed and retyped with unfailing effectiveness my unreadable manuscript..."), the necessary constellation of students and young research workers.

All of this is needed to do science today. It is not given free to scientists to amuse themselves with: it is part of a societal project, it satisfies needs and interests (sometimes contradictory), it reflects - in its structure, functioning, ideology - the larger world that makes its existence possible.

Before going on to a detailed analysis of the role of military funded research, one should unravel as much as possible the interplay of the different components of the institution of science. It is dangerous, as a matter of fact, to become so concerned about military research and military funded research, as to try and understand their role in a vacuum , as a degeneracy of the system, as a perversion of science (I shall speak henceforth of m.f.r. , meaning by it the whole set of research that - independently of its direct, indirect or null relevance to weapons systems and explicit military affairs - is funded by or through military agencies) . I would contend that m.r.f. is an integral part, a very organic and conscious part, of the whole research effort.

I shall deal with only a small part of the whole pattern, mostly with scientists: what they are, what they think they are, what other people think they are. And, mostly, why they are what they are. In particular, why they are so willing to serve the powers that be (23).

There are several myths that should be dispelled, if one wants to tackle this problem. One of the most persistent ones - together with the use/abuse model discussed above, which is quite consistent with it - is the following: the scientists are (or would like to be, or should be) the critical consciounsness of our society. Let us see how much there is to this myth.

> "We, representatives of German science and art, protest - in front of the entire civilized world - against the lies and calumnies by means of which our enemies try to dirty the pure cause of Germany, in the difficult struggle for existence that has been imposed on her... It is not true that we have criminally violated Belgian neutrality... : we would have destroyed ourselves if we had not taken the initiative... It is not true that our soldiers have taken the life or the property of a single Belgian citizen, except when constrained and against their will... It is not true that our troops have brutally ravaged Louvain. They have been obliged to retaliate, against frenzied inhabitants that have treacherously attacked them; it has been with a bleeding heart that they have shelled the town... The famous Hôtel de Ville stays brilliantly intact: risking their lives, our soldiers have kept it from burning... Without German militarism, German culture would long since have disappeared from the world." (24)

You are not dreaming. this is not a text from a book of science-fiction: it is only a small part of an "Appeal to the Civilized World" signed, on October 4th, 1914, by 93 famous German scientists and artists. As we are talking abour science, let us have a look at the scientists' names, the very cream of the German intelligentzia, Nobel Prizes and the like: P.Ehrlich, E.Haeckel, F.Klein, W.Nernst, W.Ostwald, M.Planck, W.Roentgen, W.Wien...

Each one of these scientists had given an essential contribution to his research field, by challenging established dogmas, by painstakingly trying to restructure on a new level a domain torn by contradictions, by looking iuntelligently at new facts and phenomena. And then they sign this "Appeal": without any proof, any possibility of checking and proving/disproving what they are saying, any reservation about the pure cause of Germany. They have been asked to serve, and they do so. That is why I say that they (we) have been trained to serve, in a much subtler way than poor soldiers in an army.

What is striking in the German Appeal is not its content; it is its early date, 1914, a time at which the complex web of military agencies, m.f.r., research laboratories, experts' panels, think-tanks, etc. had not yet been woven. It was only during and just after World War I that the institution of science began to be shaped so as to be ready to provide support and to propose improvements to the military.

With respect to industrial production, this dependence already had a long history. "During the first three decades of the twenthieth century, therefore, the corporate engineerss undertook to organize and harness science to industry" , writes David Noble (25) , who identifies three phases: the establishment of organized research laboratories within the industrial corporation; the active support of and collaboration with research agencies outside the corporation; the national coordination of research activity in support of corporate industry. "The research laboratories, above all, gave to the corporations command over the flow of scientific investigation. In the ninetheenth century, scientific ideas had given rise to industrial manifacture; now the industrial corporations undertook to manifacture scientific ideas." (26)

In the United States, out of the Civil War came the Naval Observatory, born as a "depot of charts and instruments" and then grown to be the Office of Naval Research. Out of World War I came the National Research Council: "... the wartime NRC became a central directing agency for American science to a degree unprecedented in earlier history" , states Yarmolinsky in his very perceptive analysis of the military establishment (27) . Out of World War II came the whole panoply of "directing agencies for American science" : the National Defense Research Committee, to "correlate and support scientific research on the mechanisms and devices of warfare" (28) ; the Office of Scientific Research and Development, "for the purpose of assuring adequate provision for research on scientific and medical problems relating to national defense" (29) ; the RAND corporation, "to harness civilian science to military strategy" (30) ; the Advanced Research Project Agency, the Atomic Energy Commission,...

In this light, the preoccupation expressed by Eisenhower in is "farewell address" seems funny and incongrous:

> "The prospect of domination of the nation's scholars by Federal employment project allocation and the power of money is ever present - and it is gravely to be regarded." (12)

3.3 The science-military marriage

> "An outstanding example of imaginative rivalry is the foundation of the Lawrence Livermore Laboratoy of the Atomic Energy Commisision. While important work on nuclear warheads was done at the Commission's Los Alamos Laboratory, some scientists were dissatisfied with the speed of acceptance of new ideas there and organized the new laboratory in order to let their ideas have fee play. Out of the ensuing rivalry came the speedy development of the hydrogen bomb and of many other devices which micht have becomer available only after much longer time-intervals." (31)

An even more outstanding example of the symbiotic relationships between scientists and the military is the famous Jason Division of the Institute for Defense Analyses (IDA) (32). IDA was used to address young scientists "at a crossroad in their career":

> "Consider IDA - an avenue worth exploring in your quest for professional advancement. IDA is an independent not-for-profit organization in Washington that performs significant scientific and technological studies on problems of national importance for the Office of the Secretary of Defense... At IDA you're free from commercial pressure. You're free of vexing administrative duties that can cramp your effectivemess. Your whole intellectual capacity is free to focus on critical problems - giving them the full benefit of your technological expertise and analytical initiative... IDA can serve as a stepping stone in your career... Areas of interest where the value of your background and judgement is needed at IDA are: Tactical Systems, Strategic Systems, Sea Warfare, Weapons Effects, Advanced Sensors, Missile Defense, Space Technology... " (33)

The Jason Division is only one of the many bodies/agencies/research labs/think-tanks that channel and shape this fruitful symbiosis between the scientists and the military. The symbiosis is fruitful to the scientist, as it provides easy funding for research, "a stepping stone for one's careeer" , prestige and personal power in

the scientific community. It is fruitful to the military, as it provides them with a body of scientists (and, on a more general level, it structures for them the institution of science) willing to listen, for instance, to Reagan's latest appeal:

> "I call upon the scientific community who gave us nuclear weapons to turn their great talents to the cause of mankind and world peace: to give us the means of rendering these nuclear waeapons impotent and obsolete." (34)

What Reagan is asking his scientists to do, is to develop beam weapons (the words about peace and the cause of mankind sound inintentionally ironical in this context). You can be sure that his scientists are already enthusiastically answering his appeal. Teller dit not even wait for the appeal:

> "The most important developments may come about in national defense. This probably will not mean bigger explosives. Defense against incoming missiles is more challenging, more important and more in accordance with what we wish to do." (35)

I think that, if we want to understand the structure, the functioning, the peculiarities of the institution of science, we have to think of the scientists as an organic part of this structure. The way they think, act, take initiatives, fight, etc.: all this is related to the institution to which they belong and that has formed them. And this institution if more and more dependent on military funding of research. This objective dependence shapes the policies of the individual scientists and of their institutes.

Here again a few simple, significant data:

For the US: federal R&D funds by budget function 1985 (36):

- national defense	37.0 billion dollars
- health	4.9
- space research and tech.	2.7
- energy	2.4
- general science	1.9
- transportation	1.2
- natural resources and env.	.9
- agriculture	.8

(If you accept now that a lot of "energy" and "space" research + some "health" science is of definite military interest, you arrive at the conclusion that about 80% of the US R&D budget is war-oriented; as an example: the Energy & Technology Review - a Lawrence Livermore National Laboratory publication - has published in 1984 24 papers on research programs sponsored by the US Department of Energy, 11 of which were labelled "defense programs - military applications", while only 2 papers were relative to research directly sponsored by DoD.)

For a look at the development in time of this dominance of military R&D, let me quote Leger Sivard:

> "The post-war take-off in weapons research was even more spectacular than the rise in military expenditures in general. In the US, government financed military R&D jumped from $1.7 billion in fiscal year 1947 to $22.1 billion in fiscal year 1983 (both in 1980 prices). The 13-fold increase in research expenditures was 4 times as fast as the very rapid growth of all US military spending over the same period." (37)

(Many more details on the weight of military R&D can be found in Väyrynen (38), with an analysis of its impact on science policy; Acland-Hood (39), for the US and Soviet Union; Holloway (40), for Soviet Union; Sapolsky (41), for a long range trends analysis.)

Confronted with this enormous quantity of resources allocated to military R&D, a legitimate questions is: which research the military are funding? and why?

> "Modern technology and science are so complex and so interrelated that even in the final stages of the development of a weapon there is no necessary concentration on a specific 'military' technology." (42)

> "It was recognized from the outset that the activities of the committee (the National Research Council) should not be confined to the promotion of research bearing directly on military problems, but that true preparedness would best result from the encouragement of every form of investigation, whether for military or industrial application, or for the advancement of knowledge without regard to its immediate practical bearing." (43)

The military is funding:

- research that is specifically designed to provide better weapon systems (i.e., of larger mass destruction and delivery precision);

- research on parallel fields, whose results could lead to the discovery and development of new or more efficient weapons, but that are so fragmentary that they can be published openly with no danger;

- research that is quite clearly and definitely of no military interest, be it direct or indirect (an example of the last category is research on "a model for pattern perception with musical applications", in which Bach's music is taken to pieces and analized in depths (44)).

What is the rationale behind this generous shower of funding by the military?

Among those who, under different perspectives, are engaged in a critique of science in our society and, in particular, in a critique of the role of military funding in research, there is a widespread opinion that is, I believe, incorrect. It is the opinion that "you can never know" how much military interest some proposed research might have (which is correct), and "you will never know" the hidden reasons that led the military, in some instances, to fund research that - to our naive eyes - looks totally immaterial to them (and I think that this last part is too limitative and can turn out to be incorrect). I think the quotations above make quite clear that the military is not only looking for explicitly military research and results. It is looking for a more general "state of alert" of research institutions and scientists, a state of alert that, in turns, generates "sweet solutions" (as Oppenheimer called them once) that make the military happy.

The position of the NATO Science Committee is quite explicit about it:

> "As the industrial democracies move from predominantly responding to the challenges and limitations of man's natural environment to fulfill the need for more effective control and management of the technological environment... science and technology have been necessary - if not sufficient - in the social transformations of the period since the Second World War. What science and technology have made possible is a continuation of the division of labour that is a distinctive feature of all society... We have some reason to be confident that this tendency will continue. We have every reason to hope that it will. ...
>
> The vagaries of shifting national priorities have always affected alliances between nations, tending to make them short-lived and of decreasing value... When the North Atlantic Treaty was written, this had come to be well understood, and in extending the concept of mutual security to include co-operation in matters of social, economical, and political concern, it sought to widen the common interest of the alliance nations by strengthening and monitoring the stability of their institutions...
>
> In this way, the Scientific Committee would respond to the repeated request to shift the emphasis of its effort, to build bridges of cooperation between different scientific areas besides - as it did so effectively in the past - building bridges for the co-operation of scientists from different countries of the Alliance." (45)

There is no doubt about it: the military, at least in the countries in which some information is available, such as the USA and other NATO countries, is concerned with <u>all fields</u> of research. A healthy

science (in the sense of an institution of science efficient, aggressive, collaborative) is a guarantee of power, control, potential mobilization. There is however a point that still needs to be clarified: if the military is interested in a healthy scientific system in its country, why should it fund it? Why not leave the job to civil agencies (which have the same aims: power, control, potential mobilization of the institution of science) ?

It is here that a specificity of m.f.r. strikes our attention. It is true that all fields of research are potentially fundable by the military. But there are some fields that are more so. In a subtle way, military funding alters priorities, emphasizes one field pwith respect to another, establishes "military values" in the elaboration of a research policy. And, more than anything else, its value to the military lies in the web of dependencies that it establishes among scientists (it is significant that the work quoted in (45) , by two senior NATO officers active in the Science Committee, bears the following two subtitles for the two volumes: "Building on scientific achievement" and "Technological challenges for social change") . It is this dependence, I think, that above all interests the military. When it becomes clear that the survival of a field of research or its developmnent depend on the military, the corresponding scientists and technicians become willing to serve . The generosity of today is a good investment, in view of the domination of tomorrow.

4. How things could change?

It is difficult to arrive at any clear-cut answer to the question "What to do?" . I think that much depends on who is doing what, and why is doing it. I think that the community at large (for instance, in a small University town or around a large University campus) can hopefully struggle to impose the condition that all research carried out at the Universities be open as to funding, employer, results and long term policy guidelines. In particular, the presence on a campus of specific biological research toward biological warfare could sound the alarm for many people and lead to a constructive and aggressive mobilization. I think that students and young research workers should impose their right to be explicitly and accurately informed about the research proposals in which they participate. For instance, only too often a young assistant is sent to scientific Summer Schools or meetings on military funds about which only the responsible of the research is aware.

I think also that any left-minded research worker in our societies, at any level, should refrain from asking for military funds. I know that the traditional alibi is "If the military had not given me those 10.000 dollars, they would have bought another gun" . It is a silly alibi. What the military is willing to buy, is not the gun but the scientist; the accrued dependence of the Academy on the military is all in their interest.

To expose military research (and any other form of explicit or

hidden m.f.r.) in the Universities could become an aggressive mobilisation topic in several countries. However, I would advocate a line of argument and mobilisation that steers clear - as much as possible - of the traditional moralistic approach according to which the military is ugly, while civil research is for the common good of humanity. It is not true, and that gives us a false start in the struggle. What is true is that dependence on m.f.r. can be harder to control or destroy than dependence on other civil agencies. Scientists involved in this kind of dependence tend to become more and more embedded in the military ideology. And the contribution by scientists to the increase of the power of the military is essential. No "star wars" program could be possible without the explicit complicity of scientists.

Above all, there is need for information about m.f.r. in our research intitutions. A detailed analysis of what is known, of what can be found out by searching patiently throughout the available material, can stimulate initatives and new, original forms of struggle.

5. Aknowledgements

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6. References

(1) The Intern.Her.Trib., 27/3/1985

(2) this these contradicts the so-called "baroque arsenal" model; see note (20) for more details

(3) this these contradicts some positions on a sort of "degeneracy" of contemporary science; see, for instance, M.Kaldor: Détournement de technologie - Le Monde Diplomatique, janvier 1982

(4) I would like to quote here a little known but very sensitive analysis of "science as the continuation of policy" by L.Lamarosse: D'obscurs savoirs - Esprit, octobre/novembre 1981

(5) the famous "Farewell address" to the US nation by Eisenhower (1961) contains a number of statements on potential contradictions in the power system; see note (12) below

(6) K.E.Knorr and O.Morgenstein: Science and defense; some critical thoughts on military research and development - Center for International Studies, Princeton 1965, p.14

(7) A.Yarmolinsky: The military establishment - Harper and Row, New York 1971, p.289

(8) "Physicists try to forget Vietnam while promoting the neutron bomb" - The New Scientist , 23 september 1977 ; on the history and rationale of the neutron bomb, see B.Vitale: On the neutron bomb - ENDpapers , winter 1981/82

(9) for a complete text of Einstein's letter (sollicited by Leo Szilard), see e.g. L.L.Strauss: Men and decisions - Macmillan, London 1962, p.178

(10) extracts of the letter are published in J.P.Baxter: Scientists against time - Little, Brown and C., Boston 1946, p.97

(11) ibidem , p.99

(12) Eisenhower's Memorandum on scientific and technological resources as military assets (1946) and his Farewell to the Nation (1961) are both given (in Appendix) in S.Melman: Pentagon capitalism; The political economy of war - McGraw-Hill, New York 1970

(13) G.I.Pokrowsky: Science and technology in contemporary war - Moscow 1956, 1957 (in Russian) ; English translation: Stevens, London 1959, pp.64, 101, 126

(14) L.Neel, as quoted by A.Aigrain - Sciences nr. 79 , mars-avril 1971

(15) A few quotations more on the "technological imperative":
"It is my contention that missile technology, not man, has dominated the evolution of our defense policy." (R.E.Lapp: Arms beyond

doubt; The tiranny of weapons technology - Cowles Books, New York 1970); "It is a truism that the arms race today is driven by a technological momentum." (M.Thee: The race in military technology, in J.R. (ed.): Scientists, the arms race and disarmament - Taylor & Francis, London 1982); "A new scientific competition is starting that, volens nolens, will give rise necessarily to a new industrial competition and a new arms race." (General Fricaud-Chagnaud - Le Monde, 29/1/1985)

(16) R.Leger Sivard: World military and social expenditures; An annual report on world priorities (annual, since 1974) - World Priorities, Washington

(17) M.J.S.: The Soviet army, 1939-1980: a guide to sources in English - ABC-Clio, Santa Barbara 1982

(18) "Costs of the arms race", a poster by the World Disarmament Campaign, Department of Disarmament Affairs, United Nations, New York 1985

(19) W.Leontief and F.Duchin: Military spending; Facts, figures, worldwide implications and future outlook - Oxford Univ.P., New York 1983 contains a few scenarios on long-range trends for military expenditures

(20) the huge dimension of military budgets and the incredible sophistication of some of the most recent weapons systems has led to the "baroque arsenal" model dear to M.Kaldor: The baroque arsenal - Deutsch, London 1982; see a critical review of this book by T.B.Millar, in J.Strat.St., december 1983

(21) D.S.Greenberg and A.D.Norman (eds.): Science and government report (1978-1979) - Science and Government Reports, Washington 1979

(22) D.M.Gvishiani, R.S.Mikulinsky and S.A.Kugel (eds.) - The scientific intelligentzia in the USSR; Structure and dynamics of personnel - Progress Publ., Moscow 1976

(23) B.Vitale: What becomes of a scientist? in T.Segerstedt: Ethics for science policy - Pergamon Press, London 1979

(24) the complete text of the letter and the list of signatures is given in H.Kellermann: Der Krieg der Geister - Heimat und Welt, Weimar 1915 ; the "Aufruf an die Kulturwelt" is at p.64; a French translation is given in M.Schröder-Gudehus: Les scientifiques et la paix; la communauté scientifique internationale au cours des années 20 - Presses Universitaires, Montréal 1978, in an Appendix

(25) D.Noble: America by design; science, technology and the rise of corporate capitalism - Knopf, New York 1977, p.112

(26) ibidem , p.118

(27) Yarmolinsky, op.cit. , p.287

(28) from the "Order establishing the National Defense Research Committee" , june 27, 1940 ; see Baxter, op.cit. , p.451

(29) from the "Executive order establishing the Office of Scientific

(30) Yarmolinsky, op.cit., p.58

(31) Knonr and Morgenstein, op.cit., p.28

(32) early in 1973, Jason Left the Institute for Defense Analises, which had been its home for almost 15 years, and moved into a new home created at the Stanford Research Institute in California; much information on the Jason Division can be found in B. Vitale: The war physicists; documents about the European protest against the physicists working for the American military through the Jason Division of the IDA (1972) - Liguori, Naples 1976

(33) IDA advertisement, Scientific American, november 1972

(34) President Reagan's "Appeal to the Nation", March 23, 1983; see the text of the Appeal on The Bulletein of the Atomic Scientists, june/july 1983

(35) E. Teller: Role of physicists in the 1980's - Physics Today, febroary 1981

(36) Science for the People, march/april 1985

(37) Leger Sivard, op.cit., 1983 report

(38) R. Väyrynen: Military R&D and science policy, Intern.Soc.Sc.J., 35-nr.1-(1983)

(39) M.Acland-Hood: Military R&D: some aspects of its resourse use in the USA and the USSR, in SIPRI-Yearbook 1983

(40) D.Holloway: Military R&D in the Soviet Union, Bull.Peace Prop. 9-534-(1978)

(41) H.M.Sapolsky: Science, technology and military policy, in I.Spiegel-Rösing and D.de Solla Price (eds.): Science, technology and society: A cross disciplinary perspective - Sage, London 1977

(42) Knorr and Morgenstein, op.cit., p.31

(43) G.E.Hale, astronomer, as quoted by Yarmolinsky, op.cit., p.286

(44) D.Rothenberg: A model for pattern perception with musical applications - Math.System Theory 11-199-(1978); "this research was supported in part by grants and contracts AF-AFOSR..."

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