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## U.S. Office of Naval Research Report on the Priore Machine

16th August, 1978

### Index

- [Cover Page #1](#)
- [Cover Page #2](#)
- [Table of Contents](#)
- [Page 1](#) (transcription)
- [Page 2](#) (transcription)
- [Page 3](#) (transcription)
- [Page 4](#) (transcription)
- [Page 5](#) (transcription)
- [Page 6](#) (transcription courtesy of Guy Antequera)
- [Page 7](#) (transcription courtesy of Guy Antequera)
- [Page 8](#) (transcription courtesy of Guy Antequera)
- [Page 9](#) (transcription courtesy of Guy Antequera)
- [Page 10](#) (transcription courtesy of Guy Antequera)
- [Page 11](#) (transcription courtesy of Joe Spears)
- [Page 12](#) (transcription courtesy of Joe Spears)
- [Page 13](#) (transcription courtesy of Joe Spears)
- [Page 14](#) (transcription courtesy of Joe Spears)
- [Page 15](#) (transcription courtesy of Joe Spears)
- [Page 16](#) (transcription courtesy of Joe Spears)
- [Page 17](#) (transcription courtesy of Joe Spears)
- [Page 18](#) (transcription courtesy of Joe Spears)
- [Page 19](#) (transcription courtesy of Joe Spears)
- [Page 20](#) (transcription courtesy of Joe Spears)
- [Page 21](#) (transcription courtesy of Joe Spears)
- [Page 22](#)
- [Page 23](#)
- [Page 24](#)
- [Page 25](#)
- [Page 26](#)

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**PRIORE**

J. Beal



# ONR LONDON REPORT

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A BIOLOGICALLY ACTIVE COMBINATION OF MODULATED MAGNETIC AND MICROWAVE FIELDS: THE PRIORE MACHINE

J.B. BATEMAN

16 August 1978

### UNITED STATES OF AMERICA

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A generator invented by A. Priore of Bordeaux is said to produce radiation which causes certain implanted tumors to regress and cures trypanosomiasis in animals. The published biological data are briefly reviewed and thought to be persuasive. The scanty information available on the nature of the active radiation is also reviewed critically. Attention is drawn to the existence of a French patent describing the invention. A full translation of the patent document is appended. A heavily funded effort to build a machine of greatly enhanced power output is mentioned. The writer considers the project to be pre-		

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CONTENTS

	<u>Page</u>
<u>INTRODUCTION</u>	1
<u>BIOLOGICAL OBSERVATIONS</u>	2
<u>THE INVENTION</u>	4
<u>THE EMERGENT FIELD</u>	5
<u>THE NEW GENERATOR</u>	7
<u>REFERENCES</u>	9
<u>APPENDIX</u> (Translation of French Patent 899.414, No. 1.342.772)	11-26

## A BIOLOGICALLY ACTIVE COMBINATION OF MODULATED MAGNETIC AND MICROWAVE FIELDS: THE PRIORE MACHINE

### INTRODUCTION

A very complicated generator invented by Antoine Priore (or Priore), a former radar operator without academic qualification, has been said to produce radiation which causes certain implanted animal tumors to regress and cures trypanosomiasis in certain laboratory animals. There are several remarkable things about the papers describing these biological effects, the most remarkable being the contrast between the careful detail in which the biological data themselves are presented and the absence of anything but the most vague, and often contradictory, information about the generator. I have given examples of these disparities elsewhere (1)

A first consequence of the publication of these communications in the *Comptes rendus de l'Académie des Sciences* (Paris) was a violent polarization of opinion within the Academy and in other French scientific circles. There were some who wished to ignore or deny any phenomenon, however completely attested, brought about by inadequately specified means; they would have opposed presentation of the reports to the Academy and would probably have succeeded in suppressing them but for the determined sponsorship of the distinguished *secrétaire-perpétuel*, Prof. Robert Courrier. Others felt that the importance of the results, if they could be confirmed, made further investigation imperative: if possible, with disclosure of the inventor's "secret"; if not, then without it.

A second result was the journalistic exploitation of a situation brimming over with human interest. Commentators (2) (3) (4) (5) ranged from a writer in *Esquire* who has since followed another path to notoriety (3) to Lord (Solly) Zuckerman writing in popular vein (4). None of them resisted the regrettable impulse to step up the popular appeal by introducing scientifically irrelevant biographical details about Priore in order to demonstrate his worthiness for political patronage, which indeed he has received in abundance. Aside from this, they maintained a nice balance between sympathy for the victim of prejudice and healthy scepticism toward his work. Zuckerman, in a

lecture given at the Lovelace Foundation in Albuquerque (5), gives Priore an honorable place in his catalogue of those whose innovative achievements remained unrecognized because of conservative prejudice and ignorance, from Babbage to Peyton Rous, though not without leaving himself a loophole should the initial promise not be kept. The main point, he insists, is that people who believe in what they are doing should refuse to be discouraged in an atmosphere of incomprehension and hostility.

The present report is the outcome of a visit to Priore's establishment sponsored by the organization ADERA for those attending a course of instruction in microwave exposure hazards (6). I shall write very briefly about the alleged biological effects, then about the Priore

## R-5-78

invention itself and the nature of its biologically active output. Impressions and private conversations bearing on these matters will be mentioned when they add, reliably or otherwise, to the total picture.

### BIOLOGICAL OBSERVATIONS

There is a pre-history of verbal recollection and gossip connected with the Priore invention. Priore himself is said (3) to have become interested in possible medical applications of electromagnetic waves upon observing that fruit and vegetables could be preserved by exposure to ultra-high frequency fields. A machine was built from US Army surplus and at some stage sick persons were placed in the field generated (3). According to a US scientist who has been interested in repeating some of the Priore experiments, a politically well-connected lady who was cured in this way of cancer after receiving a prognosis of early death is still enjoying perfect health in Bordeaux.

The first experiments on cancerous animals were done by Delmon and Biraben who withheld their results from publication after receiving an unfavorable report from a committee, and because of a fear that publication would prejudice the candidature of one of them for admission to a fellowship (*agrégation*) (7). They used (8) rats implanted subcutaneously with a well-characterized uterine carcinoma, the so-called T8 (Guérin), having previously studied the effects of x-rays and of pulsed magnetic fields upon these animals without finding anything particularly noteworthy: The magnetic fields had no effect on tumor growth or on the occurrence of lymph node metastases, while the remission produced by x-rays was only transient. After exposure to the window of Priore's machine, on the other hand, tumor growth could be stopped for as long as three months afterwards. The animals recovered good general health, and lymph node metastases were seldom seen.

The T8 tumor in rats was also used by Rivière and colleagues (9) from Guérin's laboratory in the cancer institute at Villejuif. They found macroscopic regression of the tumors and of metastases after treatment and observed no relapses up to three months thereafter. Their publication anticipated that of Delmon and Biraben.

Rivière and colleagues then worked with rats implanted with a lymphoblastic lymphosarcoma which when untreated invariably

proved fatal within 11 to 15 days, with generalized colonization of the nodes and a leukemic syndrome. Treatment under the Priore machine led to total regression of the graft and of the accompanying metastatic and leukemic phenomena (10). Certain of these experiments were done with animals from Courier's laboratory under the constant supervision of his assistant Madame Colonge. The results were the same, and Courier reported them in an addendum to a further paper by Rivière *et al* (11) describing comparable results with a mouse lymphosarcoma. Further studies with the rat (12) yielded the discovery that treated rats clinically free of the lymphosarcoma were able to resorb a second transplant of the isologous tumor while succumbing to an homologous tumor of a histologically different type.



## R-5-78

Courrier (7) complained that, because of a campaign of disparagement, no French "cancerologists" offered to repeat these experiments. Shortlived cooperation was however forthcoming from an English laboratory. According to one account (2), cancerous mice were sent over to Priore's establishment and some healthy ones were later sent from there to England, but the latter were not the ones that had been sent for treatment. The anonymous director of the English laboratory withdrew his cooperation, though not without providing "a French colleague" with a detailed memorandum. In 1977 Courrier (7) issued his own account of the episode and identified the persons concerned. The director was the late Sir Alexander Haddow (Institute of Cancer Research, Royal Cancer Hospital, Univ. of London), and his envoys to Floirac were E. Whisson and Dr. and Mrs. E.J. Arnbrose, the latter being scientists of some repute. Courrier was evidently not persuaded that any substitution had taken place, for he wrote that the rumor was put about: "*on fait courir le bruit...*"

The discovery of specific anti-tumor immunity in the treated animals may have lent force to the hunch that the Priore radiation might act upon the immune system of the host rather than directly upon the cancer cells. At any rate, Professor Raymond Pautrizel, a parasitologist already associated with the work of Rivière and Guérin, exposed mice after they had been injected with a dose of *Trypanosoma equiperdum* sufficient to kill them within five days if untreated, and they all survived (13). At this point extraordinary measures were taken to remove all suspicion of fraud.. The experiments were repeated successfully under lock and key and under the eye of a bailiff appointed by a *Commission de Contrôle* composed of university officials and local dignitaries. The official report was certified by all the members of the Commission. A positive result obtained under such conditions, said Courrier (7), should have put an end to all criticism from men of good faith.

In a further series of short papers in the *Comptes rendus* (14) (15) (16) this indirect effect upon the immune system of animals infected with *T. equiperdum* was confirmed and elaborated. These brief published statements represent a lot of work: just how much was apparent from a lecture given by Pautrizel during my visit to Floirac. When I asked about his plan to publish the evidence in detail, he told me that he had not found a journal willing to accept such a manuscript.

The evidence presented, furnished by experiments on mice (13) (14) (16), rats (14) and rabbits (15) , follows fairly conventional lines which I shall not attempt to review in detail. Briefly: the pathogenic organisms disappeared from the treated animals, which survived indefinitely. In rare cases where the parasites reappeared, they were of a different antigenic type from these causing the original infection. Treatment brought about an intense acquired immunity. Some animals were reinfected 7 times *over* a period of 6 months, eventually with 100 times the original, and otherwise invariably fatal, dose. Multiple reinfection resulted in a high titer of agglutinating antibodies. The blood of these animals conferred upon other normal animals an immunity which persisted for about 45 days. Treatment with an immunosuppressor,

## R-5-78

cyclophosphamide, depressed, but did not abolish, the appearance of agglutinating antibody when infected animals were subjected to Priore irradiation, although relapse occurred after about 12 days. Newborn animals died of the infection whether irradiated or not, and the organisms found in their blood were of the original strain.

Trypanosomal antigen of unspecified nature, injected intraperitoneally after the first irradiation of infected animals, caused an enhancement of anti-body production. When the parasites were protected from the host's immune system by being implanted in a diffusion chamber, Priore irradiation failed to inhibit their multiplication. In his talk, Pautrizel said that in order to elucidate further the apparent effect of irradiation in exalting the mobilization of the immune system, the course of change of immunoglobulins M and G, of albumin/globulin ratio, and of agglutinating and hemagglutinating titers was followed in irradiated and reinfected animals for about one year. The data were given in detail. With no time in which to understand, much less to assimilate them, I was left only with the impression that a clear picture has yet to emerge--a conclusion apparently shared by Prof. Czersky of Warsaw. One point of interest was the passing mention of a failure to modify the course of a malarial infection. This is not surprising, perhaps, remembering the vastly more complex life cycle of the plasmodium and its greater antigenic variability.

The postulated general stimulation of "defense mechanisms" by the output of the Priore machine led Pautrizel to ask whether this effect might extend to the prevention or cure of atherosclerosis. Another short paper communicated, as usual, by Courier: (17), described a "spectacular" attenuation of the hyperlipemia induced in rabbits by a diet of "industrial granules" supplemented by 1% of cholesterol, resulting in a daily cholesterol intake by each rabbit of about 1 gram. The observed effect of irradiation took the form of all inhibition of increased cholesterolemia, persisting for several weeks after treatment, and a marked decrease in the extent of aortic deposition. I find the data rather unconvincing, with quite a lot of overlap of experimental and control values. As for the explanation of the effect, if it can be confirmed, Pautrizel and colleagues (17) ask whether it could be due to an activation of lipid catabolism. Strangely enough they do not discuss the role of macrophages in the regression of tumors, the cure of

trypanosomiasis, or the prevention of hypercholesterolemia, although macrophage mobilization might provide a common mechanism.

### THE INVENTION

Much has been written deploring Priore's secretiveness. It has been an embarrassment in one camp and a ground for dismissing his invention in another. My own view is that a secretive inventor and his invention, if important, must be investigated as a part of the external world, and the obstacle posed by limited cooperation accepted in the spirit in which the inaccessibility of nature is accepted as a challenge to our wits. Priore has in fact been much more considerate than the Almighty, who after all has provided no blueprints to his creations, while Priore included in his first paper a footnote (9) informing us

R-5-78

that the physical principle of his invention has been the subject of a patent (18). How strange that none of the journalistic commentators, from Zuckerman down the line, have thought it worthwhile even to mention the existence of this document. When drawing it to the attention of several members of the party visiting Floirac, I found astonishment at its existence followed by doubts as to whether, since they had not read it, it could contain any information of value. I had no opportunity to ask Priore about it, but an associate who did so met with a similar response: it won't help very much, he said. Nevertheless the apparatus described is presumably that used by Rivière, in whose paper it is mentioned, and the amount of detail given is such that, unless indeed it is fraudulent, a reasonable guess as to the nature of the emerging radiation ought to be possible for people competent in the field.

With this in mind I planned to include only a summary in this report, but have now decided upon a full translation (Appendix), without which the odd flavor of the document would be lost. A seemingly reasonable description of components and layout is coupled with a quaint--some might say superstitious--intrusion of pseudo biology and mention of electrophysiological pioneers whose identity can only be guessed through a haze of misspellings. There is, for instance, the choice of modulation frequency of the magnetic field to match the rhythm of the patient's heartbeat. There is, too, the comment that the best results are obtained when the cathode generating a stream of positive ions is made of molybdenum, the metal whose valency is closest to the mean valency of the chemical molecules constituting living tissues.

I leave the reader to form his own impression of the invention described in the patent, save to mention that the active radiation emerges from a tube containing a rotating deflector upon which impinge, from several different sources, a stream of positive ions accelerated in a cyclotron, a beam of centimeter waves generated by a magnetron, and a magnetic field. Any or all of these may be chopped or modulated according to various patterns.

The machine was working during the visit to Floirac. One could see the exit of the tube beneath which the biological targets are placed. There was a certain amount of rumbling and crackling, and the pinkish luminescent plasma appeared to be turbulent. I asked about the speed of rotation but was told by one of Priore's assistants that the information is strictly confidential. I would guess it to be well under 100 rpm.

### THE EMERGENT FIELD

After several misleading statements about the nature of the biologically active field generated by Priore's machine (mentioned in ref 1), a short paper in the *Comptes rendus* described the results of experiments in which two physicists of established reputation had been allowed to cooperate with Priore, Pautrizel, and their associates. Berteaud and Bottreau (19) were able to analyze the radiation in some detail, up to x- and gamma-ray frequencies. Their report is confined to

## R-5-78

the assertion that they have established the presence of a 9.4-GHz pulsed electromagnetic wave, amplitude modulated at HF frequency 17 MHz, and a slowly modulated continuous magnetic field of the order of 1kG.

Other components, if detected, are not mentioned. There exists, I am told, a confidential report of the whole investigation. Bottreau assured me personally that there was no trace of ionizing radiation.

Berteaud and coworkers (19) also mapped the intensity distribution of these radiations in a plane perpendicular to the axis of the apparatus. Then, using as targets mice infected with *T. equiperdum*, they were able to demonstrate a simple relationship between the rate of decrease of *parasitemia* in these animals and the relative intensity of the UHF component. However, in separate experiments they found that fatalities among infected mice were not decreased when the animals were exposed to an unmodulated 9.4-GHz field of comparable intensity. They concluded that the UHF field generated by Priore's machine is a necessary but not sufficient condition for the observed biological effects.

The results of Berteaud *et al* leave us with some unanswered questions. If their analysis of the field was complete, the biological activity must rest jointly on the UHF component and the magnetic field. How critical are the exact value of the many parameters involved and the relationship between them for the manifestation of biological activity? Is it possible that the methods available to Berteaud and coworkers were incapable of furnishing a complete analysis?

One can only speculate. It has struck me that in all the papers describing the biological effects of this radiation, there is nowhere any mention of any search for the the correct operating conditions of the machine. Apparently the machine, if it works at all, always produces results, and one must remember that two different models have been built and found to be effective. The one quantity that is regularly mentioned is the is the magnetic field strength, 620 G in the first model and 1240 G in the second. The patent document seems to suggest that there is great flexibility in the mode of operation. It is moreover almost inconceivable

that Priore could have had any genuine theoretical basis upon which to favor one particular set of patterns over another in relation to biological changes that are themselves of intractable complexity and totally unpredictable. One is bound to suspect that the mix is anything but critical, and that if the reported biological effects are genuine they might very well be brought about by much simpler means. It is of some interest that extremely sharp frequency selectivity has been claimed in recent biological experiments with monochromatic microwaves, in contrast to the sort of flap response surmised in the present context. The need for fine tuning could of course be obviated in a machine designed for sturdiness and broad applicability by arranging for it to generate "white" energy with respect to the several decisive characteristics, including modulation frequencies and perhaps their derivatives, or alternatively to generate an output which varies rapidly in real time, systematically or randomly, over a sufficiently wide range of values. The biological effects of such



## R-5-78

radiation would then be the sum of various qualitatively and quantitatively different selective processes including the possible cancellation of additive effects such as stimulation and inhibition. However, total nullification would be no more likely it is, for instance, in the visible everyday consequences of illumination by sunlight. Such an approach, if it has been adopted by Priore or if it has emerged fortuitously as an unforeseen property of an assemblage of components chosen on the basis of some other rationale, would account for the extravagance of the machine in energy consumption in return for a very modest biological yield. There is no immediate evidence for this in the statements of Berteaud and Bottreau (19), but the relevant quality of "whiteness" might apply pertinently to other parameters than those investigated by them.

The possibility that some hitherto unrecognised feature of the radiation from a rotating plasma may be responsible for the Priore effects should not be dismissed out of hand, at any rate by those who, like myself, know nothing about plasmas. Dr. John Carstou of Brookline, MA, who counts among his accomplishments an extension of the Maxwell equations to the evaluation of ponderomotor forces, likes to call the Priore machine a magnetohydrodynamic wave guide. He considers the acceleration of the plasma to be a significant feature. He refers to the various types of oscillation that may be set up but does not, and presumably cannot, say how they can manifest themselves across a quartz window - . One's naive reaction is to doubt, in any case, whether the accelerations attainable in an apparatus as described in the patent document would be great enough to initiate a gravitational wave of any significance. Unless the suggestion is an obvious absurdity to a plasma physicist, somebody will have to do the arithmetic.

### THE NEW GENERATOR.

The further development of Priore's invention is being done under the auspices of an organisation set up for the purpose : the *Société d'Exploitation du rayonnement Antoine Prioré* (SERAP) which brings Priore into formal relationship with a company, *moteurs Leroy Sommer* of Angoulême. This company has been the recipient of a \$0.7 million contract from the DGRST (*Délégation Générale à la Recherche Scientifique et*

*Technique*) for the construction of a third machine of greatly increased output. Priore has been reported (3) to predict that the cost is more likely to be \$3 million. No doubt other sources of funding are available. In return for much support Priore promise a much bigger and better machine that will generate a more intense field of much larger cross section than those with which the results already reported were obtained. So, one can guess, larger groups of small animals will be irradiated simultaneously for shorter periods than formerly and the rate of accumulation of data will increase - if, that is, the biological measurements can keep pace. Perhaps too, by the same token, small groups of large animals will be treated, with the single sick human as the ultimate target of the entire endeavor.

- (Bearden note :) quartz transmits UV (Ultraviolet Radiation) - see tie-in to Russian work & UV "mitogenic radiation" transmitting thru quartz windows between cell cultures.

## R-5-78

Little was learned of this latest development during my visit to Floirac. The Priore residence, is coming to look like an industrial laboratory of electrical engineering geared to pilot scale operations. There are rumors of serious technical difficulties such as might have been anticipated in scaling up such a complicated device. It is said to be proving difficult, for instance, to construct a pyrex container able to cope with the very high energy flux in the plasma.

Is the new machine really needed? At the technical level the answer is almost certainly "no". Evidently technical considerations are overruled by others, no doubt of personal, political, and even patriotic nature.

The whole operation takes on a farcical aspect when one considers that the only genuine need in the present state of affairs is to get independent confirmation, or refutation, of results already obtained with equipment that was clearly adequate for the original experiments. The funds now made available would suffice for the building of several replicas of the mark 2 machine. These, placed in selected centers of research, could be used by independent teams for a critical repetition and extension of earlier findings. The success or otherwise of the time-consuming attempt to build a giant machine is largely irrelevant to the central doubts that persist as to the claims made for the Priore radiation, and this expensive diversion of effort betrays a certain recklessness which ill serves the quest for a solution to the mystery surrounding "*l'affaire Prioré*".

Note : References (3) to (5) have been available to me in the form of translations into French and I therefore cite them in this form, with the original English reference when available .

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R-5-78

APPENDIX

Brevet d'Invention. P.V. no. 889.414 No. 1.343.772 Classification  
Internationale: A 61 k-H OS g

Procedure and assemblage for production of  
radiation especially serviceable for the treatment of  
living cells.

Antoine Priore

Requested 1 June 1962, 14.52 hours, Paris

Released by decree (arrête') of 7 Oct 1963

The invention deals in a general manner with radiation capable of penetrating matter. More exactly, it aims at a procedure and an apparatus making it possible to obtain a combination of radiations of different types able to penetrate matter and especially to penetrate intimately living organic tissues in order to produce in them certain effects, particularly in human tissues with a view to a therapeutic effect without destroying essential elements such as the enzymes.

In conformity with the present invention, one emits in a cavity a stream (rayonnement) of electrically charged particles upon which one superposes electromagnetic radiation of the centimeter wavelength range, the wavelength of which is preferably between 3 cm and 80 cm, and one directs the resulting radiation emerging from the cavity on to the object to be irradiated.

This applicant has shown that the penetration and, in particular, the curative effects are very distinctly improved when one gives the electromagnetic radiation a frequency determined as a function of the organ or the tissue to be penetrated or to be treated. For example, a wavelength of 14 cm is suitable for the liver and a wavelength of 19.5 cm for the spleen.

Preferably, the stream of charged particles is accelerated in a particle accelerator in such a way as to increase the force of penetration.

The resulting radiation is advantageously applied and directed upon



the target, that is to say, upon the tissue to be penetrated, by the intermediary of a tube which is the site of electric fields and of magnetic fields for acceleration and control, the said radiation being preferably guided and/or reflected by a rotary deflector placed in the tube.

It is often advantageous to modulate or impose rhythm on this stream of particles by means of variable magnetic and/or electric fields so as to augment still more the force of penetration. This rhythm is preferably consistent, especially in medical applications, with the intrinsic period of the tissue to be penetrated or of the neighboring tissues, for example, muscle. These intrinsic periods are well-known in medicine and are applied, particularly, for diathermy; they are situated in the wavelength range from 1 m to 50 m and more especially from 1 m to 18 m.

## R-5-78

Preferably, one arranges to modulate the emission of radiation, the accelerating electric and magnetic fields, and perhaps also the rotary deflector, to the cardiac rhythm of the subject.

It seems that the result obtained by the invention in the treatment of maladies of living cells (vegetable or animal) are due to certain phenomena which will be described, it being understood that this exposition will not circumscribe the invention.

As a function of its electro-physico-chemical constitution, the cellular pair nucleus-protoplasm is endowed with electric conductivity in direct relationship with ion exchange processes provoked by metabolic phenomena. One finds in tissues the presence of an accumulation of electricity at different potentials according to the different cellular densities of the tissues.

The work of Renshaw, Forbes, Morison, Amassian, de Vito, Buser, Albe-Fessard, Tauc, Adrian, etc. has shown with the aid of micro-electrodes the existence of slowly oscillating elementary electric activity in the interior of cells; it can be thought that the rhythmour (or pace-maker) is achieved by the oscillatory electro-magnetic system comprising the cell nucleus. This nucleus, in effect, is made up essentially of tubular filaments of insulating material (related to chitin) containing in its interior an electrically conducting saline liquid, and these filaments, coiled upon themselves, can be considered to constitute real little oscillatory circuits.

The recent work of Warson [sic] in America, as well as that of French scientists, including a communication from Polonsky, Donzon and Sadron presented to the *Academie des Sciences* by Prof. Frances Perrin on 16 May 1960 (*Rec. comptes rend. heb.*, 250, No. 20, 3414-3416) making it clear that experimental samples of solid DNA manifest properties analogous to those known in ferroelectric materials, makes plausible the hypothesis that a potential difference may exist between nucleus and periphery of cells. Certain recent theories go even further and liken the cell to an electronic receiver-emitter device normally functioning in harmony with the ambient media. The oscillatory system of damped waves, constituted by the cell nucleus, would behave in accordance with the laws governing

semi-conducting materials.

The applicant is led to the conviction that in a normal state of physico-electric equilibrium, the cell nucleus is positively charged but can acquire a negative surcharge following phenomena analogous to polarization.

The invention, especially, enables organs afflicted by this inversion of their electric potential, particularly in the case of the pathologic negative surcharge of cancerous nuclei, to recover their former equilibrium.

The following description in regard to the attached drawing, given as a non-restricting example, will make it possible to understand how the invention can be realized, the details which emerge both from the

## R-5-78

text and the drawing being, of course, part of the said invention:

Fig. 1 is a schematic section showing an apparatus for production and emission of an electromagnetic field combined according to the invention.

Fig. 2 is a frontal elevation of the cathode, taken from the right of Fig. 1.

Fig. 3 is a section through III-III in Fig. 1.

Fig. 4 is the overall scheme of the electric supply.

Fig. 5 is a view analogous to Fig. 1 showing another mode of implementation.

Fig. 6 is a section through VI-VI in Fig. 5.

Fig. 7 represents schematically an apparatus for pulsing the electric current.

Fig. 8 is the circuit of an amplifier permitting activation of the apparatus of Fig. 7 at the cardiac frequency.

Fig. 9 is the circuit of an oscillator permitting modulation of the electric current according to a wavelength between 1 m and 18 m.

The assemblage of Fig. 1 contains an apparatus 1 emitting electrically charged particles 2 in a cavity or passage 3, a cyclotron 4 accelerating the particles 2 and sending them into a cavity 5 forming a tube into which merges another cavity 6 acting as wave-guide for electromagnetic radiation of frequency in the centimeter range emitted by a magnetron 7. The cavity 8 formed by the joining of tube 5 and waveguide 6 leads into a tube 9 in which the resulting radiation is accelerated and aligned. The interior of the cavity-formed by the assemblage of elements 1, 3, 5, 6, 8 and 9 contains argon at a pressure of 2 mm mercury.

The particle emitter 1 consists of an electron gun comprising a plate 10 and a cathode 11.

The cathode 11 is of molybdenum and has the very special form represented in Figs. 1 and 2. It consists of a rim 11a connected by two aligned spokes 11b to a hub 11c pierced by a hole 11d with its axis along XX'. The rim 11a is in two parts (as one sees in Fig. 1) which may be held together by screws (for example) forming a cavity of revolution 11e traversed by a number of holes 11f parallel to the axis XX' and regularly spaced. The filament for heating, 12, situated in the interior of the cavity 11e and is connected to the power supply conductors 12a.

The best results are obtained with a cathode 11 of molybdenum. The applicant has obtained satisfactory, but slightly inferior, results with tungsten cathodes. It turns out that molybdenum, and to a lesser degree

## R-5-78

tungsten, are the metals whose valency is closest to the mean valency of the chemical molecules constituting living tissues and more particularly those of human beings. One might well seek to use this fact to explain scientifically the phenomena involved, but it is understood that the invention is not limited by any scientific explanation. Concerning, on the other hand, the gas present in the apparatus at low pressure, the best results have been obtained with argon; the applicant has also obtained satisfactory, but slightly inferior, results with other gases of the rare gas series.

Surrounding the tube which constitutes the electromagnetic chamber are arranged: an electromagnet 13 with its winding 13a, placed at the level of the cathode, and the accelerating coils 14 and 15. Other accelerating coils 14, 15 and 16 are similarly dispersed around the cavities 3, 5 and 8.

The two semi-circular boxes or "dees" 4a of the cyclotron 4 are placed in the usual manner between the poles of the frame around which are wound the accelerating coils 4b and 4c.

The magnetron 7 is of a familiar type and must be capable of emitting in the cavity 3 a centimeter wave of adjustable wavelength from 3 cm to 80 cm.

The lower portion of the tube 9, for acceleration and alignment, contains a cathode 17 resembling the cathode 11, with a filament 17a. This cathode 17 is supported by a hollow pillar 18 pierced by holes 18a close to its junction with the bottom of tube 9. This pillar 18 communicates with a tube 18b emerging on the axis of a rotary deflector 19 carrying at each end a "crown" of graphite plates 19a inclined at 45 degrees to the vertical. The rotating axis 19b of the rotary deflector is mounted in a support 20 fixed to the interior of tube 19 and carries at its upper extremity magnetic bobs 19c which ensure that it will be set in motion in cooperation with the magnetic bobs 21a mounted on the shaft 21b of a motor 21. The lower extremity of the rotary deflector 19 is composed of a piece of molybdenum or of tungsten 19d in the form of a pyramid whose apex is opposite the open end of the tube 9.

The hollow base 18 and the tube 18b can be of a borosilicate glass of low coefficient of expansion such as that sold under the trademark "Pyrex". They may also be of quartz. Tube 9 itself can be of "Pyrex" as above or of another glass of the quality currently used for the manufacture of electronic tubes, but its bottom 9a, which is traversed by the radiation, is advantageously made of quartz.

The duct 8 joins the tube 9 by way of several tubulures[sic] such as 8a and 8b directed in vertical planes towards the plates 19a at a certain angle, which is advantageously about 22 1/2 degrees. An electromagnet 23 analogous to the electromagnet 13 of the emitter tube 1 is placed around the cathode 17. Similarly, accelerator windings 24 are disposed around the tube 9. This tube also carries, at positions indicated in the drawing, three elec-

## R-5-78

trodes 25, 25a, and 25b surrounded by windings 26, 26a, and 26b, respectively. The drawing shows the supply lines, 17b, 17c of the cathode and its filament and that of the plate 22a.

The basic plan of the electric supply is represented in Fig. 4. The part 27 feeds an initial branch with low voltage alternating current: this consists of a rectifier 28 (e.g., a Kenotron) whose rectified current is modulated at a frequency variable between 30 and 120 pulses per minute of means of a resistance 29, the control apparatus for which will be described with reference to Figs. 7 and 8. The current so modulated is passed through the electromagnets 13 and 23 in such a manner as to generate, normal to the cathodes 11 and 17, a modulated field of 10,000 to 20,000 gauss.

The part 27 also feeds a variometer (interrupter) 30 which modulates the current of this part at a variable frequency 30 to 120 pulses per minute, the current pulsed in this way serving to feed the remainder of the installation, to wit: The magnetron, 7;

A converter 31 whose excitation is modulated at a variable frequency 300 to 900 Hz, yielding a doubly modulated current (first at 30-120 pulses per minute, then at 300-900 Hz) which feeds the coils 15, 16 and 26;

Another converter 32 producing a low voltage direct current modulated at 30-120 pulses per minute by the variometer 30. This current feeds the motor 21 as well as the motors driving the variometer 30 and the apparatus controlling the resistance 29.

The current produced by the converter 32 also feeds a voltage step-up apparatus 33 consisting of a vibrator followed by a transformer and a rectifier, and producing a direct current varied at 30 to 120 pulses per minute imposed by the variometer 30. The maximum value of the voltage produced by the apparatus 33 is, for instance, 300,000 V, but this value may vary up or down, depending on the power one wishes to operate with.



The current produced by the voltage step-up apparatus 33 feeds the coils 4b of the cyclotron and 24 of tube 9, as well as a rheostat 34 permitting regulation of voltage to the desired value between 5000 V and 70,000 V. This voltage is applied to an oscillatory circuit 35 which produces oscillations at a frequency variable at will of wavelength between 1 m and 18 m. The current available to the output terminals 35a, 35b of this oscillating circuit 35 is thus a high tension current modulated first at 30 to 120 pulses per minute (by the variometer 30) and secondly at a wavelength 1-18 m. This current feeds the coils 4c and 14; the electrodes, 25a, and 25b are connected to terminals 35a and 35b, respectively, and electrode 25 is connected to the midpoint 35c.-

Cathodes 11 and 17, the "dees" of the cyclotron, and the plates 10 and 22, not shown in the diagram of Fig. 4, are connected to the output of the step-up assembly 33, while the heating current for the filaments 11e and 17a is furnished by the resistance 29.

## R-5-78

To operate the apparatus, one adjusts the controls of the resistance 29 and the variometer to the desired rhythm; in medical applications, this is advantageously the subject's cardiac rhythm: This rhythm is thus imposed upon the whole installation. The cathode 13 emits toward the left a stream of positively charged particles 2, which are concentrated by the electromagnet 13 and accelerated by the coils 14, 15 and 16 and by the cyclotron 4. Superimposed on this particle stream in the duct 8 is the electromagnetic radiation from the magnetron 7, which is adjusted to the wavelength found by experience to be most appropriate to the cells which are to be penetrated, e.g., 14 cm for the liver and 19.5 cm for the spleen. The resulting radiation is deflected, directed and accelerated in tube 9 and is directed by way of the base of this tube toward the target to be penetrated.

It must be noticed that the magnetic field of the coils 15, 16 and 26 is modulated, by means of the converter assembly 31, at a frequency adjustable between 300 and 900 Hz. This modulation has the effect of concentrating the particles, that is to say to detach them from the walls of the tubes, and it also permits an appreciable saving in weight of the iron cores of the coils. One chooses the highest frequencies (i.e., around 900 Hz ) when one wishes to produce hard radiation at the exit of tube 9, and the lower frequencies for soft radiat[i]ot[sic] (radiation?).

The unidirectional magnetic fields of the coils 4c of the magnetron (sic) (cyclotron?) and the accelerator coils 14 as well as the electric field of electrodes 25, 25a, 25b, are modulated by the oscillatory circuit 35 at a chosen wavelength between 1 m and 18 m. In medical applications notable one selects the wavelength that best suits the organ to be treated or its surroundings, such as muscle. As already indicated, experience with diathermy makes it possible to determine the most suitable wavelength.

It must be noted that the resulting radiation already possesses, in tube 8 (Fig. 1) a considerable penetrating force. One could therefore use the assemblage described by omitting tube 9 and terminating the cavity at the end of tube 8 by means of a glass or quartz base, the resulting radiation being accelerated and directed, for

example, immediately upstream from the base, by a final coil (not shown) surrounding tube 8, However, tube 9 appreciably improves the results.

Figs. 5 and 6 represent another mode of realizing the assemblage in accordance with the invention, in which the elements playing the same role are indicated by the same signs as in Figs. 1 and 3, modified by primes.

The arrangement of the connecting ducts of Fig. 5 in relation to tubes 1' and 9', to the magnetron 7' and the cyclotron 4', is different from that of Fig. 1 and has been used successfully by the applicant. The waveguide 6' of the magnetron 7' opens into the end of tube 1' and the duct 3' carrying the resulting radiation, divides into two branches: Branch 36 which conducts the radiation directly to tube 9', and branch 37 which conducts it to the cyclotron 4'. This blocks the electromagnetic radiation and accelerates the stream of particles which is passed by way of duct 38 to the tube 9'.

## R-5-78

This arrangement can be used with a particle emitter and an accelerator and director tube similar to tubes 1 and 9 of the preceding figures. However, tubes 1' and 9' of Figs. 5 and 6 are constructed in a different manner with regard to their cathodes and anodes.

Tube 1' contains a first electrode 11' exactly like that of the cathode 11 of tube 1, and an identical second electrode 39 furnished with a filament 39a. Tube 9' (Fig. 6) contains in its lower part a first electrode 17' with filament 17'a and an identical second electrode 40 with its filament 40a.

In normal operation, i.e., to produce radiation identical to that described in connection with Figs. 1 to 4, electrode 11' serves as cathode and electrode 39, given a positive potential, plays the role of the plate 10 in Fig. 1, the filament 39a being unheated. Electrode 40 and its filament 40a are disconnected; cathode 17' and plate 22' are supplied, as in Fig. 3.

To obtain particularly penetrating radiation, the polarities are reversed: Electrode 11' becomes an anode and its filament 11'e is disconnected, while electrode 39 receives the cathode supply and its filament 39a is heated; electrode 17' (with filament 17'a disconnected) and electrode 22' become anodes, while electrode 40 serves as cathode and its filament 40a is heated. For example, one can establish a potential difference of 250,000 V between 40 and 17', and 50,000 V between 40 and 22'. It is understood that in these conditions the cathode 39 emits to the left a stream of electrons which is concentrated, modulated and accelerated by the various coils and in the cyclotron, the polarities of which must of course be established in the proper direction. This stream of electrons is combined with the centimeter radiation emitted by the magnetron 7', resulting in tube 9' in the emission of very hard x-rays, modulated at the chosen frequencies, combined with the centimeter radiation of the desired frequency.

The assembly shown in Figs. 5 and 6 thus permits one to obtain at will either very hard x-rays or the radiation described in connection with the preceding diagrams.

The following description, referring to Figs. 7 and 9, relates to certain

details of the apparatus used for modulating the electric current.

Fig. 7 represents schematically the apparatus for control of the resistance 29 and the variometer 30. The variable resistance 29 consists of a graphite helix 29a immersed in a conducting liquid 29b; another electrode 29c, also of graphite, partly immersed in the liquid, is set into up-and-down oscillations by a connecting rod 41a linked to a fly-wheel 41. The fly-wheel is set in rotation, through the intermediary of a worm transmission 41b, by an axle 42 which can be driven, thanks to a double clutch 42a, 42b, either by a motor 43, or by the shaft 30a of the variometer 30. The variometer 30 is driven by a motor 44 by way of the worm transmission 44a.

## R-5-78

If the fly-wheel 41 is driven by the motor 43 at the proper speed, the resistance 29 causes the supply current of the electromagnets 13 and 23 (Figs. 1 and 4) to vary at the chosen rhythm which as we have seen can be between 30 and 120 pulsations per minute and which can be checked by means of a rotation counter shown schematically in 45. In this case, the motor 44 of the variometer 30 can be stopped and the remainder of the installation is then not pulsed. If, on the contrary, the fly-wheel 41 is engaged in 42b and disconnected from 42a, the motor 44 activates the variometer 30 and the resistance 29 at the chosen rhythm.

The speed of rotation of motors 43 or 44 can be regulated at the required speed, corresponding visibly to the cardiac rhythm of the subject, by acting upon the excitation of these motors by means of a manually adjustable rheostat. If one prefers to regulate the speed of motors 43 or 44 in direct accord with the cardiac rhythm of the subject, one can use an assembly such as that represented schematically in Fig. 8: At 46 there is a contact microphone which, when placed over the subject's heart, produces impulses. These are amplified in the circuit shown and applied to an electromagnet at 47 with a moving core which activates a rheostat; this in turn regulates the current running the motors 43 or 44.

Fig. 9 shows schematically the principle of the oscillating circuit 35. The rectified potential, adjustable between 5000 V and 70,000 V by means of rheostat 34 (Fig. 4) is applied between the terminals 48 and 48a. Terminal 35c (which is also connected to electrode 25, Figs. 2 and 4) is connected to the neutral point on the high tension side of the transformer which is a component of the step-up assembly 33 (Fig. 4). The terminals 49 and 49a receive the heating current produced by the resistance 29. The variable condensers 50 and 50a make it possible to regulate to the desired wavelength (which, as seen, is between 1 m and 18 m) the current available at the output terminals 25a and 25b of the oscillator shown.

The modes of implementation described have been successfully carried out but it is self-evident that these are only examples, and that they might be modified, notably by substitution of equivalent techniques, without going beyond the bounds of the invention. In particular, the electron gun 1 or 1' could be replaced by another

charged particle generator.

R-5-78

Resume'

The invention includes especially:

1. A procedure for obtaining a combination of radiations of different kinds capable of penetrating matter, especially of intimately penetrating living tissues in order to produce in them certain effects and more particularly in human tissues with a therapeutic effect in mind, consisting of the emission in a cavity of a stream of electrically charged particles, upon which is imposed electromagnetic radiation in the centimeter wavelength range, and the guiding of the resulting radiation emerging from the cavity toward the target to be penetrated.

2. Types of implementation exhibiting the following features taken separately or in the various possible combinations:

a. The centimeter radiation has a wavelength between 3 cm and 80 cm;

b. This wavelength is set at the value found by experience to be most suitable for the tissues to be penetrated, e.g., 14 cm for liver and 19.5 cm for spleen;

c. The particle stream is accelerated by magnetic and electric fields such as those which are used in particle accelerators;

d. The resulting radiation is accelerated and guided, before its emergence from the cavity, by means of electric and magnetic fields;

e. The resulting radiation is guided, before its emergence from the cavity, by means of deflecting and/or reflecting surfaces;

f. The stream of particles and/or the resulting radiation are concentrated and accelerated by means of individual magnetic fields modulated at a frequency between 300 and 900 Hz, the highest frequencies being used to produce hard rays and the lower frequencies to produce soft rays;

g. The emission of the particle stream, as well as the acceleration and concentration of the radiation resulting at its exit from the cavity, are aided by individual magnetic fields of temporally variable intensity,



advantageously pulsed at a rhythm between 30 and 120 pulsations per minute and preferably at the cardiac rhythm of the subject;

h. The assemblages for production of the resultant radiation are pulsed in their entirety at the same rhythm as the magnetic fields according to g;

i. The stream of particles and/or the resulting radiation are accelerated and concentrated by direct magnetic and/or electric fields modulated at a wavelength between 1 m and 50 m and preferably between

## R-5-78

1 m and 18 m, this wavelength being advantageously chosen as that which is known in diathermy as suitable for the tissues to be penetrated or for the surrounding tissues.

3. An assemblage making it possible to obtain a combination of a stream of electrically charged particles and a beam of centimeter electromagnetic waves in order to penetrate intimately and to irradiate living tissues and particularly human tissues, the said assemblage comprising at least a particle emitter, means for channeling said particles in a cavity serving as waveguide for an emitter of electromagnetic radiation of which the wavelength is included in the range of centimeter waves and preferably adjustable from 3 cm to 80 cm, means for generating in the cavity magnetic field for acceleration and concentration and means for concentrating and accelerating the resulting radiation at the exit of the cavity.

4. Modes of implementation with the following details taken separately or in the various possible combinations:

a. The particle emitter is an electron gun of which the anode is at the end of the cavity and the cathode is situated further along, this cathode being hollow and placed in the magnetic field of an electromagnetic in order to ensure emission of a stream of particles towards the mouth of the cavity;

b. The cathode consists of a rim connected by two aligned spokes to a hub, the said rim being provided internally with an annular housing containing a heated filament and the said housing communicating with a number of holes arranged annularly and traversing the rim transversely;

c. The cathode is made of a metal of valency close to the mean valency of the chemical molecules comprising the tissue to be penetrated;

d. The cathode is of tungsten or preferably of molybdenum;

e. The cavity contains a rare gas, preferably argon, under a vacuum of

the order of 2 mm Hg;

f. The cavity contains a duct carrying at least part of the stream of particles to a cyclotron and a duct bringing back into the cavity the particles accelerated in the cyclotron;

g. The cavity passes through several coils, the supply current for the various coils being capable of undergoing modulation at different frequencies;

h. The downstream end of the cavity is composed of a tube containing, in the part from which the resulting radiation must emerge, a cathode and an electromagnet which may be identical to the cathode and the electromagnet according to para. a, an anode near the other end, and a rotary deflector consisting of a number of plates arranged *en*

## R-5-78

*couronne* on a rotor facing the incident radiation at such an angle that the radiation deflected and/or reflected is directed toward the cathode, several coils whose supply current can be modulated being distributed over the length of the tube;

- i. This tube also contains electrodes supplied by alternating current generating an electric field at the level of the rotary deflector, each of the said electrodes being surrounded by a bobbin of which the supply current can be modulated;
- j. Methods are anticipated for modulating, at an adjustable rhythm between 30 and 120 cycles per minute, the supply current of the electromagnetic according to a and h, and preferably to modulate the supply current of the rest of the assemblage at the same rhythm;
- k. Methods are anticipated for modulating, at a frequency between 300 and 900 Hz, the supply current of the bobbins surrounding according to i and one or several coils according to g;
- l. Methods are anticipated for modulating, at an adjustable wavelength between 1 m and 50 m and preferably between 1 m and 18 m, the supply current of the electrodes according to i, of one or several of the coils generating the magnetic field of the cyclotron;
- m. The electrodes of the electron gun consist of two electrodes identical to the cathode according to a, b, c, or d, the cathode of the tube according to h is replaced by a double electrode reproducing the arrangement of the electrodes of the electron gun, and methods are anticipated for reversing at will and simultaneously the polarities of these two pairs of electrodes and the direction of flow of the current supplying the acceleratory coils, a first pattern of polarities assuring the functioning of the apparatus in the conditions which are laid down according to a, and a second pattern of polarities assuring emission in the cavity of a stream of electrons combined with the centimeter radiation and giving rise, at the exit of the said tube, to emission of very hard x-rays.

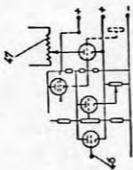


Fig. 16

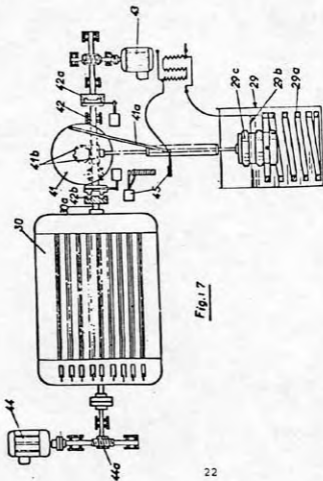


Fig. 17

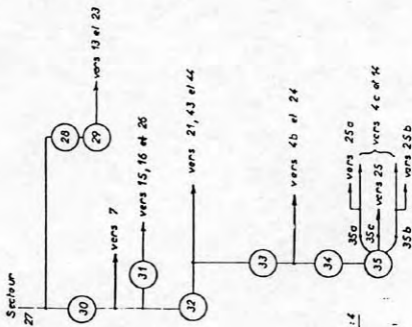
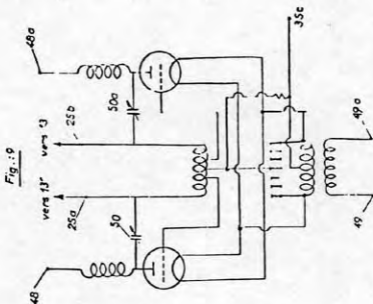




Fig. 3

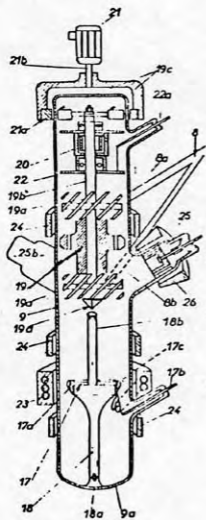


Fig. 6

