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# The organisation of a physics service for radioterapy and radiology

## Introduction

*Mr. Chairman, Ladies and Gentlemen,*

One of the disadvantages of speaking towards the end of a particular section of the program is that earlier speakers have already said much that one has planned to say. For this reason, and also to take account of some of yesterday's discussion, it has been necessary for me to make a number of changes from the printed version of my contribution. For these changes I apologise especially to an excellent interpreter.

The task allocated to me is to discuss the sort of physics service which should be available for radiotherapy and radiology. How much a service can be organized in, for example, the prevailing conditions in Italy, is not my concern in this paper. The subject is large and therefore I can only give a general picture with a few examples. Prof. Lenzi has regretted that so much discussion has been on practical matters rather than on the higher principles discussed earlier. My contribution, I fear, is at a lower level still.

The first major call for physics help from clinical medicine for anything other than teaching came in the 1920's from radiotherapist. Then it was realised that radiotherapy could only progress if it became quantitative rather than qualitative. It was realised that the safe and efficient use of radiation, both from the point of view of the patient and from the point of view of the worker, demanded better and more accurate methods of radiation measurement than were available at that time. The physicist's task, therefore, was to develop accurate methods and ultimately a unit, for the measurement of x- and gamma-rays. In this work they were successful and radiotherapy progressed from that day onwards to become a major curative agent. For this reason, if for no other, I cannot agree with the interpretation given yesterday to the remarks quoted from Mayncord. Today, accurate dosimetry is the most important service that physics can provide for radiotherapy.

### Importance of Constant Dosage Standards

The biological effects of radiation are not immediate and they are influenced by a number of factors besides the dose administered. Therefore radiotherapists can only gradually acquire information on which they can establish optimum dosage levels and desirable dosage patterns for the various treatments that they wish to use. The radiotherapist has to make observations and accumulate information over many years, so that it is vital that his dosage standard should, throughout any period of his work, remain as constant as possible.

Now to take an extreme view for one moment, I think one can say that it is not necessarily important within one clinic, as to what particular dose unit or method is used, so long as that unit remains constant and reproducible. If it remains constant, no matter what its particular name or magnitude, then within that hospital, a perfectly satisfactory dosage convention can be built up, and perfectly sound radiotherapy carried on. This, of course, cannot be done if the basis of all observations — the dosage standard — is continually changing. I would like to illustrate this from our own experience at the Christie Hospital in Manchester.

I do not think that our method of using radium moulds (or plaques) and implants has been unsuccessful, yet it is based on what we now know to be a false dosage assumption. In 1932 Paterson and Parker decided to use 8·4 r per hour as the so-called specific gamma-ray dose rate for radium, and on this assumption our fairly accurate knowledge of optimum dose levels has been established. Actually, the true value is probably 8·25, a difference of less than 2%, which is not probably detectable clinically. But even if the difference had been even greater it would not have prevented our establishing a perfectly satisfactory dosage convention for this particular type of treatment. Constancy of unit, not its absolute accuracy, is the important factor.

My second example happened about 15 years ago when is was revealed by the work of Kemp that there was an error in the British Roentgen Standard which meant that those of us whose clinical x-ray dosimetry was based on this standard, were in error, in the absolute sense. Nevertheless, at that stage we decided to ignore the change because we knew that our local dose meter had remained constant over at least fifteen years, and therefore that we could continue to give the same doses that we had found to be satisfactory. It was not until lst January 1957 that we made any change, and then we introduced several. We not only took into account the roentgen factor error, but we also adopted the rad as our dosage unit. At the same time we started using more accurate Depth Dose Data and introduced what we regard as a much more satisfactory output calibration method. Therefore, there is a distinct break in our x-ray dosage history at lst January 1957, but fortunately we know fairly precisely the factors required to convert the old dosage into new and therefore the change did not materially interfere with our accumulation of accurate « dose versus effect » information.

Strictly, as far as our internal work was concerned, the change was probably unnecessary, but a department does not work completely in isolation from all others, so that dosage convention differences between departments can be confusing, and even dangerous. For example, one of our younger radiotherapists moved to work in another Centre and there tried to put into pratice the dosage levels that he had been using in Manchester. Unfortunately the dose standard at this second Centre was different from ours, so that when he prescribed the same numerical dosage, the actual dose delivered was different, and therefore trouble resulted until the difference was resolved. Therefore, whilst internal constancy is vital, it is also important that the local dosage standard should be based on the national — and hence on the international — unit, and that the method of applying it to the patient should be common to all Centres. Dr. Massey, and probably others, will be dealing with this point more fully later.

I have dealt with these examples at length because I want to stress that, to me, the prime object of a physics service to radiotherapy must be the provision, for all branches of radiotherapy, of constant dosage levels. Internal consistency, as I have said, is essential. At the same time, agreement with other Centres is most desirable and there is no reason why it should not be achieved, especially if the methods to be outlined by later speakers are adopted. If this agreement is obtained, other people's findings may be compared on a realistic basis with the findings of one's own department, and other people's experience can be directly transferred to one's own, to the benefit of all concerned, especially the patient.

Now, with these points in mind, I want to consider — in broad outline — the physics service that should be provided for the radiotherapist and the radiologist. Others will be discussing some of the services in greater detail later.

*Radiation Beam Therapy*

Since a large part of modern radiotherapy is carried out with external beams, of x-rays, gamma-rays or, in a few places, with electrons, a large fraction of the physics service will be engaged on this work.

The problem is how to enable the radiotherapist to deliver any desired dose to any point in a patient, or to know what dose a particular treatment delivers. To do this, the output of the beam apparatus must be measured by a suitably calibrated instrument for each beam used, at a standard point in a phantom which simulates the patient. From these output figures the dose at any point in the patient (who is assumed to be homogeneous) can be calculated by use of central axis percentage depth dose tables and isodose charts. Finally, correction may be applied to allow for inhomogeneities of the patient.

The first essential for this work is that the service should be equipped with appropriate dosemeters, one of which, even in the smallest department, should be kept solely as the local standard. It should be calibrated regularly (once every two years is the recommendation of the International Commission ond Radiological Units and Measurements), against a national standard, at all radiation qualities likely to be used in the department, but for most of its life it should be kept locked away, only being brought out for its own three-monthly constancy check against a radioactive standard, and for the regular — probably three-monthly — calibration of all other instruments in routine use. This procedure will ensure a constant departmental dose unit firmly linked to the international standard dose unit.

In order to ensure the maximum comparability, with work in other centres, output calibrations should also be carried out by a standard method, such as the one which will be described later by Dr. Massey, whilst it is probably advisable for a service to purchase its isodose charts and depht dose tables rather than to attempt to measure its own. The International Atomic Energy Agency in Vienna is a source that can be recommended.

Allowance and correction for the contours and cavities, the lungs and bones which make the patient different from the water phantom in which the depth dose measurements were made, should be carried out wherever possible. Data for this are not as complete as could be wished but such as exist should be used, and the service should always be considering how these corrections can be improved.

When, a few moments ago, I recommended the purchase of isodose curves from some central agency, I was not suggesting that the service should not make measurements of this sort. Quite the contrary; it should be trained and equipped for such work, which it will have to undertake, for example, when designing special compensating filters. There is no point, however, in undertaking the laborious and very time-consuming task of isodose chart production when they can easily be purchased.

What role the physics service should play in the planning of individual treatments usually depends upon local philosophy. In some hospitals the radiotherapist supplies the relevant information and the physics service plans the treatment. In other hospitals, and mine is one, the radiotherapists prefer to do the major part of the planning themselves. Then the physics service usually provides a complete isodose curve diagram of the dosage distribution achieved. If all the planning is in the hands of the service this diagram is usually the end product of their work.

*Radium Moulds and Implants*

Radium moulds, or plaques, and radium implants (or similar techniques using other gamma-ray emitting isotopes) are much less used than they were some years ago. Nevertheless, implants — for example — can, in the suitable case, produce such excellent results that the physics service must play its part in ensuring this desirable end. Dosage or treatment times calculations must be available, using reconstructors or radiographs, and every effort made to ensure that the criteria of interpretation of the latter remain as constant as possible. Computers are now being used in this work, and the methods being developed, for example at Houston, Texas, are worthy of considerable attention.

*Instrumentation*

It is seldom possible to do direct measurements of implant dosage but there are other occasions, such as in treatments of cancer of the uterine cervix or other body cavities when it is possible and desirable, to undertake direct measurement of the dose at vital tissues. An example is the dose at the recto-vaginal septum or in the bladder, during cervix treatments.

The provision of special instruments for this sort of work is, I think, one of the most satisfying aspects of the physicist's collaboration with his medical colleagues. The instrument has to work towards the limits of sensitivity and yet it must be both robust and reliable. It has to work in the somewhat unfavourable conditions of the operating theatre, or in the rush and bustle of a busy therapy department. Often only one reading is possible, so it must be correct. Even though our final accuracy may sometimes be no better than $\pm$ 5%, it represents an achievement far greater than those who spend their days in the relative calm of a research laboratory will often credit.

*Protection*

Turning away, now, for a moment from the physicist being concerned with the treatment of a patient, I would like to mention the physicist concerned with protection problems. The second of the reasons why physicists come into hospital work at all was to try to establish the safe working conditions for radiation workers. This, I think, they succeeded in doing, and the maximum permissible dose rates and so on of today's international recommendations stem originally from this early work.

Today the physicist still has a most important role to play in this aspect of radiation work. Firstly in the designing of the protection or protective barriers and protective instruments in the x-ray department, in radium and isotope handling laboratories and so on. And secondly, he has a very important part to play in personnel dosage monitoring schemes. In many places it is the custom, I think, for this work to be undertaken by the National Atomic Energy Authority or some other central national protection service. Now, personally, I think that this is a mistake. A protection service is something more than an organisation that issues, collects, develops film badges and sends out the answers. It must not only be able to deal with frank overdosage problems as they arise, but is must know and must be able to keep an eye on departments which are not as good as they ought to be. Many an x-ray department has personnel doses which are well below the maximum permissible levels and yet are still quite a lot higher than they ought to be, when the amount of work, or the conditions of working in the department, are taken into account.

Information about how much work is done, or on departmental conditions, is seldom available to a large central organisation, whereas it is usually well known to a Radiation Physics Department working in the particular area concerned. This department will probably have trained many of the radiologists, radiotherapists and radiographers working in the department and therefore will know not only the problems which these people have to meet, not only their outlook upon these problems, but their weaknesses as well as their virtues. Therefore I feel that the physics service to a radiotherapy department should not only be responsible for personnel monitoring and protection within its own hospital, but that it should also cover hospitals within its own geographic area.

### *Diagnostic Radiology*

Now I want to turn to a different subject — radiotherapy's sister subject — diagnostic radiology. The need for a physics service to diagnostic radiology is very considerable, even though some of the problems that arise are probably beyond the scope of all but the largest physics group. Nevertheless there is much that the smallest department can do to help to improve the quality of radiography work in its own hospital and in hospitals in general. Dr. Greening, some time ago showed how, with relatively simple apparatus and relatively simple measurements, one could investigate timer accuracy, focal spot changes, the constancy of voltage supplies to x-ray tubes, or changes in supply waveform with loading or time. Such investigations can reveal faults which have been causing radiographs to be less than completely satisfactory, and whose elimination improves the general standard.

On a more ambitious scale I might quote the experience of my own hospital when apparatus for Transverse Axial Tomography was installed some years ago. The pictures taken with it were disappointing, to say the least. They were useless, if the truth were to be told. A member of my department therefore undertook an investigation and by a series of elegant yet quite simple experiments, was able to diagnose a number of mechanical faults, the correction of which turned a useless instrument into one which produces now results which, I think we can claim, have no superior anywhere.

My second example has no happy ending - as yet. Recent experience, in our area at least, has shown that Image Intensifier Units with television display get out of adjustment fairly easily, and even more so in the hands of some radiologists who love to take a screwdriver and « *improve* » — or so they hope — the picture. Furthermore, contrast can be varied at will, simply by turning a knob. Therefore, either because the set is out of adjustment, or because it is desired to change the contrast to be more suitable for the work in hand, there is a need for some kind of phantom which can be used to show when the desired contrast is attained or restored.

Finally, in this section, a word about patient dose. These new Image Intensifying Units make life much easier for radiologists but sometimes at the expense of extra dose to the patient. One unit known to me, compensates for greater thickness of patient by increasing amplifier gain to give the desired brightness of picture. On the other hand, another attains the same result by increasing the x-ray tube current, and hence the patient dose. Radiologists are not always aware of such facts and probably the best person to bring them to their attention is a radiological physicist.

*Research*

In the time at my disposal I can only give some examples of the sort of service that should be provided for radiotherapy, and I shall have to leave many (for example, in the use of radioactive isotopes, or in teaching) without discussion because I now want to turn to the question of the place of research in the physics service. Whilst I cannot agree with the view held by some physicists, who ought to know better, that routine hospital physics work is beneath the dignity of an experienced scientist (though not, apparently, beneath the dignity of an experienced surgeon or pathologist, for example), I feel very strongly that every member of a radiotherapy physics team should have time and facilities to undertake some original work.

And here I must register my strong disagreement with the suggestion been made yesterday that research can only be carried out under the aegis of a university. The great majority of the basic contributions to radiotherapy physics from Great Britain has been made by workers who, at the time at least, had no connection or very little connection with a University. It is then man that is important, not where he works.

There is certainly plenty of scope even for the smaller department. Although physicists have been working in the radiotherapy field for nearly 30 years, there are many unsolved problems, whilst new developments in other branches of physics open new avenues almost every day. To take just one example, the phenomenon of thermoluminescence obviously has considerable possibilities for radiotherapy dosimetry.

Or if something in a rather wider field is wanted, there are almost endless possibilities for collaboration with medical colleagues in their many problems or in, for example, the vast subject of radiobiology. Here especially the physicist's experience in dosimetry proves a useful introduction and, to judge by some radiobiological papers, such collaboration is most desirable.

Recently I saw a paper by two radiobiologists who described at length and with great delight that their observation of a marked energy dependence of a particular biological reaction was not, in fact, a feature of their test material but a manifestation of the energy dependence of their dosemeter. A word or two with a radiological physicist would have saved them a great deal of time and effort!

Useful as such collaboration is to others, it is from the physicist's point of view that I feel that it is important. Through its challenge and interest the physicist remains alert, progressive and receptive of new ideas. Time and facilities for original work must, therefore, be available, in some measure, for each member of the team.

*Collaboration*

This, then, is the general pattern of the physics service that must be provided for radiotherapy and radiology. As I have said, there are other features which I shall not have time to discuss, but one other service I must mention. It is the most difficult to define and yet the most important of all. This is the general collaboration of the physicist with his medical colleagues. The bringing to bear, on the same problem, of two very different approaches and sets of knowledge, the almost artistic approach of the doctor coupled with the factual, logical approach of the physicist, forms a much more powerful weapon than the sum of the individual parts could do, and is the basis of most of what is best in radiotherapy. How this collaboration comes about I hope to say a little more later, but it is extremely important that, however it comes about, it should exist. It is the vital feature of any medical physics service, not only that to radiotherapy, that there should be one of the closest possible collaborations between the physicist and his medical colleagues.

## The Organisation of the Service

I want now to turn to the way that these services can be provided. Obviously the organisation in any particular hospital will depend on local circumstances and no two organisations will be the same. However, I think that it is worth taking a concrete example and while doing so, to lay down general principles which will apply to all, or almost all, situations. For my example I am going to assume that the radiotherapy department is part of a fairly large general hospital. Physicists, as I have said before, came into hospital work to help the work of the radiologist, especially in radiotherapy, and most physics departments grew up as part of the radiotherapy department under the direction and control of the Director of Radiotherapy. Many departments still exist under this pattern - my own department being one, and a very happy relationship it has always enjoyed. However, in spite of my own very fortunate and, I think, very productive years as part of the radiotherapy department, I have no doubt that nowadays, in the circumstances that I am discussing, the physics service to radiotherapy should be provided by an autonomous physics department under its own Director. The physics department in general will be available to give service to all departments of the hospital, not just radiotherapy, and in this it will be rather analogous with the departments of Pathology, or of Biochemistry, or of Diagnostic Radiology. Having said this, however, I must stress that I regard the physics service to radiotherapy as the central and most important service that the general physics department that I have envisaged, has to provide.

Radiotherapy was the first clinical « customer » of physics and still remains the only medical speciality that needs continuous and continuing physics service. Therefore, I think that the hospital physics organisation is best built round the radiotherapy physics service. If I were setting up a hospital physics service I would plan that staff should be one or two physicists more than the number needed to carry out the radiotherapy service which, of course, includes some research. With the extra man-hours that this staffing provides, problems arising from other medical specialties can be dealt with as they come along. If these are obviously calling for continuous physics help, or if the problem is a lengthy one, then extra staff to cope with this has to be recruited. One would envisage the radiotherapy service as providing a pool for help to deal with these other problems that come along, but obviously a pool that must be enlarged as the demands expand.

Apart from a large hospital with university connections where there are already some problems calling for physics assistance, I would suggest that it is a mistake to establish a physics department in a hospital not having an associated radiotherapy department. Another point is that the radiotherapy department is an excellent training ground for any physicist planning to spend his life in medical or in biological physics. The appreciating of the clinician's problems, getting to know the ways of thought of medical colleagues, the acquiring of a working knowledge of anatomy and physiology, as well as something of the psychology of sick people, all these are invaluable to any medical physicist, and often can only be gained by working on clinical problems. This can be done more readily in a radiotherapy physics service than in any other specialty. Thus, a radiotherapy service provides not only a pool of staff for other problems, but is an excellent source of training for those who will be tackling these problems.

The close collaboration between physicists and their medical colleagues has been a recurrent theme in what I have been saying. It is, I believe, the most vital part of any medical physics service. Its existence, of course, carries an implication concerning the relationship of the physicist to his medical colleagues. In Britain — and, I believe, in many other countries — it has been accepted that the physicist should enjoy equal status with his medical colleagues. This is something which has not always been accepted by our medical colleagues, nurtured as they are in a tradition which has always given the medical doctor a supreme place in hospital work. Nevertheless it must now be accepted as the normal, in fact the only basis of collaboration between doctor and physicist.

### *Technical Assistance*

As I have already said, there is much in the physics service to radiotherapy which is of a routine nature and the question that must be answered is just how much of this work can and should be carried out by technicians rather than by graduate physicists. In fact, some people go further than this and ask whether physicists are necessary at all. If you buy a radioactive cobalt beam unit the manufacturers can supply complete Isodose Curves, so that standard treatment patterns can be drawn up. Why, then, would a physicist be needed? This, is, of course, a valid question but, if you take the matter to its logical conclusion, then not only is the physicist unnecessary, but the radiotherapist is also. A surgeon, or a diagnostic radiologist, could localise the tumour, a suitable treatment pattern could be selected from a standard set, and a trained radiographer could carry out the treatment. So neither a radiotherapist nor a radiation physicist is needed — a conclusion that is logical but also extremely false. However, to return to the much more important point — there are indeed many parts of the physics service which could very well be carried out by suitable trained technicians, and any physics department must be provided with adequate technical assistance and advice. To begin with, most departments will use a considerable variety of electronic equipment and almost every one will develop instruments of its own for special purposes. Therefore, both for the maintenance and repair of existing instruments, and for the production of new ones, the physics department must have both electronic and mechanical technicians and, of course, they must have properly equipped workshop facilities with all the apparatus that they need for their work. And here I must stress that the normal hospital electrical and maintenance services are quite inadequate and unsuitable to fulfill the specialist requirements of the physics department. The establishment of a physics department — whether purely for radiology or for more general purposes — implies without any doubt the provision of workshop facilities under the direct control of the physics department.

Technicians will also be needed to help with radioactive isotope work, the radiation protection service and, for example, in the planning or charting of x-ray treatments. Just how much of the routine work of the radiotherapy physics department can be undertaken by technicians, however, is a matter of some debate. Whilst it is unwise to take up too much graduate time with work that can be done very adequately by technicians, there is another side to the problem.

Every hospital physicist must be able to undertake the routine work, must know to do it, so that he can teach others, and so that he can appreciate the problems that others may bring to him for advice. Furthermore, by doing the routine work the physicist is kept in touch with clinical work and problems; a most important part of his training, as I have already pointed out. What is the correct balance between work to be done by technicians and work to be done by graduate physicists must in general be decided in the light of local conditions. Both extreme views — the physicist should do it all, or the technician should do it all — are wrong, but I do think that it is especially important to remember that the physicist must never just sit in his office or laboratory and have experimental results taken by somebody else brought to him for inspection and judgement. He must never be afraid or unwilling to get his own hands dirty by experimental work.

*Accommodation*

I now want to turn to the question of accommodation. The amount of accommodation that has to be provided for a physics department depends, of course, on local conditions so that all that may be usefully given here, I think, are some general points. In any department there must be adequate laboratory space for experimental work, room for measuring of radioactive materials, and things of that sort, as well as proper mechanical and electronic workshops, as I have already mentioned. A library and reading room where small group meetings could be held are also very valuable. Except for the smaller departments — and it's doubtful whether very small departments are justified in these days — except for small departments there must be also office accommodation. Of all the technical assistance that is provided for a physics department, that given by a secretary is amongst the most important.

In the circumstances of my discussion the main physics department may be housed at some distance from the radiotherapy department. Therefore it will be necessary to provide, within that department, some space for the use of the physicists. A place where apparatus can be stored or prepared for use, where calculations can be made and results considered in relative calm. All too often the work has to be done on the edge of the control task in the main treatment hall.

And this reminds me to make a plea. However the department is organized and housed provision should be made for each physicist to have some private space for his own. It need not be large but he should have somewhere to which he can retreat to write, to read, to think or even to have a short siesta!

**Conclusion**

This general discussion has had to deal with many aspects of the service and has perhaps been more confusing than informative. However, I hope that it has left you in no doubt about one central and vital fact. Physics has much to offer to many branches of modern medicine, but at the moment, and probably for a long time to come, its major contribution will be to radiotherapy. For that branch of medicine a proper physics service is an essential. I would go further and say that radiotherapy cannot be at its best without one.

## INTERVENTI SULLA RELAZIONE

### A. ROSTAGNI

La relazione del dr. Meredith ha messo nella giusta luce la questione, più volte affiorata nelle discussioni di questa prima giornata, della posizione del fisico di fronte al lavoro tecnico, o di « routine ». E' chiaro che questo lavoro rappresenta un'esigenza fondamentale dei reparti clinici ed ospedalieri, ed il fisico ne deve avere la responsabilità. Egli deve perciò conoscerlo a fondo e praticarlo direttamente quando occorre. Ciò non vuol dire che certe operazioni, che non siano di particolare delicatezza, e che debbano essere ripetute sistematicamente, non possano poi venire affidate ad un tecnico, che il fisico sarà in grado di istruire e di guidare, proprio per avere molte volte compiute quelle operazioni egli stesso. Questo è anzi desiderabile, perché si capisce che chi ha una formazione intellettuale superiore male si adatti ad un lavoro puramente sistematico. Questo è il criterio da considerare, quello della ripetizione sistematica, e non quello di una presunta maggiore o minore dignità di un lavoro. Vi sono poi altre operazioni, come la riparazione di apparecchi del commercio, che vengono senz'altro eseguite meglio da tecnici specializzati.

Io non sono per nulla del parere che un fisico debba rifuggire da lavori manuali: molto della fisica sperimentale consiste anzi in questo. E sono pienamente d'accordo con Meredith quando dice che il fisico non deve sedere nel suo studio ad attendere che gli portino i risultati dell'esperienza da lui ideata: l'esperienza la deve eseguire, per quanto è possibile, personalmente.

Quando si parla di operazioni o misure che si ripetono sistematicamente, e che perciò è desiderabile poter affidare a persone di livello culturale inferiore, non bisogna confonderle con quelle che possono essere le operazioni sistematiche che il medico compie su un malato in ogni visita: che in queste interviene sempre come elemento essenziale la sensibilità personale del medico, mentre nulla di personale interviene nella lettura di molti strumenti che interessano le misure fisiche, salvo l'attendibilità.

### A. RATTI

Ho seguito con molto interesse la chiara, ordinata relazione del dott. Meredith che nasce dalla lunga esperienza presso il noto Istituto di Manchester. Desidero sottolineare quanto egli ha detto a proposito dei controlli fisici a scopo protezionistico che è bene, là dove esista un servizio di fisica sanitaria efficiente, vengano eseguiti direttamente nel proprio ambiente di lavoro sia esso universitario o ospedaliero. Le valutazioni dosimetriche effettuate in centri che sono lontani dai luoghi di provenienza dei film dosimetrici, sovente forniscono indicazioni che possono considerarsi come numeri bruti, dei quali non è possibile una esatta valutazione, che può essere consentita soltanto a chi conosca bene le condizioni ambientali del lavoro. Soltanto in questo modo i rilievi dosimetrici potranno servire realmente alla modifica di condizioni ambientali di lavoro ed alla correzione di errori personali.

Per quanto riguarda il tema della collaborazione tra fisici e medici, ritengo che essa debba fondarsi soprattutto sulla reciproca stima e sul riconoscimento di quello che ognuno può portare nel lavoro comune. Sono d'avviso che l'iniziazione e la preparazione ai compiti della fisica applicata alla medicina da parte di un laureato che ha intrapreso i propri studi con vocazione diversa da quella della medicina, debba avvenire in un ambiente di natura biologica e clinica. Dove il giovane fisico dovrà essere aiutato con intelligente e cordiale comprensione a superare anche gravi difficoltà psicologiche derivanti dal suo inserirsi in un ambiente, dal punto di vista dottrinale, così diverso da quello da cui proviene e dove esistono problemi psicologici di non facile soluzione ma che devono essere affrontati con uno spirito aperto di umanità.

M. COHEN

I have been asked to say a few words about the education of physicists and radiotherapists in different countries. I should begin with a short personal explanation: any background is hospital physics in England but for the past 3 years I have been attached to the International Atomic Energy Agency in Vienna. Since the Agency is an international organisation we think in international terms and so I try to shake off any English prejudices. This is not always easy — you probably know about the headline in the English newspaper « Thick fog in the Channel: the Continent is isolated » — but I do any best.

The Agency is mainly concerned with helping the developing countries and so we get comparatively little opportunity of observing the educational and training systems of advanced European countries. We are, however, able to see what happens in Austria and I want to say a few words about this because Austria is typical of Central Europe as a whole. The social and educational systems of different countries vary so widely that an educational programme developed in one country may have little meaning in the greatly different context of another system. For example, this afternoon we have been hearing about the M. Sc. courses in London. This could be difficult to apply to Austria because the Master of Science degree does not exist — indeed, the whole complex of first degrees and higher degrees, which is bound up so closely with the structure of British and American Universities, does not exist in many other countries.

The relevance of this to our present discussion is as follows: there is, I think, no doubt that the best way of encouraging an atmosphere in a hospital in which the services of physicists are sought after and appreciated, is for the young post-graduate doctor to work with physicists and to receive part of the specialist training from them. Now a person wo whishes to become a radiologist in Vienna does not enrol in a course such as the DMR (Diploma of Medical Radiology). Such courses do not exist. He receives his training solely by working under a recognized specialist in a hospital — an apprenticeship, in fact, but without formal instruction, without a concluding examination and with no higher degree or diploma. After a certain number of years, which varies with individual circumstances, the specialist-in-training receives a letter from his chief stating that he vas worked in the department for such and such a period, and this letter consitutes his specialist diploma. The system has undoubted advantages in relieving the candidate of the strain of formal instruction and examination, but it also means that the radiotherapist-in-training has little opportunity of coming into contract with physics and physicists. As a result, in Central Europe appreciation of the need for hospital physics is growing only slowly.

Turning now to the developing countries, the situation is rather different since the majority of specialists, both physicists and physiciens, go abroad to receive their training. The International Atomic Energy Agency assists this training, in the fields of radiotherapy and nuclear medecine, in 2 ways. Firtsly, we provide fellowships, for up to 2 years and sometimes larger, for individuals to go to advanced institutes for specialist training. Secondly, we organize courses, international and regional, and also assist countries to run their own national courses. For exemple, last year we ran an advanced course in radiation physics in the United Kingdom, in cooperation with the Hospital Physicists' Association. The course lasted 5 months, and during this time the students (from 15 different countries) received not only formal lectures but practical training in different hospital physics departments. We hope to organize another such course next year.

E. CASNATI

Facendo riferimento alla relazione del dr. Meredith ed anche a quella del dr. Greening, del dr. Warrington e del prof. Spiers, credo di poter interpretare almeno in parte e se pur soggettivamente il pensiero di quei fisici italiani che svolgono la maggior parte della loro attività negli ospedali e negli istituti universitari della Facoltà di Medicina, condividendo l'impostazione data da quegli oratori alla collaborazione tra medico e fisico. Personalmente, basandomi su un'esperienza di lavoro undecennale a fianco dei medici, ritengo pienamente valido quanto detto dal dr. Meredith. Devo riconoscere che questa mia approvazione è probabilmente influenzata dal fatto che fu proprio un mio soggiorno a Manchester a convincermi dell'utilità e dell'interesse che avrebbe potuto avere il lavoro a fianco del medico e delle soddisfazioni, anche morali, che un fisico ne avrebbe potuto trarre; ovviamente queste ultime conclusioni implicavano un'approvazione di principio all'organizzazione messa in atto al Christie Hospital.

Stabilita questa necessaria premessa, credo di capire da quanto è stato sinora detto che il problema dell'inserimento del fisico nelle attività mediche debba essere risolto in due differenti modi a seconda che trattasi di istituti universitari o di ospedali e ciò anche per le diverse finalità che le due istituzioni hanno.

Trascurando le soluzioni transitorie, mi pare che la meta da raggiungere, per quanto riguarda il settore universitario, sia stata adeguatamente illustrata stamane dal prof. Caldirola.

Nel campo ospedaliero ritengo che il suggerimento del dr. Meredith sull'esistenza di un reparto di fisica possa e debba essere preso in considerazione. Il campo della ricerca è infatti estremamente vasto e sebbene oggi si sia abituati a suddividere la ricerca in fondamentale, applicata, ecc., in sostanza non è che tali denominazioni creino dei confini molto netti. Ora se gran parte della ricerca si svolge nelle università, non è detto che nulla possa essere fatto negli ospedali. Si hanno d'altronde esempi di soddisfacenti ricerche effettuate, in altro settore, presso le industrie.

L'esistenza di un reparto con uno o più fisici, con uno o più tecnici a seconda delle possibilità dell'ospedale e di quello che il corpo medico considera utile ottenere da quella disciplina, presenta numerosi vantaggi: consente al fisico di non operare come isolato ma di avere un ambiente di lavoro e scambi di idee con altri colleghi, offre implicitamente maggiori possibilità di carriera, consente all'organizzazione ospedaliera di poter meglio sfruttare la competenza specifica che rende più proficuo sia il lavoro di routine che la ricerca applicata. Infatti se è pur vero che un buon fisico ha gli strumenti per risolvere la maggior parte dei problemi che possono essere sottoposti alla sua competenza, non sempre conviene, in termini di tempo e quindi economici, che una sola sia la persona chiamata a risolverli.

Concludendo, ritengo che nel caso degli ospedali sia opportuno pensare, almeno come meta da raggiungere, ad un reparto di fisica ciò che d'altronde è parallelo in parte a quanto suggerito dal prof. Caldirola per gli istituti universitari.

## RISPOSTA DEL RELATORE

W. J. MEREDITH

First I would like to thank the speakers for their kind remarks and for their various agreements with what I have said. Their extra emphasis on individual points is most valuable. I must confess that I am rather surprised that no one has disagreed with my paper which I deliberately made rather provocative. Perhaps this is one more sign of the kindness and generosity of Italian hospitality which we are enjoying so much and for which we are all very grateful.

In reply to Dr. Ellis I would say that, of course, I agree that a common method of dosage measurement and statement is important for all departments. However, one physicist can only influence his own department and the only thing that he can ensure is the constancy of his own dose levels. This should not prevent him, however, from lying to be in agreement with others. I.C.R.N. are making great efforts to promote agreement between alla workers and I would commend to all their recent report entitled « Clinical Dosimetry ».

Concerning responsability may I say that in my opinion there is no doubt about it. The doctor is responsible for the magnitude of the dose — he decides the treatment. The physicist is responsible for the accuracy of dosage.

Finally may I add something to my earlier contribution? It was based upon my own experience without any knowledge of Italian conditions. I now know something of your difficulties but having regard to the enormous importance of physics to radiotherapy I want to commend to you the words of Prof. Spiers. Appoint some physicists — get starked — do the experiment. The results will be interesting and valuable.