INTERREGIONAL MEETING ON THE MAINTENANCE AND REPAIR
OF HEALTH CARE EQUIPMENT

Nicosia, Cyprus, 24-28 November 1986

"In one South American country it is estimated that the replacement value of medical equipment is $5 billion. Forty percent of this is not functioning, representing a loss of assets of $2 billion. The annual bill to properly maintain the equipment, added to that for purchase of equipment and devices would be $650 million. For comparison, the drug bill of the country is $400 million, although this smaller expenditure receives much more scrutiny."

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* Additional agenda item - Special plenary session
1. INTRODUCTION

The first Interregional Meeting on the Maintenance and Repair of Health Care Equipment was held in Nicosia, Cyprus, 24-28 November 1986. The meeting was organized by the World Health Organization, Division of Strengthening of Health Services, and was hosted by the Government of the Republic of Cyprus, Ministry of Health. It was attended by 42 participants from 25 countries of all WHO regions, representatives of the Commonwealth Secretariat, the International Federation of Hospital Engineering, the International Federation for Medical and Biological Engineering, the Council for Mutual Economic Assistance, the UK Overseas Development Administration and industry.

At the opening session, Dr A. Malloupas, Head, WHO/EMRO Regional Training Centre, Nicosia, Cyprus, observed that the problems of maintenance and repair of health care equipment needed urgent, coordinated and committed attention. He indicated that this meeting marked a landmark in the long process of identifying, discussing and promoting the necessary action pertaining to these problems and hoped that it would be a starting point for a global policy encompassing all aspects of health care equipment maintenance and repair.

Dr E. Tarimo, Director, Division of Strengthening of Health Services, WHO, Geneva, on behalf of WHO welcomed the participants and thanked the Government of the Republic of Cyprus and particularly the Ministry of Health for agreeing to host the meeting and to share the extensive experience of the WHO/EMRO Regional Training Centre at the Higher Technical Institute in Nicosia, with other countries.

Dr Tarimo noted that the problem of proper selection, procurement, distribution, utilisation, maintenance and repair of health care equipment has deep economic consequences and impact on all aspects of health care delivery and should be addressed systematically by national strategies for achieving the goal of Health for All by the Year 2000. Ineffective policy and infrastructure, including facilities and manpower, for the maintenance and repair of hospital and medical equipment result in the wastage of limited national resources and draining of foreign currency reserves. From some country sources and the experiences of workers in the field the estimation of this wastage comes to as much as 80 percent. At present there is a serious lack of awareness at all levels of the whole magnitude of the problem of the effective management of a wide variety of equipment used in health care and as a result only few countries had developed policies or approaches specifically relating to this area and the situation deteriorates because of a lack of coordinated common action at the international level.

Isolated efforts and activities exist in most countries, addressing one or several aspects of maintenance and repair of health care equipment, including the establishment of inventories, setting up standards, strengthening of infrastructure, increasing training opportunities, the establishment of workshops, use of mobile maintenance units, maintenance and repair or training of local personnel by manufacturers as part of the original contract, etc. At the international level a number of efforts are under way to support countries in various aspects of the issues involved. For example, UNIDO, UNICEF, UNDP, IAEA, ILO, World Bank, Commonwealth, a number of NGOs and donor agencies had developed collaborative activities with countries to this extent.

Dr Tarimo observed that during the last few years WHO has been deeply concerned about this subject and a general impression of WHO's endeavours could be obtained from the Seventh General Programme of Work. In WHO Headquarters related specific activities were included in a number of programmes and mentioned more specifically the medium term programmes of SHS and DTR and such programmes as EPI, PHE and some others had also undertaken similar activities during the last years. In the WHO regional offices a variety of approaches have been used and a number of activities have been undertaken. The main focus was on increasing the awareness of member states of the issues involved, including the need for improved managerial and technical capacities; supporting the development and strengthening of national and regional training centres and courses; providing technical advice and consultancy service on the selection, procurement and use of equipment as well as on the development and strengthening of maintenance and repair facilities.
Dr Tarimo indicated that the growing importance given to the subject and the ultimate aim to make activities which are undertaken by countries, WHO, and other international organizations and agencies more systematic and more coordinated at all levels resulted in this very important Interregional Meeting. He described it as a significant first step towards the promotion of information exchange and a unique opportunity for representatives from both developed and developing countries to gain knowledge and experience that will enable them to work out recommendations and ideas on which all of us will base the coordinated action directed to the improvement of the situation in management, maintenance and repair of health care equipment.

Dr Tarimo outlined the objectives of the meeting as follows: (a) to assess the current situation and problems concerning national policies, strategies, infrastructures, facilities and manpower for the management, maintenance and repair of health care equipment; (b) to outline the requirements for the administrative, managerial and technical components necessary for establishing effective national infrastructure in order to meet the demands of technology required by different levels of health care; (c) to exchange information concerning the work of existing training centres and to discuss future training needs and activities; (d) to elaborate recommendations on follow-up action by countries, WHO and other agencies for strengthening management, maintenance and repair of health care equipment, and believed that the participants' extensive experiences in different aspects of management, service and training in this field would enable the meeting to achieve its objectives.

In opening the meeting, the Minister of Health of the Republic of Cyprus, His Excellency Dr T. Pelekanos, welcomed participants to Cyprus and noted that the problem of maintenance and repair of hospital and medical equipment had been in the last years gradually but steadily gaining ground in the thoughts and policies of all concerned due to the ever-increasing influence of technology in the medical field. He observed that Cyprus has been fortunate to have been selected by WHO/EMRO in the 1970s for the establishment, under the umbrella of the Higher Technical Institute in Nicosia, of a Regional Training Programme on the Maintenance and Repair of Hospital and Medical Equipment. As a result of this programme Cyprus was able to follow closely trends and developments in this area and to identify its broader objectives concerning the establishment of an effective health care technical service and corresponding manpower training. He added that purposely designed maintenance and repair workshops with permanent staff are included now as a part of district hospital complexes. Dr Pelekanos noted that the choice of Cyprus to host this meeting has been a reflection of the WHO/EMRO Regional Training Centre's contribution in promoting awareness as well as in manpower training for many countries of the WHO Eastern Mediterranean region and of the Commonwealth.

Dr Pelekanos observed that we could claim a steady improvement in the situation of equipment maintenance and repair, but the influx of new technology is so rapid and the problems it generates so extensive that we still have a lot of ground to cover and in this respect he looked forward to the recommendations of this meeting on effective policies and strategies that could be adopted by countries.

Finally Dr Pelekanos thanked all concerned, particularly WHO, for their assistance in re-establishing hospitals and clinics lost during the 1974 invasion and in training the technical and engineering staff to man the hospital workshops and health care technical services.

After the opening session Dr A. Malloupas, Cyprus, was elected Chairman and Professor J. McKie, United Kingdom, Rapporteur. The participants were divided into three working groups and the following days the meeting worked in plenary as well as in groups.

2. BACKGROUND AND SITUATION ANALYSIS

During the lifetime of WHO there has been a great increase in the volume and variety of equipment used for health care. In every country there is equipment used at all levels of health care; the greatest complexity is encountered at the tertiary referral level but there is increasing reliance on equipment at the primary health care level. In relation to problems of equipment management and maintenance, countries fall naturally into two categories. In the first category are those with a strong industrial and manufacturing
sector which produce and export many types of health care equipment. Such countries may import many types of equipment as well as export, but they are able to care for both imported and indigenous equipment because of high GNP and the availability of technically-qualified manpower. There is usually a mixture of reliance upon manufacturer’s capacity for maintenance and repair and upon a capacity of the health sector’s technical services to effect in-house maintenance and repair and to supervise the service for the commercial sector. Some of these industrialized countries have a uniform policy and practice throughout their health care sector; some exercise a general control over activities which are the responsibility of local authorities or private health care institutions; some allow policy and practise to be determined by each hospital or health-providing institution. This variety leads to different degrees of cost-effectiveness, but there is generally sufficient national wealth to provide the financial resources necessary to avoid great waste due to inoperable or inefficient equipment, and the necessary manpower is available. However, even in countries which have, in the past, allowed uncoordinated and uncontrolled approaches to equipment management there is a trend towards the development and implementation of national policies and the training and employment of engineering staff in the public health care sector.

The second category comprises nations which do not have a high level of industrialisation, which import virtually all medical equipment and which have relatively low GNP. Typically, there exists a wide variety of equipment, some chosen and purchased by the health care institutions and some provided under international or bilateral aid programmes. The most elaborate and sophisticated equipment may be maintained, at great cost, by the manufacturer’s own service organization but for the majority of equipment, particularly remote from the principal cities, the user relies upon the service provided by a local agent which is expensive if it is effective, is generally slow and is all too often expensive, slow and ineffectual. The equipment is often used by inexperienced, uninformed operators and is in a ‘hostile’ environment as regards humidity, dust, reliability of electrical supplies, water, etc. Consequently the probability of malfunction is high. The consequence is that a large proportion of all equipment is not functional or is functioning inefficiently. The estimates of this proportion are seldom supported by accurate documentation since adequate records are not kept, but the personal observations of both local engineers and visiting consultants are too many and too consistent to ignore. A developing country will seldom have 50 percent of its equipment in usable condition; in some countries 80 percent may be inoperable.

These countries have sought advice and assistance from WHO and other international agencies, or from industrialized countries, and many consultants have written reports. The first consultants, coming from industrialized countries in which the infrastructure had grown in a gradual, uncoordinated and irregular manner rather than through the implementation of an explicit policy, failed to appreciate the significance of this infrastructure, the difficulty of establishing infrastructure in developing countries and the costs involved. The attention of governments of aid agencies and of WHO was diverted towards the need to train staff who would maintain and repair equipment as is done by technicians in industrialized countries; the problems of this technology transfer were seldom appreciated.

In several WHO regions, training centres have been established: much effort has been applied to overcoming the difficulties of technology transfer and considerable success has been achieved in training students in some centres, notably the EMRO centre in Nicosia, Cyprus. Some national training centres have been established through bilateral agreements, and have achieved similar results.

But the impact of these training activities upon the general situation of equipment management has been small and has satisfied neither governments nor the training centres. The reasons are now becoming understood. The training of low- to medium-level technicians is seen to address only one factor of a multifacational problem. Without an infrastructure within which these technicians can be employed, without staff who can manage their activities, without career prospects, without adequate salaries and incentives the trained persons cannot be used efficiently or retained in the face of competitive employment. Without national policies the range of types of equipment becomes unmanageable, there is inadequate finance to provide a repair service, logistic support is inadequate. The question of working experience which is a necessary accomplishment to structured training, cannot be given where no service centres are in operation. These and many other facets of the problem must be analysed and workable solutions found.
In general the present state remains unsatisfactory even where determined attempts have been made. Training centres attract too few students of the right type or are unable to offer training at the appropriate levels. There is a great shortage of staff capable of giving satisfactory training. Where service workshops have been established there is a shortage of staff and sometimes of the resources to equip them. A central workshop may have little impact because of inadequate logistic support, but a distributed network is impossible without more staff and better financial management. Resources continue to be used to supply more equipment without consideration of the maintenance problems. Even the relatively satisfactory training programmes are not as effective as they would be if there were schemes for collaboration between centres and exchange of information, expertise and training materials. There is therefore widespread dissatisfaction with the present situation and a growing demand for more and better action at all levels from WHO to local institutions. The meeting seeks to discover whether there is a consensus of opinion on the causes of dissatisfaction and the necessary remedies amongst the participants who include officers of WHO and other international agencies, officers of national ministries, heads of training centres, heads of service centres, representatives of medical equipment manufacturers and servicing agencies and representatives of professional bodies.

3. KEY ISSUES

3.1 Topic 1: National policy on maintenance and repair of health care equipment

Professor J. McKie introduced this topic by recalling that experience in bilateral cooperation on the training of manpower for maintenance and repair suggested that no efforts in training could be successful in improving the management of equipment unless there was the relevant knowledge, skill and will in the Ministry and extending down to the primary level. It was difficult to create the understanding that the problems of equipment maintenance were not due only to shortage of trained manpower but were in large measure due to lack of national policies, or mistaken policies. There was a desperate need for a group of technically-experienced persons in the MOH (or even, in the first instance, one person) who understood the policies necessary for efficient and economical management of equipment. It was not unreasonable to suppose that by diverting ten percent of the money spent on the purchase of equipment towards the maintenance of equipment, thereby doubling its average useful life, the capital value of the countries' equipment could be increased by 75 percent. The cost of implementing good policies is a fraction of the savings achieved.

Good policies include proper procurement policies which ensure that equipment is appropriate to the needs, to the ability of the users and to the working environment; they ensure that maintenance can be provided at reasonable cost. It is therefore essential to have technical advice at the stages of selection, tendering and procurement. Although more difficult to implement, similar policies should apply to equipment donated or supplied by barter agreements.

A technical service to the ministry will ensure that buildings and services are planned with the equipment needs in mind, and that logistic support is appropriate. Manpower development policies require a knowledgeable technical input, as do policies for training staff. Here it is emphasized that the training of users is vitally important.

Professor McKie concluded by insisting that good technical advice could come only from a section headed by a person with a background in engineering science, who could command respect at the highest level and who had personal experience of practical work.

In its discussions the meeting endorsed the introductory remarks. It was clear that the majority of countries do not have a specific policy for the management of health care equipment. It was believed that this lack of policy was to some extent a manifestation of a general failure of society to understand the importance of maintenance of equipment, but more especially was due to a lack of appreciation in health ministries of the severe social and economic consequences of the widespread dereliction of the technical equipment which is provided for diagnostic and therapeutic purposes within hospitals, health centres and other health care establishments at all levels.
The attention of ministers and health care professionals has, rightly, been directed towards the cost of other facilities and supplies for health care, for example, drugs. Policies have been adopted which have affected large economies without a deterioration in the standard of care. It is perhaps not appreciated that in many countries the wastage of resources due to the premature failure of equipment is even more significant when measured in financial terms, and represents a greater deprivation of health.

In the richer, industrialized countries the users of the equipment are often able to command the resources required to repair defective equipment and so conceal from official or public scrutiny the excess expenditure consequential upon the lack of a national policy. Countries which are developing but relatively affluent may either replace or repair, regardless of cost. But in the poorer developing countries the magnitude of the problem is readily seen. The proportion of medical equipment (both clinical equipment and engineering plant) which is not functional is seldom less than 20 percent and in some countries may be as high as 80 percent.

In one South American country it is estimated that the replacement value of medical equipment is $5 billion. Forty percent of this is not functioning, representing a loss of assets of $2 billion. The annual bill to properly maintain the equipment, added to that for purchase of equipment and devices would be $650 million. For comparison, the drug bill of the country is $400 million, although this smaller expenditure receives much more scrutiny. The social consequence can be demonstrated also, e.g., the number of dialysis machines which can be used at any time is insufficient for the number of patients and leads to a life expectancy for these patients which is seriously below the world norm.

In this particular instance the direct consequence is quantifiable, but generally the deprivation due to poor management of equipment is not within the knowledge of the patient and so is not the subject of protest or pressure.

Many participants stressed the importance of extending awareness of these issues. The discussions continued with detailed consideration being given to the formulation of national policies appropriate to a country’s needs and resources. This includes the identification of needs, programming, planning and budgeting, the proper division of resources between purchasing and maintenance, and the high cost of neglecting maintenance. Selection and procurement policies were examined - maintainability, advantages and disadvantages of type and brand standardization, consideration of lifetime price relative to purchase price, contractual provisions for maintenance, training, supply of information. Other issues were the needs for transport and communications systems, stores, inventories, databanks and hazard and defect control. An area for government action was considered to be the easing of problems of importing caused by customs regulations and currency controls. National manpower policies were also considered. The results of the above discussion are given in section 4 - Conclusions and recommendations.

3.2 Topic 2: National infrastructure for the maintenance and repair of health care equipment

In introducing the second major topic of the meeting, Professor McKie referred to the general experience related by the participants who had seen the futility of training technicians and engineers for work in hospitals when there was no infrastructure to support their activities. They were frustrated by formidable problems of lack of spares, equipment, facilities, technical information and, above all, lack of management. Their motivation was further reduced by lack of career prospects, of continuing training, of respect, of confidence and of financial incentives.

Countries often made training a first priority but found that training was ineffectual if not accompanied by experience in a work situation. The working service department was therefore a first priority.

Except for major, complex equipment, developing countries could not afford to rely wholly on service from manufacturers and so had to provide a health-care technical service to provide repair and maintenance, give staff training and provide advice and assistance in many aspects of equipment management detailed in Working Paper No. 2 (Annex III, pages 3 and 4).
Such a service should be developed at all levels, starting with the Ministry (as discussed in Topic 1) and extending through a provincial, regional or district tier of health administration to primary level. The structure should ensure appropriate service to the level of rural clinics and health centres for primary care, and not be confined to specialized hospital departments of high technology. To ensure good utilization of facilities and expertise, the commonly used facilities should be widely distributed but the more specialized should be confined to regional centres from which service could be provided to supplement the services provided from lower level based staff. In the early stages of development the skeleton service could be directed from the regional workshop to areas of high national priority (which might be primary care). The regional or district centres would give advice at regional or district administrative level corresponding to that given at national level from the Ministry-based team.

Turning to the staffing policies, the problem of different understanding of the terms 'technician', 'engineer', etc., was avoided by classifying the whole range of skills, abilities and potential contributions of staff into the broad categories designated by code letters A, B, C. The attributes were detailed in the Working Paper No. 2 (Annex III, pages 25-28) from the craft skills of A, working under supervision on simple equipment, to the ability to formulate national policy and manage a Health Care Technical Service (HCTS) at the extreme range of C. The majority of staff would be in category B, not only because of the technical demands but because of the status and respect which must be given to them if they are to interact effectively with users and administrators, and if they are to receive the financial incentives which will retain them within the public service.

If the emphasis is placed on quality of staff, an effective HCTS can become a reality. The number of staff need not be excessive and the cost will be small compared to the resources being wasted by lack of effective policy for equipment management. It is necessary only to look at the way in which cars, television sets, etc., are maintained outside the hospitals to understand that the poor state of maintenance of simpler equipment in hospitals is due not to non-availability of manpower but to lack of infrastructure and absence of wise management of resources.

In the discussion which followed, participants addressed the topic in detail. After considering whether a HCTS was desirable, the status and government control of the service was examined and goals established at national, regional and district levels. The achievement of effective liaison within the health sector and with other sectors was considered, particularly the relationship between medical equipment maintenance and hospital buildings, plant and services maintenance.

The functions of the service and the logistic support needed were examined.

The relationship with manufacturers was discussed, as was the relationship between HCTS staff and the other staff using equipment.

The staffing structure needed was investigated, with the related issues of pay and incentives, leading to consideration of ways of funding the service.

The recommendations reached by the meeting, for action by national governments and WHO, are given in section 4.

3.3 Topic 3: Development and Strengthening of Manpower Training

Dr Andreas Mallouppas presented the third topic and began by pointing out that manpower training cannot be considered in isolation, thus before considering the main objective of the topic, Manpower Training, it is necessary to examine the environment in which the various personnel to be trained, work and function in.

In any health care system one must always try to meet the health needs of the system, whether in hospital or health centre capacity, staff, equipment, etc. In considering these needs many different factors are involved in a greatly interacting, interdisciplinary system. This cycle of events of many interventions and inputs may be termed the health technology cycle (Working Paper No. 4, Annex V, p. 20).
One precondition should be made before considering the various events of the cycle, that a dedicated, committed policy exists. This can only be decided and implemented by high level policy-makers. This is why it is considered necessary that a policy-makers meeting should follow this one in order to study its recommendations and undertake to implement corresponding actions. It is for this reason that a very short paper with the salient points intended for policy-makers is given in the references.

Assuming that national policy already exists the health technology cycle was considered. In order to determine the health needs, it is necessary to establish a programming and planning committee, at ministry level, composed of all the groups involved in satisfying the health needs, i.e., planners, financiers, medical, paramedical and engineering staff. In order to determine the equipment needs the existence of an inventory is paramount. Equipment selection should be based on market supply, availability of finance, identification of equipment to satisfy clearly defined health care functions. The procurement of equipment should be based on comprehensive generic specification of necessary, standard equipment which should be available. This will enable the preparation of comprehensive tenders and specifications. Other inputs such as medical stores, customs, etc., should also be available at the right time and act correctly.

It is clear that the notion of teamwork should be accepted and encouraged. Such a team should encompass financiers, technical managers, engineers and medical staff at the identification, planning and programming stage. The job descriptions and definitions of technical managers, hospital engineers and workshop technicians are given in Working Paper No. 4, Annex V, pp. 10-12.

Training of personnel should be identified at an early stage, both for users and engineers, and certainly before the equipment starts to be installed. However, before dealing with training in detail the system for which training is intended for, the HCTS, was considered. This system, like any other will only give outputs if it is fed with the right inputs. Budget, policy and planning are three major inputs that should be adequately present. However, correct liaison with other departments, logistics support (medical stores, transport, customs, etc.), facilities, spares, correct infrastructure and incentives are all necessary inputs. All these must be present for the system to work satisfactorily, even if training is present and adequate.

Having given these inputs, the HCTS should then be expected to produce such outputs as contributions to planning, selection and procurement, inventory, routine maintenance, repair, budgeting and training of its own staff.

Regarding training, before deciding on programmes the HCTS should consider the following factors.

- availability of financing;
- priority needs;
- academic and professional background of the candidates (engineers and users);
- graduating level of the trainees;
- post-graduation professional standing, career prospects of the trained personnel and working environment;
- assessment and methodology of candidate selection.

For those working in the field of training it is abundantly clear that the various training establishments existing at present do not have between them any contacts at all, let alone coordinate efforts and share information and experiences.

Consideration was then given to the position of the various disciplines mentioned earlier in the health care system which need to be identified and their job descriptions set out before one can consider formulating any training courses. Technical managers who ideally should be engineers with management experience should occupy high ranking posts in the central or district health authorities. The director of the HCTS should be a well-qualified engineer-manager heading other engineers and technicians at central and hospital workshops. The HCTS should cater for both plants and electrical/electronic equipment as well as some aspects of estate buildings.
If courses are to be established at regional or country level then some basic requirements need to be looked into, such as: aims and objectives of course, professional standing of graduates, academic level of graduates, course duration, level of student input, guidelines of syllabus content, equipment needs and facilities, teaching staff training, teaching process and assessment of performance (see Annex IV, Annex V of Working Paper No. 4, pp. 14-18).

Courses should be done at both country and regional level. At country level courses should be formulated to country capabilities whereas at regional level the more expensive and difficult higher level courses may be done.

Training should also cater for PHC level situations and training 'equipment appreciation' to medical and paramedical staff as part of their normal courses should be established. In such training the DOs and DON'Ts should be very clear.

The notion of teamwork was stressed, which must be backed-up by committed policy decisions. Training alone is not a solution. The identification of the different level posts is necessary in order to formulate the correct training policy. For all types of courses, whether purely academic or practical it should be recognized that time is a major factor. Time is needed to establish national experiences, expertise, how-to, tradition and confidence. It should be recognized that it took the developed countries 100-200 years to establish the present system of health care equipment service.

The meeting discussed extensively the various issues raised by the presentation and its conclusions and recommendations are given in section 4.

3.4 Topic 4 : Use of computer database systems in health care equipment management

This was an additional agenda item and was discussed in a special plenary session, where it was generally felt that there was a need for access by the various national governments and institutions to databases which would provide information on:

- selection and procurement of sources of appropriate equipment, and on
- maintenance and management programmes.

The above tasks are the areas where the immediate availability of information would improve efficacy and efficiency and enable optimum utilization of financial and manpower resources.

To achieve these aims certain basic requirements have first to be established.

3.4.1 Compatible hardware to be used

Considering that the most commonly available type of computer in present use within the institutions and governments represented at the meeting is the IBM PC. This would seem to be the most logical choice.

3.4.2 Software

The choice of programmes to be used was initially DBase III. This will have to be reviewed when final requirements are identified.

3.4.3 Standardization of item coding systems

In order to enable international interchange of information it was deemed essential for a common coding system to be employed by member states. The choice of a common system should be decided upon following the investigation of the different systems of coding already available and will require an indepth review of each one, in conjunction with an exchange of dialogue with those institutions which have already started to examine this question.
Some European institutions, which at present are using such coding systems are:

a. Centre National de l'Équipement Hospitalier (France)
b. Department of Health and Social Security (UK)
c. Department of Clinical Physics and Bio-engineering (Glasgow, UK)
d. Consiglio Nazionale Ricerche (Italy)

Other widely used systems are those developed by ECRI of the USA and by the Centre for Biomedical Engineering (Brazil). Once a satisfactory system has been identified, then further planning can proceed, with the dialogue being extended to include representatives of interested governments and institutions.

Having considered the above discussion the meeting proposed recommendations for action by WHO, which are given in section 4.

3.5 Topic 5: Collaboration with other agencies and bilateral donors

The above topic was the second additional agenda item which was discussed in a special plenary session. It was recognized that WHO has responded to the need to train staff for repair and maintenance by its support for its regional training centres. It is from the most active of these that many of the lessons propounded at this meeting have emerged, and the meeting testifies to the value of this support. International dialogue, collaboration and coordination between developed and developing countries and in the spirit of ICD/ECDC should be encouraged. The dialogue begun here should be continued so that lessons of the more advanced centres are assimilated by those still being developed. Support for an increase in activities will be required. Detailed recommendations were developed by a working party and presented to a plenary session. The agreed recommendations are included in section 4.

4. GENERAL CONCLUSIONS AND RECOMMENDATIONS

4.1 General conclusions

Underlying many of the problems common to many countries is a serious lack of awareness of the importance of the contribution of effective equipment management towards the goal of 'Health for All by the Year 2000'. This lack of awareness exists at all levels and is exacerbated by lack of reliable information. WHO has just begun to seriously address the problems as an essential part of strengthening of health systems based on PHC. This resulted in the first Interregional Meeting on the subject but as yet it does not have enough staff and resources to deal with the issues.

Throughout the world there is a great wastage of resources due to premature failure or inefficiency of health care equipment. Where it has been quantified it proves to exceed the wastage due to other causes, such as avoidable wastage on drugs, which have attracted much more study.

There is a general lack of understanding that the cost of making equipment available for use is greater than the cost of purchase since, over the expected, useful lifetime of the equipment, the expenditure on maintenance, repair and consumable items may greatly exceed the purchase price. Where all available funds are used for purchase and none reserved for maintenance, the useful lifetime is greatly reduced and the total stock of usable equipment will be low relative to the expenditure. When a substantial proportion of available funds is used for maintenance, the average lifetime is extended and the stock of equipment (achieved by the same total expenditure) is increased. It is important that all countries apply this rule, but particularly important that donor countries or agencies ensure that their financial support is similarly divided: this would dramatically increase the provision of health care equipment throughout the developing world, without any additional resource expenditure.

Few governments have a comprehensive national policy covering equipment management and the ministries of health do not have staff competent to prepare such policies or plan their implementation. Too often the perceived need has been the training of low-level technicians, but resources applied to meet this need have been ineffectual because of the lack of an infrastructure of technical service and absence of policies of equipment need, selection and procurement which would make attainable the goal of proper maintenance.
There is a need in every country for a Health Care Technical Service (HCTS), extending from the ministry to all levels of health care provision, with a clear structure, adequate funding, with staff having a range of abilities and responsibilities from craftsmen repairing simple equipment to engineers capable of management at the highest levels in ministries. The staff must have adequate salaries and career prospects after training appropriate to their levels of responsibility, including managerial responsibilities. A high degree of intersectoral collaboration is essential between the ministries of health and other sectors concerned. WHO regional training centres have contributed to the training of staff at several levels but should now give priority to higher levels of training with the lower level training being undertaken locally in native languages. Everywhere the training of trainers should receive the highest priority. There is insufficient contact and collaboration between the regional centers and between these and other training establishments; much effort is unnecessarily duplicated and WHO could encourage effective collaboration among them, promote exchange of information and assist in the development of training materials, trainers' training, etc.

Many other problems common to developing countries could be helped by action or coordination at international level. Guidance could be prepared on appropriate equipment, standardization of equipment, specification, procurement and tendering, maintenance procedures, etc. With increasing dependence on computer databases, effective international collaboration requires action to ensure compatibility of software and standardization of codes.

There are many existing programmes which have the goal of improving the maintenance of equipment, initiated and supported by WHO and other international organizations, development banks and through bilateral agreements involving national and development agencies. There is often confusion and overlap due to lack of information and lack of cooperation, leading to wastage of resources in some areas, with others neglected. An initiative to promote collaboration and exchange of information is urgently needed.

4.2 Recommendations to countries

The following recommendations are made to national governments:

1. Each country should have an explicit policy on the management of health care equipment and should ensure its implementation by its health management authorities. The policy should be consistent with national needs, goals and resources and should cover and integrate activities relating to identification of need, use of appropriate technology, planning, budgeting, legislation or regulation of standards of safety and efficiency, specification, procurement, commissioning, inspection, maintenance, repair, replacement policy, technical and logistic services to support equipment, manpower development, education and training. This would require a high degree of awareness, strong political will and effective intersectoral collaboration.

2. Within each national health ministry there should be a technical service organization to implement the management policies for equipment and supporting services. It should be headed by a person of technical background and include administrators, engineers and the medical profession and should form part of, or be coordinated with the organization for management of health facilities and the services provided for "hospital engineering".

3. National policy should include the provision of an appropriate infrastructure - "Health Care Technical Service (HCTS), at all levels of health delivery or the strengthening of such a service as exists. It should be controlled and coordinated from the ministry of health, and below this level should be organized at provincial/regional (district) level. The staffing policy should recognize three broad levels of qualifications and achievement. Details of organization and staffing should be appropriate to national needs and resources (relevant guidelines are contained in Working Paper No. 2, Annex III).

4. Ministries of health should provide adequate funds for the HCTS. This may be done by ensuring that funds available for the provision of health care equipment are apportioned between purchase and maintenance. Normally not less than 20 percent should
be allocated for maintenance. Additional income may be generated from the sale of expertise by the HCTS to other users (e.g., the private sector). All revenue generated by HCTS should be recycled within the HCTS. Ministries should explore possible sources of additional funding.

5. Governments should ensure that salaries of HCTS staff approach those of comparable staff in the private sectors. Where this requires schemes of incentives, these should operate from the commencement of the service and should be legal and well-controlled. The schemes may be financed by overtime payments, and by generated revenue from contracted work within the public or private sectors.

6. The HCTS below ministry level should be coordinated at provincial/regional (district) level; the first workshops should be established at this level. Pilot schemes will allow the most appropriate structure to be developed. Local workshops should form part of the regional (district) structure. To strengthen the service, communication between regional staffs should be encouraged.

7. Ministries should ensure that there is effective engineering input at the important stage of selection and procurement of equipment and that this process is carried out by a team consisting of administrators, engineers and the medical profession.

8. Governments should ensure that adequate and comprehensive equipment inventories exist and are updated.

9. When tenders for equipment are being prepared, tender documents should include not only specifications of the equipment but also conditions to be fulfilled concerning provision of documentation (e.g., user and service manuals, spare parts lists, warranty), the provision of after-sales service and the identification of the agents responsible, the provision of training for operators and for hospital technical personnel, the supply of spare parts and consumable items.

10. When health care equipment requires to be sent overseas for repair, governments should allow for its free export/reimport. Similarly they should allow the free import of parts required for the repair of equipment already imported.

11. In order to facilitate the provision of spare parts, the governments should operate a scheme to allow funds to be deposited in a trust fund account at the time of purchase of equipment and withdrawn to meet costs of spares or repair from abroad. The trust fund could be administered by WHO or other international agency. Rapid procurement by telex/telefax would then be possible utilizing these 'funds in trust'.

12. Countries should recognize the need for different levels of training to provide staff for the national HCTS. This should range from craftsmen to graduate engineers and should include management training. All training programmes should be strongly service-linked. If possible all low level vocational courses should be conducted in the native language.

13. When selecting candidates for training, countries should be careful to select those who have qualifications and/or experience appropriate to the level and requirements of the course. This is particularly important when selecting candidates for the WHO regional training centres.

14. Ministries should ensure that HCTS staff have adequate post graduation career prospects and are given appropriate recognition for their qualifications and experience. Appropriate phasing-in of certification should be considered in conjunction with the relevant national and international professional bodies.

15. Countries should give high priority to programmes for 'training of trainers' to enable them to carry out low level training. Trainers should have experience in the field of engineering which they are to teach and should receive tuition in training techniques. Their training should aim to impart leadership skills and a willingness to share knowledge so as to counter negative attitudes.
16. Education and health ministries should ensure that in the education and training programmes of medical, nursing and paramedical staff more instruction is given on the principles of operation and care of equipment used for health care. This should emphasize the economic and social awareness of the mishandling and lack of care of this equipment by the operating staff.

4.3 Recommendations to WHO

The following recommendations are made to WHO.

1. WHO should continue its efforts to promote awareness and to sensitize countries to the issues involved in the maintenance and repair of health care equipment as well as to coordinate activities undertaken within the organization and by various international bodies concerned.

2. The subject of management, maintenance and repair of health care equipment and the necessary supporting services should be an item for discussion on the agenda of the World Health Assembly due to its critical role in achieving the goal of Health for All by the year 2000.

3. WHO regional offices should place increased emphasis on the subject of maintenance and repair of health care equipment and should discuss it at regional committees. Meetings similar to this Interregional Meeting should be held within all the regions, with a comparably wide range of participants, followed by another Interregional Meeting in three years' time in order to evaluate the progress achieved.

4. WHO should convene a study group on the maintenance and repair of health care equipment in order to review the whole magnitude of the problem including policy, economic, organizational, managerial, training and technical aspects and to make technical recommendations on the subject.

5. WHO should create a special programme or at least a steering committee with an engineering input at headquarters level and should consider the possibility of establishment of posts for engineers at the regional offices in order to deal more effectively with issues involved.

6. WHO should call upon member states and international agencies to subscribe to the following convention:

"When health care equipment is donated or exchanged by agreement between this state/agency and another, recipient state for the purpose of aiding a programme of health care, this state/agency will apportion not less than 20 percent of the funds which it has applied to, or made available for, the provision of equipment towards the cost of maintenance or repair of that equipment during the three years following the expiry of any period of warranty of the equipment, such funds (or equivalent resources) to be held in trust or otherwise administered as may be mutually agreed between this state/agency and the recipient state".

7. WHO should evaluate the effectiveness of different national policies and HCCTs infrastructures and prepare appropriate guidelines and recommendations.

8. WHO should collect, evaluate and make available information on the economic and managerial aspects of health care equipment and supporting services.

9. WHO should recommend appropriate levels of provision of communication, transport and logistic support.

10. WHO should make available standards or codes of practice relating to the manufacture of equipment and encourage their adoption by governments, in order to ensure a high level of safety. It should ask governments to establish programmes of inspection to ensure conformity with standards of safety.
11. In order that databases which can be used to provide information for the selection, procurement and management of equipment should be compatible between countries and international agencies, WHO should initiate steps to identify the hardware and software systems of choice and a standard common coding system and communicate their findings to the appropriate offices, which need to use these database systems, including WHO regional offices.

12. WHO in collaboration with other international agencies and bilateral donors should promote standardization of health care equipment and procurement of standard, serviceable equipment.

13. WHO should establish an information centre to facilitate the exchange of information between countries. Ministries should be invited to send their national information to this centre which should list it to other ministries. Consideration should be given to the regular issue of a newsletter covering the topics involved.

14. WHO should further stimulate the design, development and production of appropriate technology using indigenous expertise and resources.

15. WHO in collaboration with other international agencies should identify sources of second-hand equipment useful for training purposes and make available its existing procurement system to ship the equipment to training centres.

16. WHO should compile lists of basic equipment for each level of health care, produce functional and technical specifications and collect information on manufacturer's equipment meeting the specifications.

17. WHO should prepare a "guide to procurement" detailing the conditions which should be met by tenders, e.g., warranty, contract, documentation, service provision, training provision.

18. WHO is urged to establish a project to produce and circulate a series of 'use and maintenance' manuals for biomedical equipment, using a format similar to the EPI cold chain manuals. It is suggested that this should begin with simple laboratory equipment, anaesthetic machines, sterilizers, primary health care equipment.

19. WHO should compile and circulate a list of existing training centres, including those of manufacturers, which will contain information concerning courses on maintenance and repair for various levels of trainees and trainers.

20. WHO headquarters should request regional offices to collect the existing training materials within their regions and circulate it to the various training centres.

21. WHO should examine the possibility of producing training materials for self-programmed learning of skills (including audiovisual aids) combined with practice under the supervision of a tutor.

22. WHO should encourage manufacturers to cooperate with regional training centres in providing training materials and seminars on their products.

23. WHO in collaboration with other international agencies should encourage manufacturers and suppliers to produce operating and maintenance manuals in local languages.

24. WHO should encourage training centres to exchange information and cooperate to produce common core syllabus on various specializations.

25. WHO regional training centres should become more committed to the provision of higher and more specialized levels of training (including training in management) and less in training at the craft level.

26. Regular review and assessment of WHO regional training courses should be made by a committee representing WHO and the countries in the region. This should include assessment of graduates from the training centres.
27. WHO should give high priority to programmes for "Training of Trainers" to enable them to carry out lower level training. Trainers should have experience in the fields of engineering and management which they are to teach and should receive tuition in training techniques. Their training should aim to impart leadership skills and a willingness to share knowledge so as to counter negative attitudes.

28. WHO should encourage a high standard of professionalism, in association with international professional bodies.

29. WHO should promote bilateral and multilateral collaboration and cooperation in the management, maintenance and repair of health care equipment both between developed and developing countries and in the spirit of TCDC/ECDC.

30. WHO should be in contact with other international organizations and agencies involved in this field with a view to cooperative measures in the promotion of the above activities, e.g., IAEA, ILO, ISO, CMEA, Commonwealth, OECD, UNDP, UNHCR, UNICEF, UNIDO and other IGOs and NGOs concerned.

31. WHO should also seek the cooperation of bilateral aid agencies active in this field to implement proposals at country level, e.g., CIDA, DANIDA, DTH, FINNIDA, GTZ, NORAD, SIDA, UKODA, USAID and others.

32. WHO should initiate a dialogue with the international development banks, the World Bank and its regional affiliates, with a view to providing necessary support for the programmes outlined in the above recommendations.
ANNEX I

Summary of Situation Reports

Before beginning the presentation and discussion of the main topics of the meeting, a situation analysis was obtained by presentations given from the WHO regions, countries, other agencies, professional bodies and manufacturers present.

1. Global and regional situation

The underlying theme present from all WHO regions is that only a few countries have committed and coordinated national policies and strategies specifically relating to procurement, use, maintenance and repair of health care equipment. Where they do exist, they may not be directed to priority needs, or may take too little account of the capabilities, skills and resources available. Where national budgets include allocations for equipment, this may apply only to purchase, ignoring maintenance, servicing and repair costs. Countries which have a health care technical service lack the infrastructure and back-up necessary to implement required actions to meet the needs of health care services at different levels. In addition, there may be insufficient middle-management staff to properly advise higher levels on planning and policy, or to coordinate the approaches and activities of the other levels. At the technical level, many of the same problems can be identified, and lack of management expertise and technical competence may adversely affect decisions concerning location, installation, distribution, etc., of equipment and parts. Insufficient use may be made of maintenance and repair contracts already established with manufacturers, adding to delays or increasing down time of equipment. Technicians need continued training to maintain their skills and to ensure quality control and assurance, and to keep abreast of new developments, and national education and training facilities may not be used as extensively, or effectively, as they should be.

During the last few years WHO has been deeply concerned about this subject and a general impression of WHO's endeavours could be obtained from the Seventh General Programme of Work. In WHO headquarters related specific activities were included in a number of programmes and mentioned more specifically in the medium term programmes of SHS and DTR and such programmes as EPI, PEH and some others had also undertaken activities during the last years.

In the WHO regional offices a variety of approaches have been used and a number of activities have been undertaken. The main focus was on increasing the awareness of Member States of the issues involved, including the need for improved managerial and technical capacities; supporting the development and strengthening of national and regional training centres and courses; providing technical advice and consultancy service on the selection, procurement and use of equipment as well as on the development and strengthening of maintenance and repair facilities.

For example, AFRO supports two equipment repair and maintenance training centres in Lomé (Togo) and Freetown (Sierra Leone). There is a centre in Lagos (Nigeria) which receives financial assistance from TDR (HQ) and has staff support from the University of Liverpool Bioengineering and Instrument Repair department. In AMRO a number of national projects are in operation in Central America and Caribbean countries. National training centres offering various forms of maintenance and repair training, as the one in Campinas, Brazil, were established. EMRO is giving priority in its collaboration with Member States of the region to achieve self-sufficiency in developing maintenance and repair of health care equipment. To this effect its activities are directed towards collaboration with the national health authorities in the development of national policies and programmes for maintenance and repair of health care equipment as well as in formulating appropriate policies and strategies for the procurement of medical equipment taking into consideration countries' needs and resources, training programmes were established at country and regional levels. A regional
training centre for the maintenance and repair of medical equipment was developed in 1978 at the Higher Technical Institute in Nicosia, Cyprus, and since then 263 technicians have graduated from its courses. The national training centre at the Intermediate Technical Health Institute, Damascus, Syria, will eventually serve as a regional training centre for Arab-speaking students. Close collaboration and support are maintained with training centres at Abbasays, Cairo, Egypt and the Health Science Institute, Bahrain. A French-speaking training centre is being developed in collaboration with UNDP in Rabat, Morocco. EUROMED activities are geared towards the creation of an international dictionary, computer code system and legal classification system for devices and equipment. An information clearing house on medical devices and equipment is being developed, and courses are being planned. SEARO is concerned with the need for standardization of procurement, development of inventories, strengthening of overall management capabilities and improved logistics of distribution, repairs and maintenance. In collaboration with UNDP support is provided to countries to enhance their capabilities in repair and maintenance chiefly through training, infrastructure strengthening and better logistics development. WPRO has created a post for biomedical engineering as part of their intercountry projects and a number of short-term consultants have focused on increasing the awareness of the importance of maintenance and repair of equipment, cooperation with member states in planning and organizing preventive maintenance, support to training of national technical staff, institutional support and provision of technical advisers to member states in selecting and procuring equipment. In the framework of intercountry projects on managerial processes for national health development in the South Pacific two training packages were developed on the management of medical supplies and equipment and on maintenance of equipment.

At the international level a number of efforts are under way to support countries in various aspects of the issues involved. For example, UNIDO, UNICEF, UNDP, IAEA, ILO, World Bank, Commonwealth, a number of NGOs and donor agencies had developed collaborative activities with countries to this extent.

However, the problems faced are vast and complicated. The lack of awareness at all levels of the magnitude of the problem of ineffective management of a wide variety of equipment used in health care, as well as the lack of coordinated common action and collaboration at the international level, impede the overall situation.

2. Country reports

2.1 Region of Africa

2.1.1 Nigeria

There is no clear national policy concerning appropriate medical equipment acquisition, maintenance and repair. What exists presently according to the Federal Ministry of Health are unwritten guidelines on equipment purchase, repair and maintenance. The federal government of Nigeria purchases equipment through tender and a contract agreement is entered into with the vendors for maintenance and repair. Most of the time the vendors are mere agents without adequate infrastructure and manpower resources for effective repair and maintenance of the purchased equipment. The result of such a lopsided agreement is that a lot of equipment becomes redundant as appropriate resources for their maintenance and repair are lacking.

One of the major problems militating against effective maintenance and repair of medical equipment in Nigeria is a total lack of standardization, specification and spare parts for imported equipment. This problem has been further compounded by the economic recession afflicting the country.

The lack of appropriately trained manpower with adequate incentives geared towards job satisfaction has compounded the problem which has deteriorated by the misuse and abuse of most medical equipment as enough attention is not paid to user training.
Presently there are three institutions where training and education on medical equipment maintenance and repair are offered, namely Ahmadu Bello University, Zaria; University of Maidugri and The College of Medicine of the University of Lagos. The medical electronic equipment workshop of the College of Medicine of the University of Lagos is fairly well-equipped for repair purposes. The training programme has been geared towards medium-level manpower development. The course content lays much emphasis on theoretical knowledge of electronics and other relevant physical sciences. However, the advantage that is gained from good grounding on theory is lost owing to the lack of adequate instructional aids in addition to lack of appropriately trained trainers. Also important test equipment for routine maintenance, certification of safety of equipment and calibration and recalibration on a routine basis are lacking.

2.1.2 Sierra Leone

The absence of coordinated and effective policy concerning maintenance and repair and inability of the technical service to effectively carry out its objective constitute two of the major problems facing the country. Lack of funds is the other major factor that contributes to the ineffective maintenance and repair actions. Although a WHO/AFRO regional training centre operates in Freetown, the lack of HCIS infrastructure, tools and spare parts, poor management as well the lack of career structure result in the ineffectiveness of the training.

The WHO regional training centre in Freetown, Sierra Leone, offers a modest contribution for medium-level technicians from anglophone countries of the region. It conducts an eleven-month training in electro-medical equipment leading to a Technician's Certificate. Electrical and electronic subjects and principles of selected electromedical equipment including conventional diagnostic x-ray machines are covered. A total of just over 150 students from 17 countries have received training since 1974.

2.2 Region of the Americas

2.2.1 Brazil

Health care equipment is in a critical condition in Brazil: about 20-40 percent (i.e., 2-3 billion dollars worth) of all existing equipment is not working because of the lack of installation, service, parts and/or supplies.

At the moment, there is no national or local policy on management of devices and plants. There is not even any enforced regulation on manufacture and sale of medical devices, trying to ensure safety and efficacy.

The great majority of the hospitals do not have engineering departments, so repairs and preventive maintenance are usually provided by manufacturers and their representatives, if the former can afford to pay the high costs. Even then the quality of the services is rather uneven.

In the last 5-10 years, a few institutions established their own in-house maintenance teams. Besides providing significant savings, they are contributing to the improvement of the whole process of introduction of technology into health care delivery. For example, equipment planning and selection methods, lifetime costs analysis, negotiation and purchasing contract terms, and technical information data banks have been worked out.

In spite of their unquestionable success, this self-reliance scheme is having difficulty in being widely adopted. The major reasons are:

1. Lack of awareness of the health care officials and administrators;
2. Insufficient number of qualified technical personnel;
3. Difficulty in obtaining spare parts and technical documentation; and
4. Uncooperative attitude of most manufacturers and their local distributors.
Presently the only formal training in Biomedical Engineering available in Brazil is at the level of graduate school. There are about six courses offering Master's degrees and one doctoral programme being established. Only in one of these programmes is there a possibility of specializing in hospital engineering. There are no undergraduate nor high-school level courses specifically designed for biomedical engineering or health care equipment maintenance. Most people have been trained in-service by the manufacturers and/or their representatives, or in hospitals by senior technicians and engineers. In the last couple of years, a few special courses have been organized by the Ministry of Health, the Ministry of Education and the National Institute of Medical Services. The courses are, however, not offered on a regular basis and are exclusively for their own employees and some invited guests. Other sporadic, small-scale efforts have been made by some hospital engineering teams in order to increase their own staff, or to help other institutions. For example, the Centre for Biomedical Engineering has trained engineers and technicians for a number of hospitals and universities through internships lasting from a couple of weeks to over six months.

Responding to public pressure, the government is becoming increasingly aware of the problems, so new policies are expected within the framework of the national health plan that is being formulated. To implement the necessary changes, international cooperation will be needed to complement limited local resources.

2.2.2 Canada

Over the past 20 years in Canada, while the variety and number of medical equipment in hospitals were steadily increasing, the problems and cost of medical equipment maintenance began to plague hospital workers. Through some independent initiatives scattered over different parts of the country, uncoordinated by government or voluntary organizations, in-house maintenance and repair of medical equipment by technicians and biomedical engineers were being established in some hospitals. Today, many major hospitals have clinical engineering departments, or some form of electronic workshops, for the maintenance of medical equipment. However, usually the full spectrum of medical equipment is not covered by the in-house service, and a considerable number of hospitals still rely entirely on services provided by manufacturers. In general, there is a shortage of technicians and engineers with experience in the medical equipment field.

A model of a hospital clinical engineering department in Canada, which has proven to be cost-effective, is combining in-house service and manufacturers' service. The in-house group performs about 90 percent of the total maintenance and repair, while the rest are covered by manufacturers. It is more cost-effective to maintain certain equipment by the manufacturers even though in-house staff can be trained to maintain it. On the other hand, the clinical engineering department offers medical equipment service contracts to five other regional hospitals thus earning revenue for the department. This department has been operating in a stable manner in the past four years and will continue to do so.

2.2.3 Costa Rica

Since 1975 all hospitals belonging to the Ministry of Health were transferred to the Caja Costarricense de Seguro Social. The maintenance department at the Caja Costarricense de Seguro Social was established with the final aim of producing an integrated maintenance system for the 30 hospitals and 100 clinics with a total of 6,963 beds.

Within the framework of national integrated maintenance systems the following activities were developed:

- Training: workshops, formal technical courses covering at present 1,000 persons from every part of the country.

- Technical evaluation of the equipment: development of the methodology for collecting and processing the information.
- Test sample and evaluation of all hospitals.
- Technical evaluation of the physical resources for maintenance.
- Development of the methodology for collecting and processing the information.
- Evaluation accomplished.
- Management of a scholarship programme for maintenance personnel.
- Beginning the reorganization actions at central level.

Under the subregional project an international meeting was held in which the methodology for collecting the information required by the project was developed.

The maintenance system operates at three levels: central, regional and local, each of them with defined structure and objectives. The programmes developed by the maintenance department in accordance with its objectives are:

- Corrective maintenance
- Programmed maintenance
- Preventive maintenance
- Training

The maintenance department has at its central level 14 engineers and 160 technicians which is 63 percent of required manpower; the regional level is in the stage of development at the moment and at the local level there are 14 engineers and 606 technicians, plumbers, electricians, mechanics and lay assistants, which is 74 percent of required personnel.

The workshops at central and local levels are well-equipped but still require further improvement.

The budget of the maintenance department and its workshops at the central level is US$2,500,000. At the local level each hospital or clinic assigns 1.5-2 percent of its budget for maintenance.

The maintenance department with external financial support has accomplished the establishment of a continuous training programme for the maintenance personnel. The programme considers not only the formal and service courses for maintenance personnel, but also for the people that operate the medical and industrial equipment at the hospitals and clinics.

In these efforts Costa Rica receives continuous financial and technical support from PAHO/AMRO and external financial projects.

2.3 Region of the Eastern Mediterranean

2.3.1 Bahrain

Policy with respect to maintenance and repair of medical equipment is dictated by the Bahrain national policy governing the whole machinery of the health service which could be summarized as the provision of the best possible health care at its various levels to all the people in the State of Bahrain. In case of hospital equipment maintenance, repair and calibration, it is recognized that efficient services can only be brought about by an efficient equipment control and management in the hospitals and health centres and the sophistication of equipment in use should be matched by an elaborate set-up of skilled and equipped technical personnel that is able to meet its demands and needs.

The medical equipment centre as a service department and in association with the college of health sciences as a regional technicians training centre for the Arab Gulf region was established in early 1977. Its role can be summarized into two distinct but interrelated functions in the provision of service and manpower to man it:
1. Training of medical equipment technicians that eventually serves the whole Arab Gulf region in similar service departments.

2. Maintenance and repair of all pieces of medical equipment used for clinical diagnostic and teaching purposes at all Bahrain hospitals and health centres.

Although the training role caters for the regional needs, in the form of providing trained technicians, the second role is at the present time confined to fulfilling Bahrain service needs. This may change, should the establishment of shared maintenance and technical services among the Arab Gulf countries be contemplated.

The service function of the medical equipment centre has been designed so that it caters for all the requirements of medical and scientific equipment from the procurement stage right through all the major phases of equipment management. The service undertakes commissioning of new equipment, planned preventive maintenance, calibration, safety checks, acquisition of spares and training of users.

As a training centre the medical equipment centre accepts also foreign students and has two training programmes - associate degree and vocational. One hundred and ninety biomedical equipment technicians from nine countries have graduated from these two courses up to 1986.

As the two above-mentioned functions are purposely integrated, the same technical staff who run the maintenance service are also managing the training commitment. Our experience shows that such training approach is more realistic than training in isolation from the hospital environment.

The training curriculum has been prepared and designed to produce not just skilled technicians but rather a health manpower able to function in the health care environment.

After the training, Bahraini students are automatically employed by the Ministry of Health for the Medical Equipment Centre where they undergo further training in Bahrain and abroad. Gulf students return to their countries and hopefully follow a similar career structure.

The medical equipment centre has been the subject of intensive national and international assessment and evaluations.

The Ministry of Health in Bahrain shares a cooperation agreement with the department of Clinical Physics and Bio-engineering in Glasgow and the Bahrain-Glasgow collaborative agreement has proved to be of great benefit and is likely to continue for the coming years.

2.3.2 Cyprus

In Cyprus the maintenance and repair of health care equipment is carried out by the department of electrical and mechanical services, which belongs to the Ministry of Communications and Works.

The scope of work of the department on activities related with the Ministry of Health also extends to the following functions:

a. Technical advisory service
b. Management of equipment
c. Retrieval information system
d. Replacement policy of equipment
e. Plant operation and maintenance
f. Maintenance and repair of specialized electronic installations and systems

The field training of the fellows of the World Health Organization at the regional training centre is also carried out by the department at four hospital workshops.
Maintenance and repair of health care equipment is carried out by personnel permanently placed at the workshops of the department in each district hospital (two in Nicosia, one in Limassol, one in Larnaca and one in Paphos). The same personnel are responsible for the maintenance and repair of health care equipment in all other hospital and rural medical centres within the respective district.

The coordination of the services offered by the various workshops is carried out by personnel attached to the headquarters of the department in Nicosia. The same personnel are responsible for:

a. Maintenance and repair of very specialized health care and laboratory equipment.

b. High level electronic support to all hospital workshops.

c. Coordination of the procurement of spare parts and implementation of the purchasing policy on spare parts.

d. Supervision of maintenance contracts established with private companies for the execution of the maintenance of health care equipment and other electronic installations found in the hospitals.

The maintenance schedule is organized in three parts, namely, user servicing, planned preventive maintenance (scheduled servicing) and repairs (unscheduled servicing).

Training of technician personnel is mainly carried out at the WHO/EMRO Regional Training Centre at the Higher Technical Institute, Nicosia. Other training is mainly secured through agreements with the manufacturers both for users and service staff.

2.3.3 Egypt

1. Main resources for effecting maintenance and repair

A. Manpower development institutions

Egypt has developed the following institutions for preparing the required manpower for management of medical equipment in health care facilities:

i. Systems and biomedical engineering department, Faculty of Engineering, Cairo University, which graduates biomedical engineers in the B.Sc., diploma, M.Sc. and Ph.D. levels. It was established in 1976.

ii. Department of medical equipment, Abbassia; which provides formal education for BMET (polyvalent two years course). The department is also giving specialized training courses for technicians and engineers. It has two satellite training/service centres in two hospitals. The department of medical equipment has been established in 1974 and remodelled in 1978 using technical assistance from the Clinical Physics and Bioengineering Department in Glasgow.

iii. Department of medical equipment, Assuit; same model as Abbassia - established in 1982.

iv. Department of medical equipment, Mansoura; same model as Abbassia - established in 1984.

B. Service centres

According to the 'Plan for Biomedical Engineering Services in Egypt' developed in 1980, Egypt has the following types of service centres under the Ministry of Health:

i. Service/training centres attached to the department(s) of medical equipment.
11. Regional service centres which provide BME services to all health facilities in a governorate. The Giza pilot centre is the one which is now replicated in three other governorates.

In addition there are many service centres that belong to private hospitals and manufacturers' agents.

2. Future needs

This may be summarized as follows:

1. Policy development: to cover the areas of incentives, career structures, legislation related to equipment, routine testing and equipment standardization.

11. Completing the maintenance and repair infrastructure countrywide.

2.3.4 Somalia

A government policy for the establishment of workshops in each of 18 regions has not yet been implemented. A centre for the repair and maintenance of medical equipment was established in Mogadishu as a WHO project. The objective of the project is to collaborate with the Ministry of Health in the development of a comprehensive workshop in order to organize a countrywide repair and maintenance service for all the equipment used in health institutions. Other project aims are to train technicians and assistants to perform repair and maintenance, to advise Ministry of Health on the procurement of equipment to actual needs of health facilities and to train users to operate the equipment and perform routine maintenance procedures.

The pilot workshop in Hargeisa (northern Somalia) which was closed due to the shortage of national staff was re-established by the project. Three other workshops are planned.

There have been short training courses within a WHO project. Training courses on X-ray equipment were held in 1984 and 1986 and one on laboratory equipment in 1986.

The Somalia government also receives support from Finland for the development of repair and maintenance services as a bilateral agreement.

2.3.5 Syrian Arab Republic

A. Existing facilities

1. The central workshop of the MOH was established in 1980. More than 30 engineers and technicians are working now in this workshop. The workshop handles a wide range of equipment up to sophisticated X-ray units as well as modern laboratory and diagnostic equipment. It is also responsible for the supervision of the performance of works carried out by the agents and other contractors as well as the inventory campaign for medical and other ancillary services equipment already taking place. The workshop is used as a practical training facility for educating the technicians in the course described below. The productivity of the workshop has increased noticeably in the last two years due to the extensive efforts provided by the MOH and the assistance of WHO.

2. Other workshops: According to the MOH five-year plan, the existing few workshops at some of the large hospitals will be developed. Around 150 engineers and technicians are already employed. The MOH started to concentrate on one pilot workshop that is the workshop at Damascus hospital.

3. The medical equipment maintenance and repair training institute: A two-year course on maintenance and repair of medical and other hospital equipment started late 1984 at the Intermediate Technical Health Institute in Damascus. Forty students are now attending this course.
Eleven students graduated in September 1986 and have started their work at MOH hospitals. The course is polyvalent but highly concentrated and is conducted in Arabic. Arabic technical literature for the course is being prepared, but joint efforts with other Arab countries have to be encouraged. This centre will eventually serve as a regional training centre for Arab-speaking countries.

4. Hospital design and equipment planning: This activity takes place at a governmental consulting company. The following tasks were conducted by hospital projects having in total more than 5,000 beds: equipment planning, technological studies, checking of architectural drawings, programming, preparation of tendering documents and specifications, supervision and commissioning, etc.

8. Future plans

The integration of the above-mentioned facilities together with other related activities is under discussion. The MOH has outlined its policy for maintenance and repair in its five-year plan.

2.4 Region of Europe

2.4.1 Finland

In Finland, in the tiered municipal health care system (health centres, central hospitals, university hospitals), there is already a long tradition of cooperation among the institutions at the various levels. The most prominent characteristic of this cooperation is the fact that it is voluntary; there is real motivation on both sides, and both sides benefit from their cooperation.

At the legislative level, the central hospitals (20 in Finland) have been given the obligation to arrange certain special services corresponding in essence to PHC, on behalf of the health centres. The National Board of Health has issued circulars in which it has gone into detail as to the application of the relevant acts and decrees. In regard to the legislation, it is interesting to note that, while the central hospitals are obligated to organize or provide the services in question, the health centres themselves may choose either to use the central hospital services or obtain these services elsewhere.

The maintenance of medical equipment is well organized through regional cooperation; for example, preventive maintenance can be arranged on the same trip for equipment both in the central hospital and in the health centres, which saves the repair technician both time and money. In Finland, maintenance services are found primarily in southern Finland, and then only in the large cities, which makes maintenance trips to eastern and northern Finland fairly expensive. Maintenance works best when procurement has been a joint venture, and maintenance activities are planned.

In part, central hospitals also directly provide maintenance services to the health centers. All central hospitals in Finland have a technical office or corresponding department, whose staff as necessary may make maintenance and repair trips to the health centres in the region.

Maintenance also forms part of regional quality control, for which the expertise is in the central hospital. An example of this system is the technical quality control of radiology equipment.

In some regions in Finland, the central hospitals have acquired back-up equipment, which is loaned to a health centre in case its own piece of equipment breaks down. The central hospital repairs the defective piece and keeps it in reserve for the next instance of breakdown. Transport can take place, e.g., as freight on the regularly scheduled bus lines, in which case delivery of the new, working equipment can take place in only a few hours.
2.4.2 France

Five hundred thousand of the nation's 700,000 beds are in the public sector hospitals which are self-governing regarding management and maintenance of the equipment. However, hospitals must purchase approved listed equipment; this homologation is given by the Ministry of Health after technical and clinical tests on compliance with standards, security of patients and users, suitable for intended use and after examination of quality control rules used by manufacturers.

The CMEN, National Centre for Hospital Equipment, is a technical advisory centre for both government and hospitals in the fields of informatics and medical technologies. The centre recently conducted a study on the maintenance situation, the cost of which represents one percent of total annual running expenses and roughly half of the annual purchases of medical equipment. Twenty percent of the 100-300 beds category hospitals have a specific facility for maintaining medical equipment. The figure is 95 percent for the 600-1,300 beds category and 100 percent above 1,300 beds. The maintenance cost per bed varies from 2,900 francs to 5,300 francs per year with a global mean value of 3,500 francs.

The maintenance situation is influenced by the proximity of suppliers which can offer maintenance on a contractual basis. With only 100 engineers, 500 technicians and 800 craftsmen, French hospitals can afford the maintenance in close cooperation with manufacturers. The compromise between in-house maintenance and maintenance done by manufacturers has proved to be successful. The level of maintenance done in-house varies according to category of equipment. It is quite low for X-ray equipment and higher for intensive care equipment where a quick reaction is needed.

A clinical engineering programme in the University of Compiègne and the National School for Public Health established in 1974 operates at Masters' level for graduate engineers and has been attended by 80 percent of French clinical engineers. The University of Compiègne also offers an intensive bilingual (French/English) training programme for clinical engineering and many specialised short courses. The number of students from developing countries is constantly increasing.

International technician training is provided in the Higher International Institute for Training of Health Personnel established by the Civil Hospitals of Lyon under the aegis of WHO since 1984. The aim of the course is to train specialised technicians to carry out basic routine installation, maintenance and repair of the entire health care equipment. There are about 20 students per year following a nine-month course plus one month on-the-job training which leads to a Hospital Maintenance Technicians Certificate recognized by WHO. The course is attended by the students from French-speaking developing countries and by French technicians from the Bioforce Development Group (Lyon) who are willing to work in the field of maintenance and repair in developing countries.

2.4.3 Italy

The Italian health system is run by the local administrations of the 20 regions in which the national territory is divided. Health delivery is provided by 665 local health units with populations ranging from 7,528 to 1,634,638 (1981) with some degree of administrative and organisational autonomy supervised by the regional health department.

National Law 813 of December 1978 concerning the establishment of the National Health Service does not specifically mention activities, services or departments in clinical or biomedical engineering. The need for development of clinical engineering activities in Italy has been underlined on many occasions by university and research organizations as well as by the Trade Unions.

Activities in clinical engineering started in Italy in 1973 when the University Hospital of Bologna (region of Emilia e Romagna) established a bioengineering department which is organized to provide the three following services: technical assistance, teaching and training, research and development. The regional health programme of Emilia e Romagna plans a department of this type for every 1-3 million inhabitants of the region. Another activity in the same region is carried out in the city of Parma within a joint medical
physics and bioengineering department and provides technical services to an 1,850 bed hospital. In the region of Friuli-Venezia Giulia a large medical equipment department providing clinical engineering services to the local health unit of Trieste was established in 1978. Clinical engineering services are carried out at the Niguarda Hospital in Milan (by a branch of the general Technical Services Department) and in the cities of Trento, Modena and Rome. Also clinical engineering activities are reported in other regions in which regional health departments supervise the provision of health delivery in 645 local health units. The experience of these departments demonstrates economies, improved effectiveness, higher safety and better productivity but the country's economic problems have prevented general application of this experience.

Universities have well-oriented courses in biomedical engineering and there are two Ph.D. courses. Clinical engineering courses should commence soon. In the medical faculties there are special topics in biomedical engineering within the curricula.

The problem of clinical engineering has been considered in a special project of the national research council which includes sub-projects on biomedical technologies evaluation and purchasing, maintenance and management of biomedical instrumentation; this covers inventories, databases, correct use of equipment and education of technical personnel for preventive maintenance and included the production of many manuals. The National Research Council defined a strategic project concerned with all aspects of activities in developing countries with special attention to biomedical engineering. An example of this support was the interregional course on the maintenance of equipment organized in Addis Ababa by WHO, IFMBE and DANIDA with the participation of the National Research Council.

2.4.4 Sweden

Twenty-six independent county councils are responsible under governmental supervision for the provision of health care. Practically all health care is public and financed by local taxes to 2/3 and to 1/3 by the state and patient fees. Approximately 10 percent of the GNP is allocated to health care. About 450,000 persons work full-time or part-time in this sector. Every day 105,000 patients are cared for as inpatients in hospitals and 50,000 patients in home-care. Every day the doctors meet 75,000 out-patients and the district nurses 30,000. Every day 1,500 operations are performed and 15,000 X-ray examinations are made. The number of PHC centres was 790 in 1985. Hospitals with more than 500 beds were 70. In eight of the 26 county councils there are regional hospitals with all kinds of specialities. The remaining hospitals cooperate with regional hospitals. All health care activities are supervised by the National Board of Health and Welfare, which is a governmental body under the Ministry of Health with the right and obligation to inspect the health care services given. The Board also performs planning on a national level. Another important organization for development and planning is the Planning and Rationalization Institute for the Health and Social Services (SPRI), which is owned jointly by the state and the county councils.

There is no specific national policy for equipment although there are supervisory bodies which exercise control of safety aspects and further controls are being planned. The Planning and Rationalization Institute for the Health and Social Services (SPRI) has developed a system for identifying medical equipment - the SPRI Code which covers 25,000 articles. Of these, 15,000 articles are of disposable and consumable types and 10,000 represent various types of equipment. In several hospitals data recording systems are being developed. Sweden is for the moment planning on introducing a control system of all medical equipment including disposables and other devices. Accidents and incidents with equipment are currently reported to the Advisory Board of Medico-technical Safety. This advisory board investigates the reports, analyses the events and presents a recommendation that can lead to a modification of the equipment, an improvement of maintenance procedures or better staff training.

It is estimated that the annual expenditure on equipment maintenance is about two percent of the capital cost, at current prices, and that this is equally divided between the purchase of service from manufacturers and the provision of service from 30 departments of clinical engineering. There are about 600 engineers and technicians in the employment of the
county councils and 300 providing service from the industry. Their competence ranks from a non-trained technician to engineers with a doctors degree. The staffing of the clinical engineering departments varies from three to 40. An inquiry from the Planning and Rationalization Institute for Health and Social Services (SPRI) about the activities in four county councils shows that medical technical departments use their resources as follows:

- Maintenance (preventive and repair) 48 percent
- Research and development 16 percent
- Education of health care personnel 13 percent
- Purchasing 10 percent
- Administration 13 percent

100 percent

In two colleges (pupils 16 years upwards) there are four year courses in clinical engineering and four out of five Swedish universities offer programmes for Masters or higher degrees in clinical and biomedical engineering. A foundation supported by the Swedish Association of Suppliers of Hospital Equipment, the National Board of Education, the Federation of County Councils, certifies technicians capable of servicing equipment and the professional associations arrange further education and training for their members. There is a perceived shortage of staff to raise the standard of maintenance to the desired goal.

2.4.5 The United Kingdom

There are some differences between the administrative arrangement in the four countries - England, Wales, Scotland and Northern Ireland - but in general the National Health Services (NHS) are the responsibility of authorities which are independent, within national constraints on wages, safety, etc., but are strongly influenced by advice from the central Government departments which provide their funds. There are two tiers of authorities in England (14 regional health authorities over 191 health authorities) and one in Wales (9 health authorities), Scotland (15 health boards) and northern Ireland (4 health and social service boards).

In England and Wales, an issue of health equipment information (No. 98 January 1982) from the ministries gave advice on the management of equipment, broadly along the lines of the working papers for this meeting; similar advice from the other ministries is being prepared. This is, in effect, a national policy, but implementation remains variable across the country.

There is no single, nationwide HCTS. Technical services are provided by most authorities but the pattern varies. Everywhere the management of hospital estate, buildings and plant is the responsibility of hospital engineers who are organised within a clearly defined infra-structure in the national health service. Originally there were graduate engineers or technician engineers who were essentially managers, and craftsmen (plumbers, electricians, etc.) who did practical work under their instruction; when they undertook responsibility for clinical equipment the engineers normally arranged for manufacturers to service or maintain it. In some places (in recent years) the range of expertise has been extended by the employment of technicians and technologists, and by the upgrading of draft skills, to undertake in-house servicing of clinical equipment.

In other authorities, particularly in Scotland, the departments of clinical or medical physics which were originally concerned with radiological problems have been expanded to include bio-engineering, in particular the practical management of clinical and laboratory equipment. For this they employ graduate scientists and engineers, technician engineers and sometimes a few craftsmen. Where clinical physics and bio-engineering departments are strong the hospital engineering departments may be relatively lightly involved in clinical equipment, and vice versa. Although co-operation is good in some places, there is friction in others. Overall, there is still substantial reliance on contact with manufacturers or their agents: usually these sources of help are close to the users, can respond quickly and are not unreasonably expensive.
The private health sector remains relatively small and, for high technology, mainly parasitic on the public sector.

The pattern of technological education and training which was established in the 19th or early 20th century is still visible, although gradually changing. Graduates follow a general engineering or scientific course at undergraduate level and may possibly undertake more specific, task orientated work for a higher degree: they will gain most of their practical experience of the health care field during their first employment in the NHS. This practical experience will probably involve specific training schemes operated by employers but will also be structured to allow individuals to gain membership of an appropriate professional Institute. Technician engineers and technicians are likely to receive a general technical education and specific job-orientated training concurrently. They will receive day-release or block release from their work to attend a higher education college where they will study for a nationally approved certificate; during the remainder of the working week or year they will gain practical experience under the supervision of experienced staff. Increasingly, this working experience is being acquired in structured schemes of training approved by professional institutions. In addition to their basic training which is carried out at local level (and which is therefore more readily provided in large centres of population) there are training centres which provide in-service training of a more specialized or advanced nature.

The NHS Training Authority's Hospital Estate Management and Engineering Training Centre at Failfield provides in-service training courses on a wide variety of specialized subjects. The Centre was founded in 1969 by the Department of Health and Social Security (England and Wales) to train craftsmen and engineers in the health service, on subjects related to health care engineering. Since its inauguration it has developed over 60 different short courses on health care engineering and estate management. However due to demand and NHS requirements the mainstream engineering training has evolved in three areas: sterilizer maintenance and performance testing; piped medical gases; electro-medical and patient-connected equipment. To ensure adequate training on these subjects the Centre now offers courses on first line maintenance, fault finding and management control of equipment. These courses which were originally for the National Health Service in Great Britain are now available to private industry and to the health services of all nations who require training in the maintenance of medical plant and equipment. Courses are also designed to suit the training needs of hospital staff on their own site. The subjects covered by this facility include, sterilization, piped medical gases, electro-medical equipment, refrigeration, automatic controls, boiler house practice, electrical supplies, electronic devices and other related subjects. Courses are pitched at various levels ranging from technical updates for professionals and managers to essential and basic skills for operational staff, through to appreciation courses for non-technical staff.

Some of the larger Departments of Clinical Physics and Bio-engineering, such as that at Glasgow, also offer training and experience-attachments to engineers and technical staff from developing countries and are prepared to support in-country service and training centres. The Department provides courses of systematic instruction in radiological physics, radiotherapeutic physics and radiobiology in addition to a wide range of short courses of in-service training for nursing and other staff. A technician training scheme provides instruction, training and experience, in conjunction with day-release courses in applied physics, mechanical, electrical or electronic engineering. Systematic training is provided in Basic Physics by rotation through several specialities. From its earliest days the Department has been host to professors, lecturers, engineers and technicians from scientific, engineering and medical backgrounds from across the world; in recent years from Algeria, Brazil, China, Cyprus, Ethiopia, Iman, Iraq, Israel, Korea, Malaysia, Mexico, Nepal, New Zealand, The Philippines, Saudi Arabia, Sri Lanka, South Korea, Thailand, Turkey, Vietnam and Zimbabwe. Training is most often requested in repair and maintenance of medical and laboratory equipment (bio-engineering servicing), nuclear medicine and radiotherapy physics. Since the late 1970s it became deeply involved in two overseas development projects in Egypt and Bahrain and some of the department's staff are located in these countries under technical cooperation agreements with the governments of those countries funded by the UK Overseas Development Administration and the State of Bahrain respectively. These activities are supported by Glasgow-based teams appointed for the purpose as well as the general resources of the department. In addition to direct support for specific development projects, staff
from the Department have also visited many other countries as consultants to the British Council, the World Health Organization, the Commonwealth Secretariat and others. These missions have mostly been to give advice on the maintenance of medical equipment, the training of servicing personnel, and sometimes the selection of equipment. In recent years visits have been made to China, Cyprus, Ghana, Iran, Iraq, Israel, Kenya, Malaysia, Pakistan, Portugal, Saudi Arabia, Somalia, South Korea, Sudan, Swaziland, Thailand, Turkey and Yemen.

2.4.6 The USSR

A uniform national policy exists throughout the USSR. Health care facilities are provided with medical equipment manufactured in the USSR and in the Member States of the Council for Mutual Economic Assistance (CMEA) with a lesser amount of equipment imported from other countries. An All-Union Organization, Souzmed Technika, is responsible for providing health facilities with medical equipment and for its maintenance and repair through the Union Republic's main boards for medical equipment. Boards for medical equipment are found at the regional (oblast), district (rayon) and city levels in every Union Republic. These Boards have factories to produce equipment, shops to sell it, installation teams as well as maintenance and repair stations.

The training of engineering personnel for health care is carried out in a few of the main technology institutes in Moscow, Leningrad, Tomsk, Tbilisi and some other cities. Bio-physicists are trained in the Second Moscow Medical Institute, with specialized bioengineering teaching. Medium-level technicians are trained in medical equipment maintenance in a number of technical schools in Moscow, Leningrad and other cities. There are also courses for advanced training of craftsmen in a number of institutes. New courses are being devised for medical, engineering and technical personnel working with complex modern medical equipment.

For equipment delivered to developing countries, maintenance and repair is carried out by the organization which supplies the equipment, the period of maintenance depending on the complexity of the equipment.

2.5 Region of South East Asia

2.5.1 Bangladesh

No declared national policy on maintenance and repair exists, although with WHO assistance Bangladesh is in the process of establishing a National Electro-Medical Maintenance and Training Centre, under the project started in 1983 for which US$14,000 has been assigned for 1986/87. The Centre is staffed by technical management, assistant engineers and technician staff. So far, a total of 192 technicians, including 129 laboratory technicians from Upazilla Health Complexes and 63 senior technicians from modernized Sadar hospitals were trained.

Maintenance and repair activities have started in hospitals on basic equipment, within the available resources. A survey of equipment for the Dhaka area has been completed and work is in progress in other areas of the country. Training for some of the service personnel for the above Centre has already begun.

2.5.2 Indonesia

Under the national five-year plan a budget allocation exists for the maintenance and repair service operated by the directorate for health facilities under the Ministry of Health. Funding may also be secured from the international agencies, such as the Asian Development Bank (ADB), and other governments. The purchase of equipment is handled by a procurement committee and under the purchase contracts, provision is usually made for maintenance cover for a certain period and factory training for sophisticated equipment.

The HCTS is staffed by engineering and technician staff in central or provincial hospital workshops, which are equipped with tools and test instruments. An inventory of equipment exists and under the directorate of general food and drugs safety, legislation, certification, testing, evaluation and approval of equipment is performed. An equipment information data bank is in preparation.
A notional training establishment is available and caters for various specializations and levels of personnel, mainly technicians, although an engineering course is being planned.

2.6 Region of the Western Pacific

2.6.1 Malaysia

The formation of the engineering programme in the Ministry of Health (MOH) was approved in 1980. The fact that the engineering programme was approved is, in itself, an acceptance of the maintenance policy for health care equipment by the Ministry. The director of the engineering services is involved in decision and policy-making at ministry level.

The Ministry has accepted the staffing requirement and in early 1986 approved a number of additional posts to strengthen the engineering department. The need to improve the infrastructure for the health care technical service was realized, and in 1984 a functional design brief for the state hospital engineering workshops in Malaysia was prepared by WHO consultants. It is recommended that all the workshops in the country be classified into four different levels (level 1 to level 4) and be equipped accordingly.

With regards to training, a few engineers have been sent overseas (e.g., Falfield) for training on specific subjects, under the sponsorship of the MOH, fellowships from WHO and the British Council, etc. Training has also been incorporated in contracts for procurement of new equipment and a few technicians have been trained in this manner for the last few years. These people who have acquired some knowledge during these trainings are then required to serve as trainers and organize training for the other local technicians.

A central workshop (in Seremban) was also proposed by WHO and it started to organize some training for local technicians. The central workshop could not carry out its activities effectively and achieve its full objectives because of certain constraints like unsuitability of site, lack of training facilities, lack of full-time staff to run it, etc.

The percentage of the budget allowed for maintenance out of the total allocation has remained low but has shown a trend of steady increase (except for 1985) for the last four years. Specifically in 1983 it amounted to 1.5 percent, 1984, 2.38 percent, 1985, 2.28 percent and 1986, 3.19 percent.

2.6.2 Philippines

No adequate national policy exists which is highlighted by the fact that no definite budgetary allocation is made for the Biomedical Engineering Division of the Radiological Health Service in charge of maintenance and repair. Due to the lack of planning, coordination and adequate management and career structure, qualified staff are leaving to go abroad and new lower level staff cannot be engaged since no provision for new staff posts exists. Staff remaining due to lack of career and incentives are engaged in private practices. Bad communications and unavailability of vehicles prevents service cover to hospitals away from the central workshop.

The Biomedical Engineering Division within the Radiological Health Service was established in 1978 to operate as the main centre for maintenance and repair of health care equipment. The present set-up is adequately equipped and capable of carrying out maintenance and repair of standard equipment. However, staff do not have enough training and experience to service higher technology equipment. Workshop personnel consist of ten service engineers and technicians. Four of these specialized in X-ray equipment, three in electro-medical and laboratory equipment, one in refrigeration and air conditioning equipment and two do mechanical jobs. At present, some 75 percent of the workload is on diagnostic X-ray equipment although work output and quality are still improving with most of the gains in electro-medical and laboratory equipment rather than X-ray. A preventive maintenance programme was started in 1981 and a survey has commenced in order to start a policy of preventive maintenance.
A national training programme was set-up in 1979 and the Radiological Health Service premises were selected to serve as the main centre for the training. Course syllabus and training schedules were prepared by the consultant and selected local instructors. So far, five courses on X-ray, electromedical and laboratory equipment were organized with WHO support with 10-12 trainees for each course. An added benefit to this training programme was the improvement in instructors capability of the service personnel involved in the training. However, due to the introduction of newer equipment models using modern technology, a need to upgrade instructors and technicians present knowledge and capabilities is very necessary in order to cope with the present situation. Further to this would be to upgrade training equipment and facilities.

3. Commonwealth Secretariat

In the experience of the Commonwealth Secretariat large investments are made by governments in the acquisition of health care equipment. However a large wastage of resources results due to incorrect procurement, inappropriate external aid and taxation and lack of effective national coordination and infrastructure in operating and servicing equipment.

Certain notions have to be recognized in order to improve the situation. One is that of basic equipment lists reflecting the medical function for which they are intended for should exist. Such lists will assist health planners, administrators, financiers in ensuring that health personnel are supplied with correct equipment for the particular purpose they are purchased for.

Another concept is the appreciation that equipment are not used in isolation but that an integral equipment cluster system exists. This situation requires that all the essential equipment of the system are available and functioning correctly.

Many of the problems begin at the acquisition stage because no corresponding policy exists and at this phase technical and expert advice usually is available. The problem may be ameliorated if basic lists of equipment are available according to function and proper tender and specification documents are available.

Manufacturers contribute to the problem since they do not usually offer 'after sales service' to developing countries. An ethical code should be agreed upon and local agents be responsible to provide service, spare parts and technical support.

The national HCTS should be properly equipped and staffed with adequate career structure and training for its staff. User training should also be made available. Standardization, technical expertise and proper liaisons between the interested parties will reduce waste and make the system more effective.

4. Council for Mutual Economic Assistance (CMEA)

In 1971 seven CMEA member-states, Bulgaria, Hungary, the German Democratic Republic, Poland, Romania, the Soviet Union and Czechoslovakia, signed an agreement on technical and research cooperation on "The creation of biomedical equipment and apparatus for medical research and clinical medicine". In 1983 the Republic of Cuba joined the above agreement.

An agreed programme covering all types of medical and health care equipment serves as a basis for such cooperation. The main objective of the programme is a joint policy related to medical equipment creation, production, distribution and maintenance with avoidance of unnecessary duplication. The programme is carried out according to countries' specializations.

The maintenance and repair of the equipment delivered to developing countries by CMEA member states is carried out by the organizations which supply the equipment. The period of maintenance depends on the complexity of the equipment.
5. **International Federation of Hospital Engineering (IFHE)**

The IFHE was founded in 1970. It is a grouping of 24 national associations and, in addition, individuals, non-profit organizations, manufacturers and firms, in all, more than 10,000 persons. Its main objectives are: promotion, development and dissemination of hospital engineering technology, comparison of international experience, promotion of the principle of integrated planning, design and evaluation by improved collaboration between the professions, the promotion of more efficient management of operations, maintenance and safety of hospitals, their engineering installations, equipment and buildings and collaboration with other international organizations. It holds an international congress every second year and publishes the journal 'Hospital Engineering'.

In 1979 and 1982 the Federation promoted the organization of "Seminars on Appropriate Technology" in Falfield, UK, by participants from many countries. The seminars were designed for senior graduate engineers with management responsibilities, employed by national governments to plan, coordinate and manage services in health care facilities. Conducted by a highly qualified faculty of experts, the seminars have proved a good success and would be repeated.

In 1986 the first courses on "Hospital Architecture and Engineering" were organized by the Spanish and Portuguese federated associations. The courses were held last October in Lisbon, aimed at Spanish- and Portuguese-speaking engineers and architects, and intended as a first approach to South-American and African countries.

IFHE wishes to collaborate with WHO to form new training centres and to play other parts in the training of engineers and middle-level technicians from developing countries.

6. **International Federation for Medical and Biological Engineering (IFMBE)**

The IFMBE which was established in 1959 is an affiliation of 30 national societies with a present total membership in excess of 7,000. Its objectives include the stimulation of international cooperation and collaboration on medical and biological engineering matters, the encouragement of educational programmes to develop scientific and technical expertise in these fields, the fostering of research and application of medical and bioengineering in support of life quality and cost-effective health care.

The activities of IFMBE include the publication of the Journal of Medical and Biological Engineering and Computing and the organization (in collaboration with the International Organization for Medical Physics) of an international conference every three years. It has constituted a special division in clinical engineering and has been concerned to establish close liaison with developing countries to encourage the development of medical and biological engineering and particularly the training of clinical engineering personnel. It is working with other international organizations to establish national and regional training centres.

IFMBE has had official relations and good contacts with WHO since 1964. It collaborated with the WHO/EURO office in a survey of centres for testing and evaluating medical devices, with WHO/Genève with respect to planning joint activities in developing countries and in May 1985 it participated in technical discussions on collaboration with non-governmental organizations in implementing the global strategy for Health for All.

After visits by Professor Bracale, Chairman of IFMBE Developing Countries Committee to Kenya, Ethiopia and Yemen, a WHO-DANTIDA-IFMBE course on 'Control, Preventive Maintenance, Repair and Management of Basic Laboratory Equipment' was held in the National Institute of Health, Addis Ababa, Ethiopia, in April 1986. The twelve participants from Ethiopia, Yemen, Egypt and Sudan included laboratory technicians, technical service personnel and administrators. The contents were 30 percent theoretical and 70 percent practical.
7. UK Overseas Development Administration (UKODA)

The British Government aid agency, the Overseas Development Administration (ODA) gives support to health care development in many countries; in several countries this has included specific projects for developing repair and maintenance facilities and/or providing training centres. Many training fellowships are provided through the British Council.

In a bilateral programme with the Arab Republic of Egypt, ODA supported the development of the training centre at Abbassia, Cairo, and is currently supporting the development of service centres throughout Egypt. Other current British-aided projects with substantial repair and maintenance components are in Pakistan, Ghana, Nigeria, Uganda and Gambia.

8. Coulter International

The Coulter International organization, with headquarters in Miami, Florida, USA, is represented in the majority of countries throughout the world. This representation is either by Coulter companies and offices, or distributors and agents. This network offers after sales service for all Coulter instrumentation in the haematology, clinical chemistry and fine particle fields.

With over 20 years experience in providing technical services to many of the developing countries, it is felt that we can make an essential and useful contribution in forums such as this. Only by close cooperation between manufacturers and international organizations such as WHO, can solutions be found to the many problems in maintaining health care equipment in the developing countries.

Criticism has been made with regard to the reluctance of manufacturers to release technical information to end-users and support bodies. It must be remembered that large sums of money are invested by manufacturers in research and development and competition is intensive, so that a certain amount of confidentiality has to be considered.

Another point is that the preparation, production and printing of technical manuals for sophisticated electronic equipment is expensive and requests for multiple documentation on a "Free of Charge" basis, have to be considered with regard to cost.

Taking into account the above comments, Coulter are willing and indeed anxious to cooperate with international organizations in supplying information and, where possible, practical assistance in providing technical services for their equipment in the developing countries.

9. IAL, UK

IAL, a wholly owned subsidiary of British Telecom, has wide experience of operating and maintaining technical facilities associated with airports, hospitals, computer and communication networks throughout the world since 1947. IAL currently employ 325 hospital technical staff who are maintaining and repairing medical equipment, installed building services and the fabric and fittings within hospitals and healthcare facilities in five countries. IAL own and operate a training centre specializing in the training of overseas students in technical subjects. Internationally recognized qualifications are awarded by the college.

IAL's approach is one of flexibility to suit the needs of the client. Its policy is to encourage the employment and development of local technical staff. Today less than half our staff are expatriates. Various options are available.

IAL's technical staff can be seconded into a client's organization in order to provide basic maintenance and can provide specialists to upgrade the level of the client's existing maintenance function and to undertake skill training of the client's staff.

IAL can offer a comprehensive maintenance contract for medical equipment and technical services.
Whichever option is adopted, IAL's long experience of maintenance in 'difficult' environments, independence of manufacturers and product ranges, its training facilities and professional approach ensure that an effective solution matched to client requirements will be provided.

10. Medicor Training Centre, Hungary

Medicor is the largest company in Hungary manufacturing and supplying biomedical equipment both for the domestic and external market. It has approximately 7,000 employees, six factories, a research and development institute and export/import departments.

It has been training Hungarian and foreign technicians since the late fifties and in 1974 organized a training course for UNIDO employees. In 1978, with the mutual agreement of UNDP, UNIDO as executive agency and the Hungarian Government, a training centre was established. It has trained approximately 900 Hungarian and 3,000 foreign servicemen in the repair and maintenance of biomedical equipment. At present it covers X-ray technology, electro-mechanical, medical electronics and laboratory instruments.

The staff of the centre has developed into a group of professionally skilled, devoted and versatile technical instructors. There is nationwide cooperation with public health institutions and also with the Medicor research and development institute. There are laboratories fitted for training purposes and up-to-date technologies such as video films for training, computer-aided teaching and visual aids are employed. Manuals, lecture notes and textbooks have been written and published.

New ideas and developments are being introduced at an ever-increasing rate and there are plans for future developments to meet the challenge of new technologies, the needs of foreign trade partners and of developing countries.

11. Philips International

The main aspects of the service provided by Philips International are installation and after-sales service which includes application and operation training. At present there is a shift from corrective service to preventive service and customer consultancy. Preventive service under the service contracts includes preventive maintenance visits. Preventive maintenance eliminates extra costs and leads to the main objectives of the service which are top performance, operational security and image quality. Future developments in new technologies and digitized data require more intensive relations between customer and supplier.

12. Siemens Medical Training Centres

The worldwide network of the Siemens Medical Service stations ensures a highly viable maintenance and repair organization for medical health care equipment. The training of personnel is a main prerequisite for the safe operation and maintenance of equipment. The expertise of our technical staff is maintained and further developed by product-oriented courses in the worldwide network of training centres. In addition to Europe, their locations are as far-ranging as the United States and Asia - Europe: Stockholm, Erlangen, Milan, Ulthoorn NL, Paris, Madrid; the Americas: Chicago Ill., Iselin NJ., Walnut Creek California; Rio de Janeiro; Asia: Bombay, Singapore, Tokyo. During fiscal year 1985/86, 99 instructors were employed full-time. Three thousand nine hundred Siemens service technicians attended basic and advanced courses. The combined number of training courses worldwide covered 90,783 participant-days. Nine percent of this total training volume was used by the technical staff of our customers who attended special courses. The customer personnel training courses offered are mainly intended for medical technicians who take care of the Siemens products in clinics and technical service centres. For the implementation of the training courses, they are supplied with the necessary training units, servicing and measuring facilities. In addition, the participants are provided with such training material as operating instructions, technical documentation and the required wiring diagrams. Medical equipment made available for training purposes equals the installation volume of a large hospital.
The modular system of training is designed to provide such personnel with both the opportunity and means to acquire the knowledge and skills necessary to carry out responsibilities demanded of them, as individuals and as members of working groups. Based on 40 years of experience, this modular training system was developed corresponding to all requirements of personnel training for health care equipment.

Each course comprises a number of appropriate training modules which, in turn, contain a number of training elements. Training modules are uniformly structured to ensure completeness and to facilitate learning. Visual aids of the highest quality are widely used. Exercises and tests are periodically reviewed and checked before each course, to confirm that they meet the training objectives:

- The participant should be familiarized with the design, functioning and application of Siemens products.
- The training should enable them to put these units into operation, to monitor their functioning and to carry out the inspections and adjustment specified in the operating instructions and checklists.
- Moreover, they should be in a position to carry out repairs in the case of breakdowns and/or to submit a detailed fault description to our technical service.

The modular system is subdivided into the following major groups: Basic courses: Introduction to product areas; Product courses - with focus on product maintenance and service. These courses constitute over 90 percent of the offered courses; Courses for technical managers - with focus on advanced managerial training; Practical service application with 50 percent of the course hours spent on practical application, such as measurements, adjustments and trouble-shooting and instructor seminars focusing on teaching methods which are offered by a separate Siemens Centre for Education and Training. Time requirements for basic training are approximately 40 to 60 training days according to product area; 21 training days per service technician; 505 man days for field service technicians and the technical training centres, and for advanced training an average of 21 training days per service technician, that is approximately 10 percent of the total number of working days per year. The number of days spent in the classroom by instructors and course participants worldwide, equals 505 man days annually. Course descriptions are available for each course module. They give details of training objectives, outline of course content, participants' prerequisites (entry standards), course duration, course location, instructional material and trainee's progress evaluation.
ANNEX II

Working Paper No. 1*

THE MANAGEMENT OF HEALTH-CARE TECHNOLOGY

Index

For easy reference, sections and paragraphs are numbered consecutively throughout the three linked working papers 1, 2, 3.

Working Paper No. 1

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SECTION 1

INTRODUCTION

1. This is the first of three linked papers which concentrate on the problems of developing countries, whose GNP is low and who do not have a strong manufacturing engineering base. The wealthier, industrialised nations may experience some of the problems described below. They may make some of the same mistakes but they usually 'buy' solutions; this wastes resources, and even these countries may profit from the lessons which should emerge from this meeting.

2. The problems which arise from inadequate provision for the management of health-care equipment will be familiar to all delegates. The symptoms are seen in most of the hospitals and other health-care establishments in the majority of countries; they are most evident in the larger, public-sector facilities. They are less troublesome in some university, private or mission hospitals where staff may be more effectively motivated - whether intellectually, financially or emotionally.

* Working paper No.1 was prepared for the meeting by Professor J McKie, Director, West of Scotland Health Boards' Department of Clinical Physics and Bio-Engineering and Professor of Clinical Physics, University of Glasgow.
3. Although the symptoms are familiar and are often described, the root causes of the disease are seldom probed. Instead of a searching analysis, one or two deficiencies are recognised, often by visiting "experts" who have noticed the lack of a provision which is familiar to them in their homeland; sometimes the same lack may be identified by a national who has returned from a period in the richer, industrialised environment. The country is then encouraged to remedy this one particular deficiency - perhaps with the help of WHO - and much time and many scarce resources are wasted before it is realised that the disease has multiple causes. To remedy only one or two is as ineffectual as building only one or two spans of a multi-span bridge.

4. The deficiency most commonly recognised is the lack of "technicians". In an industrialised country with a well-established health service, it will be seen that the user can call upon some type of "technician" whenever equipment requires service or repair. In the developing country there is no such technician who can be summoned. It will therefore be argued that the problem is lack of technicians and the solution is to establish a training scheme to produce them. This will be difficult, because there will be a lack of "professionals" in equipment management in the developing country, as there is in some developed countries also. After much effort, and perhaps, employed, but the typical outcome, after a year or so, will be a dispirited group of young men housed in a dirty, untidy basement or poorly-built room which houses dusty, rusty machines and incomplete test-gear and which is littered with partly dismantled, broken-down medical equipment which will never function again. Upon the arrival of the WHO visitor there may be a half-hearted pretense of work but investigation will show that no-one knows what they should be doing, or if they did, they could not get the parts needed, or they had no circuit diagrams: the man who used to be in charge has not been seen for months, it is thought he may have emigrated. Enquiries amongst the medical staff will show that there has been no confidence in the repair capability of the "workshop" and no expectation of regular service from it. The administrative responsibility for the staff may belong to another branch of the public service, such as the Public Works Department. The whole scheme will have been abortive, because although the provision of technician training is a necessary part of the remedy, it is useless if other deficiencies are not recognised and corrected also.

5. This meeting should identify all of the provisions which contribute to the efficient management of health-care equipment. Some of them are essential if a maintenance and repair service is to be viable and useful; others may not be vital, but will add to the efficiency, economy and safety of equipment usage. The cost of the required resources may appear alarming when the country's health-care is under-funded, but the waste which results from the provision of equipment without such supporting services is substantially greater. The need should be thought of, not as additional finance, but as correct allocation of available finance.

SECTION 2

THE SYMPTOMS OF INADEQUATE MANAGEMENT OF HEALTH-CARE EQUIPMENT

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Unsuitable environment

Inappropriate equipment

Inoperable equipment:
- equipment inoperable when received
  - due to manufacturer's fault
  - due to fault in specifying or ordering
  - due to damage in transit
  - due to customs
  - due to handling by an intermediate supply organisation
  - due to inappropriate facilities for use
  - due to lack of user experience
  - due to lack of tools and knowledge of tools needed
- equipment unusable because necessary consumable supplies or accessories are unavailable
- equipment unusable because donors have failed to evaluate local conditions
- equipment which has become defective and unusable:
  - equipment defective, awaiting service agent
  - equipment defective - no source of commercial servicing
  - equipment defective - awaiting in-house servicing repair
  - equipment defective because poor quality equipment was ordered
- equipment which is defective but which could be restored easily and cheaply

6. Introduction

Each participant who has worked in developing countries or who has visited them as a consultant will be able to relate experiences which have evoked sorrow, despair, anger or, sometimes, laughter. The time allocated to the meeting could be fully occupied by anecdotes which would merely reveal that the symptoms of inadequate management of equipment are the same and are widespread everywhere.

7. Basic equipment in need of simple repair

Perhaps the most revealing symptom is the condition of simple equipment, whose maintenance and repair requires only basic craft skills and simple materials, which are often not specific to the equipment:
- trolleys with broken castors
- suction sets with broken glass bottles
- sphygmonanometers with perished rubber tubing, blocked leak-valve, leaking mercury,
- simple colorimeters with broken lamp-bulbs.
8. Many other examples could be given of failures which undermine basic health-care provision and which are evidently not attributable to lack of necessary skills or of training in specialised technology. In nearby streets there will be many artisans effecting more complex repairs to cars and domestic appliances using the same skills necessary for the hospital repairs. The market-places will produce the wheels, metal, glass tubes, bottles and light-bulbs needed: such specialised knowledge as is required to instruct the craftsman will be possessed by the specialists who use the equipment. Thus the skills and the supplies are available, but are not used. These symptoms point to a failure of financial and manpower management which must be rectified before more complex, technological solutions can be usefully undertaken.

9. Poor performance of equipment which is in use

The attention of the visiting consultant will usually be directed towards equipment which has failed, has been taken out of service and is in need of repair. But a perceptive visitor to the working areas of hospitals will see that much equipment still in use is not functioning efficiently or being used adequately.

- Sterilisers with broken gauges or recorders, and leaking seals.
- X-ray equipment producing radiographs not of diagnostic quality.
- Anaesthetic machines with serious leakage of gas.

10. Why does the user tolerate this situation?

He may - fail to appreciate the significance of the fault: staff engaged in repetitive task, e.g. in a central sterilising department, may be ignorant of the reasons for the laid-down procedure and may be inadequately supervised, so that they follow their routine oblivious to the hazards.

- lack any sense of responsibility for quality of work.
- lack the 'status' to report the faults or insist on repair.
- know from experience that requests for repair will be lost in the administrative bureaucracy.
- know that no effective repair or replacement will be provided, even if this is attempted.

11. Mis-use of equipment

It is also commonplace to find that equipment is being mis-used, or that there is neglect of the basic care needed to keep it in good working condition. Simple cleaning is neglected, dust-covers are not used in a dusty environment, fragile accessories are not properly protected, leads are not properly stored when not in use. Lack of attention to such aspects which are the responsibility of the user leads to impaired performance and premature failure. It is clear that the users have not been given adequate training.

12. Lack of simple maintenance

Similarly, most equipment will show minor faults which, if not corrected, will develop into major failure. Many of these will be the inevitable result of wear and usage - loose screws, kinked and fraying electrical cables, arcing switches, loose hose couplings, etc. These defects will occur in all establishments but under proper management will be detected and corrected by planned preventative maintenance. Where this is absent, premature failure will occur.
13. **Unsuitable environment**

In many countries where there are extremes of climate - heat, cold, humidity, dust storms - equipment will be seen to be exposed to adverse environmental conditions without suitable precautions of air-conditioning, air filtration, water treatment. Where the hazards of the environment have been recognised and the appropriate provision made during installation of the equipment, it will often be discovered that they have become ineffective because of lack of maintenance of the plant, e.g., filters may never have been cleaned or replaced.

14. It is frequently found that equipment is operating inadequately or intermittently because the electrical supplies are unreliable: this is increasingly a problem as microprocessors are incorporated in equipment, requiring stable mains supplies free from transient voltage 'spikes'. But many earlier generations of equipment in laboratories, etc. are damaged or shut-down by the voltage fluctuations, switching transients or breaks in supply which are daily occurrences in many countries.

15. Similarly, some types of complex equipment (e.g. for renal dialysis) require continuity, pressure-stability and purity of water-supply which is not normal outside the industrialised countries of their origin.

16. **Inappropriate equipment**

The equipment design entered may not be appropriate to the conditions of use in the country; this applies not only to clinical equipment but to many other devices such as cold-chain items - refrigerators, etc. WHO has had an active involvement in the design of appropriate equipment (e.g., the Basic Radiological System) but as yet the majority of equipments supplied to developing countries are appropriate only to the environmental conditions, the specialist users and the logistics and support found in the industrialised countries of origin.

17. **Inoperable equipment**

The conspicuous symptom of poor technical management is the extent to which equipment is 'not working'. Expert consultants reporting on developing countries estimate high proportions of equipment which is not able to be used, compared to the few percent which is typical of a developed economy. It is certainly true that much will have developed premature faults because of the manner and conditions of use, and will have remained faulty because of lack of technically-qualified personnel to repair it. But these are not the only causes: it is important to try to categorise the various causes in order to understand the necessary remedial measures.

18. **Equipment inoperable when received**

Some apparatus will have been in an inoperable state when it was received

19. **due to manufacturer's fault**

Whatever the country of origin, whatever the reputation of the company, no manufacturer effects perfect quality control or has a perfect staff. There will be a small proportion of defective goods or mistakes in supplying the ordered parts.

20. In the developed countries where the equipment originates, these mistakes will be quickly recognised by competent staff at the point of receipt and rapidly reported by telephone. They will be quickly rectified, for not only will the company's reputation (and order-book) be at risk, but payment will be withheld until the contract has been fulfilled.
21. In the typical situation in a developing country the circumstances are very different. The equipment may have passed through several agencies before it is seen by anyone competent to recognize faults or deficiencies. It may be necessary for this chain to be retraced to initiate a report to the supplier, with the motivation to take action decreasing at each link of the chain. If the equipment has been gifted or received as a result of barter, the location of the supplier may be unknown within the country of receipt. When the information does eventually reach the manufacturer, he may be disinclined to believe that he is to blame, knowing that there are many other explanations for the deficiency. He may feel little motivation to correct the deficiency if he does not feel that there is an important market dependent on his good reputation in this country. Even more importantly, he may have no financial incentive to satisfy the customer if he is already assured of payment under a credit-guarantee scheme.

22. **Due to fault in specifying or ordering**

Some apparatus will have been supplied without vital parts (e.g. interconnecting cables) because of failure to order them. It is not always easy for a technically competent person to understand some manufacturers' catalogues even in their own, native language, and they may rely on visiting technical sales representative to interpret their needs to the factory. When the user is several stages removed from the orderer, when the orderer is separated from the supplier by oceans, frontiers and language barriers, and when the supplier may be an agent separated from the manufacturer, it is not surprising that orders reaching the manufacturer do not always convey the needs of the user. In specific cases where manufacturers have been criticized for failure to realize that the consignment was inappropriate or incomplete and predictably unusable in the hospital, it has almost always emerged that the manufacturer was given no information about the place or conditions of use. They may say "If we had been told that it was for use in a small town in ........, we would certainly have pointed out that additional parts were needed. To us it was merely part of a large order from the International Health Exploitation Corporation."

23. An astonishingly frequent defect is failure to specify correctly the electric mains supply — even by WHO agencies. It is difficult to attribute a mistake in mains voltage to anything other than carelessness, but where technical management is inadequate, lack of understanding and confusion of single-phase and three-phase supplies is to be expected.

24. **Due to damage in transit**

Damage in transit is a common problem, particularly for larger equipment or equipment in consignments travelling by sea and possibly subjected to rough handling at docks.

25. **Due to Customs**

Perhaps the majority of deficiencies reported on delivery to user arise during customs examination. If there is a low level of technical competence within a country's health-care system it will be likely that the level within the customs warehouses is even lower. And the greater the economic difficulties, the greater the vigilance exercised over imports and, possibly, the greater the opportunities and incentives for theft. There are countries where it is recognized that the only route of entry of equipment or technical supplies which is secure against breakage or loss at customs is via the "diplomatic bags" of UN or national agencies. When multi-lateral projects for improvement of health-care technology are operating, one of the contributions of "technical advisers" is to get the equipment for the project safely through customs; their chances of success are greater than those of the developing countries nationals.

26. Although the customs house is a likely point of damage, it may sometimes be blamed for faults which occur elsewhere: unfortunately, it is often difficult for
representatives of supplier or purchaser to gain access to the customs sheds to investigate problems, and so the culprits may be protected by using customs as the scapegoat.

27. One of the issues which must be faced is the conflict between the national agencies responsible for health care and those responsible for the protection of the national economy — and many of the conflicts will be fought in the customs-sheds.

28. — due to handling by an intermediate supplies organisation

A good supplies organisation is a desirable feature of any health-care system and a number of developing countries have established national companies or agencies to purchase and stock both consumable supplies and medical equipment. It must be recognised that without adequate technical expertise (which is expensive, difficult to acquire and even more difficult to maintain and retain in a supplies environment separated from a service function) such agencies can introduce an additional source of defects and deficiencies. If the agency is not competent to assemble equipment, to test it under working conditions and to report faults quickly, the faults may go undetected until the equipment is supplied to the end user months or years later, by which time the source of the defect or deficiency may be indeterminable and a remedy may be difficult and expensive. The interactive problems of supplier of equipment, clinical user and intermediate supplies agency are difficult in a well-organised system of a developed country. They may prove almost insuperable in a developing country.

29. — due to inappropriate facilities for use

It is possible for equipment to be supplied complete and inherently functional but to be useless because it cannot be matched to the facilities and services available. This has already been referred to in earlier sections but its importance deserves separate statement. The ordering of equipment must be technically co-ordinated with the specification of premises, power supplies, services (water, gas, waste) environmental control, furniture and fittings, supply logistics. Bureaucratic divisions between 'works', 'supplies' and 'service' can introduce mistakes or gaps in planning and must be overcome in any health-care technical service.

30. — due to lack of user experience

Failure to supply adequate instructions may often result in unsatisfactory installation and commissioning, which generally requires more technical expertise than does the subsequent use of the equipment. Agents subsequently called to assist may report that much damage has been done by inexperienced unpacking and assembly, and sometimes the cost of repairing this damage cannot be met. Even when instructions are supplied such damage is possible if there is no skilled technical service, but where no instructions are provided, damage becomes highly probable. Manufacturers will seldom fail to provide instruction books, but these seem particularly prone to becoming lost or removed at customs, by agents, etc.

31. More common than failure to supply any instructions is the provision of instructions which are not comprehensible in the language of the user. It is possible that the medical user may have adequate facility to read medical texts in a foreign language but be unable to comprehend technical descriptions of unfamiliar equipment. The problem is increased when the instructions are written in a language which is foreign to both manufacturer and user.

32. Extreme cases have been seen where good and expensive equipment remained unused because the prospective user could not comprehend the instructions, and was not prepared to admit the problem and 'lose face'.
33. Sometimes equipment remains unused because the individual into whose charge it has been given does not have the confidence that he can use it without damaging it, and knows that he will be held personally responsible for damage: at his low level of status the risk of penalty is too great and he keeps the apparatus unused and therefore in good condition.

34. Although instructional text should always be supplied, ideally the user should be given verbal instruction and demonstration by supplier or agent. This will seldom have been done in the developing country.

35. — due to lack of tools and knowledge of tools needed

The user may have the knowledge or ability needed to make simple repairs or adjustments but may not have the necessary tools — or may not know what tools are required. Few equipments provide the comprehensive tool kit which should be available for the users in developing countries.

36. Equipment unusable because necessary consumable supplies or accessories are unavailable

Sometimes it will be found that equipment has worked satisfactorily until an accessory with a short life (pH electrode, lamp) has failed, or the initial consignment of a consumed supply (e.g. chart paper, special reagent) has been exhausted. Then it has been impossible to fund the purchase of the replacement or a fresh supply of material because it is more expensive than predicted, or requires foreign currency. If the equipment has been ordered by an external agency it may be difficult to identify the needed part or to locate the source of supply.

37. Lack of experience or poor evaluation of equipment in developing countries often results in a failure to appreciate the running costs of equipment, which can soon exceed the purchase price, particularly for laboratory equipment. In fact, in developed countries manufacturers will sometimes give equipment free of charge provided the reagents are purchased from them because the profits on supplies soon pay the cost of the equipment. It is all too common for equipment to be abandoned because of the expense of the necessary consumables.

38. Equipment unusable because donors have failed to evaluate local conditions

Equipment provided by donors — including international organizations — is often the equipment of choice in the donor country but is an inappropriate choice where there is a lack of well-trained staff, and of maintenance service. In general donors fail to evaluate the efficiency (effectiveness/cost) in the country of use.

39. Equipment which has become defective and unusable

Equipment defective — awaiting service agent

In any country a proportion of equipment will be defective at any one time, and be waiting for the manufacturer or agent’s engineer to repair it. In a developed country the typical wait may be one or two days, in a developing country many weeks or months, for the following reasons.

40. Major equipment will often have been purchased from a major manufacturer who has a world-wide servicing capability: it might seem that the high standard of service experienced in the developed countries will be found world-wide also. This is not so. Whereas there may be an engineer at least in each major capital city, or within easy travelling distance of any city in an industrialised country, there may be only one or two engineers to serve a continent such as Africa. The cost of travelling imposes severe limitations on the speed of service which can be provided. However, where engineers are employed by the manufacturer’s parent company the quality of work is generally high.
41. Where the service provided by a normally reputable company is reported to be below standard, investigation may reveal concealed causes such as failure to pay the bills.

42. For the majority of equipments the servicing will depend on a local agent. This may be a company which is the national or regional manifestation of a multinational organisation - medical gas and anaesthetic equipment is often in these hands - or may be a smaller, locally-owned company appointed and approved as agents by foreign manufacturers. In some countries there are firms owned and managed by expatriates which have a range of agencies mainly but not exclusively for equipment originating in their fatherland.

43. Some agents of this last type can offer a service which is as good as can be found anywhere, but it is based on expatriate expertise or on staff paid at comparable rates. It is rare to find that such firms are regularly and extensively used by the public health-sector, because they will be regarded as extremely expensive. Whilst it is true that these firms are in a position to make substantial profits, and do so, their charges are often a good indication of the realistic cost of high-class repair and maintenance; it may be possible to organise a service at 50% of their costs, but it is unlikely that it could be achieved for 10%.

44. Most of the health sector equipment will rely on the services available from national or local firms, employing mainly indigenous staff. It is at such agencies that the bulk of criticism voiced by the users of equipment is directed. In general the speed of response is slow and lengthens as distance from the (capital) city increases; users are resigned to waits of many weeks or months even for life-support equipment. Equipment taken away for repair is unlikely to be returned for many months. But the worst aspect is the incompetence; users often have no expectation of successful repair and know that, even if the equipment appears to function on return, the basic fault may not have been discovered and corrected and the symptoms will recur. Also, the inexpert work may have produced additional malfunction. The concept of a complete and thorough functional check before the equipment leaves the workshop is unknown.

45. Not all these problems reflect blame upon the agent. A company which is financed entirely from contracts for repair and maintenance will necessarily have to make charges which seem high to impoverished health-services.

46. Most agents will derive the bulk of their income from sales of equipment and their "mark-up" will provide not only for profit but also for overheads of servicing, the stocking of spare-parts, etc., so that the charges for servicing represent the on-costs of particular contracts. But in a developing country much of the equipment will have been purchased outside the country by UN or other international agency, or will have been supplied by a foreign government under an aid or barter agreement, or will have been provided under a turnkey contract. The local agent will have been bypassed and have had no income from which maintenance services can be partly financed. Even assuming a desire to provide good service, he will have had no warning of the probable demand for parts, or no opportunity to acquire service manuals or indication of the need to familiarise his staff with equipment which they may not have encountered previously.

47. In these circumstances even an honest and responsible agent may properly be reluctant to service equipment. For these reasons, international and other external agencies must accept some blame for the problems of developing countries and should improve their policies for the supply of equipment to them. However, having made these excuses, it remains true that in very many countries the quality of service provided is poor, even by agents appointed by large and highly-reputable multi-national manufacturers.

48. Investigation will often show that the intention of the manufacturer has been good. When first appointed, the agent had sent its engineers to be trained at the factory, and perhaps they had returned with the necessary expertise and experience. However,
the life-time of highly-skilled, well-trained staff in one particular company, is short - just as it is in the public service. The cost of sending a succession of engineers to train with overseas manufacturers is prohibitive, and so the knowledge obtained by factory-training will gradually be diluted. Often it will be found that the manager of the company is the sole remnant of the factory-trained staff, but is not working at the bench. This loss of expertise can occur quickly and can remain concealed from the parent manufacturer. Few manufacturers seem to inspect the work of agents frequently and thoroughly - perhaps because the remedies are difficult and expensive and it is easier not to know of the problems.

49. In order to retain competent and experienced staff, companies would have to pay wages higher than their competitors at home or in other developing countries, and would price themselves out of the public health-sector.

50. It is also expensive to maintain a large stock of spare-parts for a wide range of equipment: again, a satisfactory stock may soon dwindle. When it becomes necessary to import parts to deal with specific breakdowns, then the difficulties and delays of currency restrictions, import licences, shipping, docks, customs, etc. act against the agent and the customer. Also, it seems likely that in many countries the delays and difficulties can be reduced and overcome if sufficient money can be applied in illegal but commonly-accepted ways: this adds to the cost of providing an effective service.

51. In the preceding paragraphs it has been implied that the agent is honest and responsible, anxious to provide good service without inordinate profit. Unfortunately this will be true only in part, and sometimes in small part. Often the moral dimension - the desire to play a part in the improvement of health care - will not be a significant component of motivation. The overseas manufacturers may assume a cultural background which does not pertain in the countries of their agents.

52. Equipment defective - no source of commercial servicing

The previous section dealt with equipment for which there was an appointed servicing agent locally - or, at least, in the country. But there will be a great amount of equipment for which there is not an obvious source of service.

53. One of the characteristics of health-care establishments in a developing country is the diversity of sources of equipment. Not only will equipment have been chosen by clinicians who have worked or trained in a variety of countries, but there will be equipment donated in aid projects from rich industrialised countries and equipment obtained in barter from countries which would not normally export widely and which therefore would not be designed or "packaged" for use abroad. In developed countries a wide diversity of equipment is recognised as undesirable from the viewpoint of economical and efficient maintenance. It is a cruel paradox that in developing countries where the difficulties of maintenance are so much greater, the task should be made much more difficult because of the multiplicity of brands and countries of origin.

54. When there is a failure in equipment which is rare in the country (excluding very large equipment such as radiotherapy machines or CT scanners) and which is not supported by maintenance contract with an appropriate agent, it will seldom prove possible or affordable to have it repaired. Even a moderately competent technologist is likely to have difficulty fault-finding without circuit diagrams and servicing instructions. Certainly, a company which has staff at the technical level required for equipment design may be able to comprehend and repair it, but this capacity will be unusual and very expensive. And the possibility of repair will depend on the availability of parts. Where a simple electrical or electronic component is required there will usually be no problem to a firm with adequate expertise, but a part specific to the particular equipment will raise the problems of identification, currency, importing and customs, which will render the effort unrewarding for most commercial workshops.
55. Even for simpler equipment which is more commonly encountered and more easily understood the repair may appear extortionately expensive for the health-care organisation but insufficiently profitable to the commercial company.

56. As a result of such difficulties it is a frequent finding that, although competent companies may exist in major cities, they are seldom used by public health-care institutions, and they may show no eagerness to become involved in general repair for this sector, except where they can acquire agencies for equipment which will be sold in reasonable numbers and backed by the manufacturer. The firms which do provide some general services will effect only simpler, improvisatory repairs, and these at considerable cost. They will merely pretend to attempt more difficult repairs or those involving the acquisition or production of special parts.

57. Equipment defective - awaiting 'in-house' repair

To overcome the lack of available commercial repair companies, or to attempt to effect economy and efficiency, some institutions will have set up equipment workshops with health service staff or, perhaps, staff from another public sector such as the Public Works Department. The work in equipment repair may be an extension of the work of building and plant repair and maintenance. It is possible that the workshop was set up under the guidance of an expatriate as part of an aid programme, or as a result of a recommendation from a visiting expert. There are several countries where the workshops were originated by one particular self-styled 'expert' expatriate who travelled from country to country propounding expensive but intrinsically useless schemes; it seems likely that he had falsified his credentials to imply experience which he did not possess, and the Governments did not investigate his previous history.

58. The majority of equipment repair workshops will have been instituted with the best of motives, and will have had some effect during the initial stages. However, the typical situation at a later date is likely to demonstrate some or all of the following features when visited.

59. There will be a few 'technicians' sitting aimlessly on floor or on bench (depending on culture). The 'man in charge' will be absent; persistent questioning will reveal that he has been absent for weeks or months - he may have gone abroad. There will be a mechanical workshop with rusting machine tools and an accumulation of dirty filings, etc. from which it will be evident that it has not been used for a long period. (An extreme alternative is the workshop which is unlocked by a senior 'engineer' when distinguished visitors appear and which is kept clean, immaculate and unused in the intervals). There will be a few hand-tools and dust-covered pieces of electronic test equipment. The floor and store-shelves will be littered with items of medical equipment, some intact, some with covers or cases removed: it will be clear that these have been in their present state for a long time. If the staff have had notice of the visit, some may be gazing or probing inside equipment, but in conversation they will reveal no understanding of what they are intended to do; removing the outer cover will seem to be the limits of their instructions or initiative. Enquiries about the other items lying around them will inevitably receive the answer 'waiting for parts' although it will normally be impossible to find out what parts have been ordered, or when.

60. Some of the 'technicians' will report that they have been to a training centre, WHO or other, and some will be awaiting their turn to go there. But whatever skill they have acquired, it will be clear that it has not fitted them, without continued guidance, to tackle the many problems of diverse items of equipment. Without the provision of a proper working environment for the returning graduate, the training will have been largely ineffectual.

61. Where some of the technicians are able and willing to discuss their work it will be evident that they are overwhelmed as much by the administrative problems as the
technical ones. In particular, it will appear very difficult to procure the supplies needed: there will almost certainly be no mechanism which will allow the staff to shop locally even for simple, everyday things such as screws, knobs, light-bulbs. The chain of administrative responsibility will often be tenuous, leading either to a Hospital Director (or Medical Superintendent of the hospital) or to a Hospital Engineer with overall responsibility for premises, plant, etc.

62. The Hospital Director/Medical Superintendent will usually evade detailed questions about the administration and financing of the workshop, but will give graphic descriptions of the small amount of money available for the upkeep and running of the hospital. Observation of the way in which his authority is exercised will show that it would be inconceivable for one of the workshop staff to go to the Director to present arguments for expenditure on parts or tools needed for the work.

63. Where authority resides with an 'engineer' it will generally be found that this is a man who sits at a desk and issues orders; he will be a graduate with clean hands and no inclination to use them in practical engineering. His expertise may be in preparing schemes of work relating to plant engineering and his workforce will comprise craftsmen such as plumbers, electricians, carpenters. He will have neither the knowledge or the desire to give detailed instructions and assistance to equipment repair technicians.

64. Staff of such workshops will almost always be very young and inexperienced: it will be found that their renumeration is low and inadequate for independent living. Some form of 'moonlighting', or concurrent work, will be common, with consequently poor attendance. As soon as a marketable competency can be demonstrated the individual will move to the private, commercial sector or will become an emigrant worker in a richer developing country.

65. There will be no 'incentive' scheme within the public sector since no monetary value will be placed on efficient equipment management. If such a scheme had been instituted previously (e.g. when expatriate advisers have been active in establishing the workshop) it will have been distorted so that the rewards are taken by persons high in the administrative chain, and do not reach those who perform the technical work.

66. Equipment defective because poor quality equipment was ordered

A frequent mistake occurs when there is no competent technical adviser involved in the process of procurement by tendering. This is perhaps most likely to occur with simple equipment and supplies which are not requested by trade or brand names. The purchasing agency invites tenders and accepts the lowest, without any quality control. The items purchased may resemble reputable brands but be made from inferior materials and with poor workmanship. As a result there will be rapid wear or early breakdown.

67. Equipment which is defective but which could be restored easily and cheaply

A common theme in the preceding sections has been the crippling effect of financial under-provision for repair and maintenance; it may seem that the appointment of competent staff in the existing situation would be useless. This is one of the main conclusions of this review, but it is not completely valid in every circumstance. Without diminishing the emphasis on the need for many managerial changes, it is worth noting that sometimes much could be done to improve the situation using the resources currently available, if there was sufficient expertise.

68. Although a typical health-care institution in a developing country may have only a small and inadequate amount of equipment in a useful condition, the total inventory of equipment (including the non-functional items) may be surprisingly large and much in excess of a comparable institution in a developed country where the facilities are gradually acquired or renewed from regular budgets. Of course, the situation varies
very much from institution to institution or from department to department within a single institution. An aid programme, a charitable appeal based on some unusual case (e.g. birth of sextuplets) or a particularly active specialist may result in a sudden influx of equipment of one type.

69. Some years later, a small fraction will be in working condition, the rest pushed into a spare room and abandoned. The defects will be varied and the stored equipment will contain sufficient parts to restore at least half of the abandoned equipment into good working order by 'cannibalisation' if a competent technical service was made available. Since this is effectively a 'labour only' service it is not a task which will be attractive to commercial contractors who make a substantial part of the profit from supplying parts; also, an external agency faces problems in dismantling rather than repairing pieces of hospital-owned equipment.

70. But a good in-house service team, backed up by a strong management which is prepared to withdraw unusable equipment and entrust it to the technical team, could greatly increase the amount of usable equipment, particularly in the larger hospitals, without a large expenditure on parts and without all the problems of currency, import restrictions, etc.

SECTION 3

GOOD MANAGEMENT OF EQUIPMENT

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71. The essentials of good equipment management are not difficult to outline.

72. Equipment should be provided to meet the needs of health care, as identified in national policies. It should be provided at the appropriate time, always attempting to establish the proper relation of needs to available resources (including manpower resources).

73. This specification should involve the user of the equipment and also the senior qualified staff of the Health-care technical service. For unusual, very expensive items the staff at the highest administrative tiers will normally be directly involved. For commoner, cheaper items the staff at lower tiers will normally take decisions within general guidelines for the class of equipment which have been handed down, or will select from lists or from stocks which have been generated at the higher tier.
74. The choice of brands should be carefully controlled to ensure
that the lifetime cost of the equipment provides the best value for money (note -
the lifetime cost may be many times the purchase price),
that the equipment can be supported in respect of maintenance, repair,
consumables, for its expected lifetime (which will involve consideration of
maintenance contracts, spares stocks, information transfer),
that there is a range or diversity of equipment which will avoid undue reliance
on a few sources of supply, but a range which does not permit unlimited diversity
of brands, leading to maintenance problems,
that development of a national industry is encouraged on a realistic scale.

75. All commercial transactions should involve technical expertise guarding the interests
of the purchaser and user, matching that of the supplier and manufacturer.

76. No staff should be expected or allowed to use equipment unless training has been given
appropriate to the degree of sophistication. This will normally involve the
manufacturer or supplier initially and the in-house technical service thereafter.

77. The finance available for the introduction or replacement of equipment should be
apportioned realistically between (a) initial purchase and installation costs and (b)
lifetime running costs (supplies, regular maintenance, repair).

78. Arrangements for maintenance should be considered at the time of purchasing and should
be systematically applied throughout lifetime.

79. Maintenance arrangements should make appropriate use of contractual arrangements with
manufacturer or agent and/or in-house maintenance from the health care technical
service (HCTS). The proportion will vary according to complexity of equipment; it
may seldom be possible to service highly complex equipment without a major input from
the manufacturer, but much simpler medical equipment should be fully 'in-house'. For
equipment which is identical to, or very similar to non-medical equipment —
refrigerators, etc. — the resources of the private sector will often be the most
appropriate. But the HCTS should monitor the service given.

80. No commercial maintenance shall be commissioned, or work paid for, unless monitored
and approved by the HCTS.
ANNEX III

Working Paper No. 2*

THE MANAGEMENT OF HEALTH-CARE TECHNOLOGY

Index

For easy reference, sections and paragraphs are numbered consecutively throughout the three linked working papers 1, 2, 3.

Working Paper No. 2*

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SECTION 4

A HEALTH-CARE TECHNICAL SERVICE (HCTS)

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* Working paper No. 2 was prepared for the meeting by Professor J. M. O. McKie, Director, West of Scotland Health Boards' Department of Clinical Physics and Bio-Engineering and Professor of Clinical Physics, University of Glasgow.
81. This paper develops the concept of a Health-Care Technical Service (HCTS) which supports the technology and technological equipment used in the delivery of health-care. The support is provided by staff qualified and trained in appropriate technologies, equipped with the facilities necessary to advise and assist the other health-care professionals and to provide a direct service at all operational levels.

82. The duties undertaken by a HCTS include -

Participation in development of national policies for the introduction, maintenance and control of medical technology appropriate to the national needs.

Providing advice on the financing aspects of these policies.

Providing data, advising on policies for the procurement of equipment. Assisting in the formulation of legislation and regulations concerning equipment, and providing technical service in the implementation of such controls.

Advising on and participating in the specification of equipment, the selection of equipment, tenders, contracts, etc.

Organisation of safety requirements and hazard control related to equipment.

Liaison with building works departments on the provision of appropriate buildings, plant and services for the use of equipment.

Provision and maintenance of equipment inventories.

Acquisition and holding of spare-parts, spare equipment; liaison with stores organisations.

Acceptance testing, commissioning of equipment or supervision of commissioning.

Training of users, or supervision of such training, covering the safe use and the user-maintenance of the equipment.

Calibration and quality-control of equipment in use.

Planned preventive maintenance of equipment/supervision of planned preventive maintenance.

Fault-finding, first-line servicing, liaison with manufacturers and agents, supervision and acceptance testing of manufacturers' work.

Fault-finding, repair, testing of equipment.

Advising on need for replacement of equipment.

Practical training of staff for provision of the HCTS.

Advice on education and training policies for HCTS.

Advice on manpower policies for HCTS.

Recruitment of staff for HCTS.
83. A Health-Care Technical Service can contribute to good equipment management at many levels, but its most obvious contribution will be at the hospital-department, in the improved maintenance and servicing of equipment. It is therefore appropriate to approach the requirements and characteristics of a successful HCTS by concentrating first on the activities carried out at hospitals. The hospital-based service is seen as part of a structure extending from hospital through regional tier to Ministry and so the total contribution of HCTS to the working, clinical levels includes aspects discussed in sections 6 and 7. The structure at the hospital level is illustrated in Figure (21).

84. It should be emphasised that the concept of an HCTS at hospital level envisages a service to all departments under a single technical management. It is not efficient or economical to allow a few departments to have their own staff working only in those departments, answerable to their heads (who are likely to have no technical expertise) leaving the majority of departments without help. This does not, of course, preclude the specialised, equipment-intensive departments from having teams or individuals based within them, outposted from the main HCTS centre.

85. In-house maintenance teams should be part of, or functionally related to, the HCTS, and should be structured so that the appropriate level of technical expertise will be available at each health-care location, but that the appropriate volume and level of work will occupy each individual. This will usually restrict the number of independently-managed teams within a country to a small number (1 to 10).

86. If the recommendations made for the establishment of an HCTS team in the Ministry (or a national centre) and others at regional level are implemented, any hospital will have services of a specialised nature - mainly related to more expensive, complex equipment - provided from these higher tiers. Much of the managerial control of hospital-based staff will be exercised from the regional centre.

87. Of course, the regional centre may be located in a hospital, so that no division of the service will be apparent there, but in this and in other substantial hospitals there will be need for staff to provide a more general, more localised service. This should include preventive maintenance, which will reduce the incidence of faults,
TYPICAL HOSPITAL-BASED HCTS

Key:
- bases of HCTS staff
- route for service
- route for service and staff management

Figure 2(1)
education of users to make better use of equipment and also reduce failures, calibration and safety checking to improve the quality of care and reduce accidents to patients and staff, first-line diagnosis of faults leading to either in-house repair by the team or requests for assistance from regional centre or from agent as appropriate, monitoring of service given by agent.

88. In support of this work there will generally be basic mechanical and electronics workshops, areas for cleaning equipment, offices for record-keeping etc. stores of components, consumables and replacement equipment. This provision in larger hospitals will be scaled-down in smaller institutions with fewer items of equipment of lower level of complexity.

89. The HCTS teams must be adequately financed in relation to their workload: this should follow from the proper partition of equipment-monies between purchase and support.

90. The staffing structure should provide adequate expertise for each task, adequate daily management of the work, adequate strategic management, adequate progression and professional incentives to ensure career development.

91. It will be evident that only a small fraction of the work could be performed by a young, inexperienced person of low status and limited technical expertise. It is a common mistake to suppose that, as the size of the team decreases (towards the smaller institutions) so the grade of staff should diminish. In the efficient HCTS there will be some staff of comparatively limited technical ability - but these will be in the larger teams and not in the one-man or two-man teams; a high level of all-round ability is essential here.

92. If this important principle is accepted, it will follow that the cost of the staff will preclude the attachment of even one staff member to many of the smaller institutions. The service to these will have to be provided by visiting staff from the larger teams, each of which will serve a group of institutions – perhaps one large hospital, several smaller hospitals and a variety of health-centres, rural clinics, etc.

SECTION 6

MANAGEMENT OF TECHNOLOGY AT MINISTRY LEVEL

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93. Too often the action taken to strengthen the management of health-care equipment is ineffecutal because attention has been concentrated exclusively on the needs for technicians and engineers in hospitals or in centres for maintenance and repair. There is also a need for professional expertise in health-care equipment management in the Ministry of Health, and it is suggested that a HCTS should be an integral sector of the Ministry. This section investigates the work which should be done at Ministry level in all countries. In small countries the Ministry will also undertake some detailed management of services in hospitals, etc. and in these countries the HCTS will have additional responsibilities which have been assigned to the Regional tier in section 6 of this paper.

94. It will be clear that none of this work can be undertaken successfully without the use of technically-qualified staff of high calibre who are well-trained and experienced in the management of health-care equipment. It will also be evident that there is a shortage of such persons worldwide, but particularly in developing countries. The meeting should attempt to strengthen programmes leading to the training and employment of these key personnel.

95. Ideally, the Ministry should ensure that the level of technology which is supported is in accordance with the national overall policies for health-care and does not distort or frustrate these policies. This is very difficult to achieve in any country, whatever its stage of industrial, economic and political development. In a developing country which receives substantial aid from more wealthy nations or agencies there will be pressures both from without and within: these pressures will tend to provide or to demand amounts and degrees of sophistication of equipment which may conflict with the declared national priorities. For example, the primary goals may be the provision of water, sanitation and good primary health services nationwide, rather than the establishment of a few hospital centres of excellence in the capital city.

96. The major issues of implementation of health-care policies are beyond the scope of this study, but it should be noted that the suggested measures for the wise management of technology, although they will not ensure the appropriate choice of technology, will provide mechanisms by which the practice can be steered in the general direction of national policies. For example, brand-reduction policies can be used to favour appropriate technology, i.e. equipment which is simple, of widespread use, reliable and easy to maintain, rather than that which is complex, fully useful only in a highly-specialised unit, prone to defects and expensive to maintain. Again, a
supporting ECTS which is made widely available may make practice in smaller towns more attractive to the medical staff whereas one which is available only to major institutions will increase the tendency of the most able doctors to concentrate in a few city centres.

97. Turning to particular issues related to medical equipment, the Ministry should regulate the quality of equipment to be used. For equipment which is manufactured in the country it should formulate a code of good manufacturing practice, or comparable control measures, and ensure compliance. For equipment which is imported it should ensure that the country of origin operates such a code and that the equipment complies.

98. For certain classes of equipment there should be national standards (specifying dimensions, materials, constructional techniques) modelled where possible on international standards. These standards should be obligatory for all equipment manufactured in the country. For imported equipment, the Ministry should ensure that the standards established in the country of manufacture have been applied, and that these are not dangerously at variance with the national standard. It may not be possible to ensure that all equipment received from different countries or "blocks" of countries is fully compatible and the parts (connectors, etc) interchangeable, but it should be possible to avoid mixtures which are operationally dangerous.

99. The Ministry should ensure that there are standards of safety applying to radiological equipment (which will be part of broader legislation on radiological safety), electrical equipment (which may be incorporated in broader regulations dealing with electrical supplies) and medical-gas and inhalation equipment. These should be in accordance with established international recommendations.

100. The Ministry should seek to ensure that quality, specification and safety standards are achieved by all equipment which enters the country, even where this occurs under bi-lateral agreements, projects supported by WHO etc, or as a result of trade-agreements. Equipment provided by barter arrangements can present special problems: not only may it fail to meet acceptable standards and so be of little value, but also its presence may detract from the level of health-care by preventing the procurement of satisfactory equipment.

101. The Ministry should establish firm control of sources of equipment to ensure that there is provision to support the equipment with consumables, spares, user-instruction and a repair and maintenance service. This may involve a limited list of approved suppliers and agents. It is important not only to examine the facilities and standards of service before the supplier is listed, but to do so at intervals thereafter and to remove firms or agents which fall below the acceptable standard.

102. This control of supply should extend to all equipment, including that supplied under aid-agreements and from international agencies. Although this may seem a difficult stipulation for any one nation to place upon an agreement, it is later suggested that international agreement should be sought which would recognise the need for such restrictions upon equipment exchanged.

103. Ministries should adopt correct policies for financing equipment, recognising that, if equipment is to be useful, the finance must be sufficient not only to purchase but also to maintain the equipment. Where there is a system which divides funds for purchase from funds for use and maintenance, the two must be integrated or automatically co-ordinated, so that it cannot happen that all the funds are used to purchase and none left to maintain. Exact apportionment will depend on the situation of the country, the type and expected life of equipment. In no case should the fraction of available resources spent on purchase exceed 70% of the available monies. In some cases, where maintenance will be very expensive, the proportion available for purchase will be appreciably less.
104. These financial provisions should be enforced not only in respect of the funds spent directly by Ministries but also at every administrative tier, and this enforcement should be a major responsibility. It will be necessary for the Ministry to ensure that the proportion allocated to maintenance is actually being made available for this purpose, whether in the form of in-house or contractual servicing. Of course, the expenditure on maintenance will occur some years after that of purchase; for a system in equilibrium (where the funds available do not fluctuate widely from year to year) the initial accounting difficulties will soon disappear.

105. Again, Ministries will wish to apply this wise financial practice to funding from external agencies, and acceptance of these principles should be codified in international agreements.

106. The paragraphs above consider only the cost of purchasing specific items and maintaining them for their lifetime. Ministries should also have a programme for funding the replacement of equipment. Again, the average lifetime of equipment will vary from country to country, depending not only on climate but on the efficiency of maintenance. Over a wide range of equipment it is a general rule that the replacement cost is similar to the initial cost of the original equipment, increased by the local inflation rate. The actual cost of an exact replacement is generally less, but this is compensated by the increasing sophistication of the available equipment which will be selected. Thus, if the average life-span of equipment is five years, 20% of the total value of equipment will require to be expended annually on replacement in order to maintain the level of service. The monitoring of replacement programmes in lower tiers should be a responsibility of the Ministry.

107. In order to discharge this responsibility, Ministries will require to ensure that inventories of equipment are maintained. There are many other responsibilities which cannot be discharged adequately without accurately-kept inventories. Ideally, inventories should be kept on computer files and a national system instituted so that the data can be used locally and also copied for incorporation into a national inventory. However, computer applications can cause many problems and it is not advisable to start individual projects until adequate expertise and a supporting infrastructure for computers has been established.

108. Equipment evaluation should form a part of the function of a Ministry's HCTS, at an appropriate stage of its development. Initially, the practical work will be best left to the highly developed countries and the published evaluation reports from the countries should be obtained and studied: however, they must be interpreted in relation to the national conditions of use (climate, specialisation, etc) and it may be necessary to extend the practical work (e.g. variations of performance over a wide temperature range).

109. Although a developing country will have some equipment supplied under extra-national funding over which it may have limited quality control but little brand-choice, for much of its equipment procurement it will experience the familiar problem of choice of manufacturer and brand. If procurement is unplanned, a wide range of brands will be requested by individual doctors and health-care professionals. Even if each individual chooses what he believes to be the best, free from improper influences, he will have a limited knowledge of the available range from his own experience or that of his immediate colleagues, and this may be out-of-date: he is unlikely to have access to information about the remainder of the range, nor will he have time and facilities to acquire this. The task of establishing and maintaining a data-bank about medical equipment is great and should be done once at Ministry level and the data made available to all prospective purchasers, ideally backed by experience of its use and local service support. This information could be provided to private-sector health-care institutions, where they exist, being a method of improving the quality of care in this sector not dependent on legislative control.
110. In the public sector, as emphasised earlier, a degree of brand-reduction is essential if maintenance costs are to be minimised. This will normally be a major responsibility of the Ministry, although in very large countries there may be geographical grounds for local variation. Efficient brand-reduction practices will necessitate the availability of a good data bank and evaluation procedures. It will have to be integrated with the work on level of technology, quality of equipment, standardisation, safety, control of supply, described in earlier paragraphs.

111. Brand-reduction should achieve a small number of brands in each establishment: the number should be sufficient to avoid undue reliance on one manufacturer (lest he cease production, or his agent proves unreliable or his prices become excessive) but not sufficient to prevent easy interchangeability within the establishment, to present difficulties of training staff in use or maintenance, to require excessive stocks of spares or consumables. Over a number of establishments it should be possible to negotiate quality discounts for purchasing (or for maintenance contracts). It may prove most satisfactory to have a greater number of brands approved nationally than is permitted regionally or locally.

112. With brand reduction policies there arises the risk that the staff involved in their implementation will be subject to corrupting influences and it is important to be vigilant.

113. The Ministry should be responsible for national policies for manpower for an HCTS.

114. It is important that the correct structure is created, with career development made possible and career progression facilitated for the high performers. Since the most common mistake is to underestimate the quality of staff needed, the Ministry must set the standard and the appropriate rewards.

115. It is unlikely that a complete uniformity of conditions of service and remuneration will be possible (e.g. because of living-costs in the capital city) but there should be a uniform structure of grading, etc, with appropriate local variations or supplements.

116. The Ministry should be responsible for maintaining standards of education, training, experience, opportunity and performance, as far as is practicable.

117. The Ministry should quantify the development of the service, i.e. manpower, and arrange the necessary recruitment, education and training. The division of responsibility within the Ministry will be a matter for national decision, but it should be noted that a common source of problems and inefficiency is a division between training responsibilities and service responsibility, with insufficient dialogue (and sometimes antagonism) between them. It is imperative that training and service are closely interlinked: a major problem in many developing countries is the inability of trainees to relate learning to practical application. It is extremely inefficient to give training in an environment which is detached from the working environment, to employ as instructors or trainers staff who do not engage in the practical service, to fail to allow the persons who gain service experience to share this with the trainees and to fail to give trainees the motivation which arises from the pressure of service needs.

118. The Ministry HCTS should be closely involved in the planning of facilities in which expensive equipment may be installed, so that buildings and engineering services are suitable for the equipment and will permit effective, safe and economical use. It should be remembered that modifications made after completion to meet the power, environment or weight-bearing requirements of equipment will be much more expensive (and less satisfactory) than their incorporation in the original specification or architects' brief.
119. The Ministry should negotiate satisfactory arrangements for the importation of spare parts and supplies for equipment — both at the stage of the granting of licences and at the stage of customs clearance. It should not be possible for large sums to be wasted due to damage to or loss of equipment, in order to collect much smaller sums in import duty. There are many countries which do not recognise the folly of paying for staff and facilities to return (by way of taxes), from the public health service to the public treasury, money which has to be supplied to the health service from the treasury, whilst wasting some of the money during the process. This is a classic example of the people being required to serve the instruments of the state, rather than the instruments of the state being required to serve the people.

120. Where the public sector hospitals are divided into Health—Ministry hospitals and University or Education Ministry hospitals, every attempt should be made to provide an integrated service to both from one HCTS. This will not only provide economy of scale to benefit both but will help to attract and retain staff of high ability who may be able to divide time between, for example, University teaching and the training of HCTS staff, or between equipment research and development and equipment service. In many countries the quality of engineering and scientific education is impaired by lack of facilities for practical work in the undergraduate curriculum, or in postgraduate courses. Access to the health services can provide practical problems for the students: in return the health services may benefit from the work done on these problems, but even more in the giving of an orientation towards health-care to some able engineers.

121. Although at the beginning of this section there was expressed the intention to exclude consideration of work to be done at the hospital level, it should be noted that there are some services delivered at the operational level which the Ministry may wish to organise on a national scale, even where there are intermediate tiers of health service administration. Known examples include cold-chain systems, the quality control and inspection of sterilisers, inspection of radiological installations.

122. This paper does not present a structure for a HCTS in a Ministry. The organization of Ministries varies from country to country, and a single pattern would be of little use. Moreover, it seems unrealistic to suggest that a structured sector can be planned and implemented at a time when the acquisition of even one experienced technical manager would be a remarkable achievement in the typical country. It is recommended that the first step should be the appointment of such a person who both understands the needs outlined in this paper and has the ability, training and experience to begin to meet these needs. From this vital first step the structure appropriate to the national system will develop. The alternative approach is to plan an elaborate structure, appoint a number of inadequate, inexperienced persons and thus add an additional bureaucratic burden to waste scarce resources and exacerbate the problems.

123. Once established, a HCTS sector in the Ministry must collaborate effectively with other sectors including those responsible for Financial Budgeting and Management, Planning, Manpower Development, Education and Training, Procurement, Stores, Communications, Works and Estate Management.

SECTION 7

HCTS IN A REGIONAL (STATE, PROVINCIAL, GOVERNORATE) TIER OF ADMINISTRATION

Index

Advantages of vertical link to Ministry HCTS

Countries without a regional tier

Para No.

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124. In describing the responsibilities to be discharged at Ministry level it has been implied that there would be a department of HCTS in the Ministry, or answering directly to the senior officers of the Ministry. It is important that this department is not organisationally separate from the HCTS in regions or hospitals. This is a mistake made in some countries, which seriously decreases the potential of the service and adds unnecessary problems. Detached from involvement at the operational level, the Ministry team will soon become technically outdated or unrealistic. This can be worse than having no expertise in the Ministry, for if there is no source within his department at least the Minister may find good advice from someone in the front-line of service: if he is always fed advice from the Ministry, and this is incompetent, he may be unknowingly disadvantaged.

125. A direct line of management from lowest tier to Ministry also helps at the hospital level. Because of the poor quality of technical staff to which the medical staff and other professionals have been accustomed, it is found that they are slow to accept advice even when it is being provided by well-qualified and trained HCTS staff. At first the individual is not seen to be a representative conveying the accumulated expertise of a larger organisation. But when the line of authority starts at the Ministry the advice and assistance is much more readily accepted, and the impact of the HCTS can be much greater and much more immediate.

126. In a small country, especially one in which the hospitals are mainly in the city which forms the seat of government there may be no need for an intermediate tier of HCTS service between the Ministry and the hospital workshops: there might be accommodation in both the Ministry offices and the main hospital centre, but one team with direct line-management of all staff.

127. In a typical situation this will not be practicable because of the geography and the country's political and administrative structure: operational aspects of the health-care service may be the responsibility of several federated states, provinces, governorates or regions. Here it will be important to have a branch of an HCTS answering to the governmental authority in each region.

128. This raises the problem of isolation of the Ministry team, outlined above. A solution which has been found useful in some countries is to enlarge the centre serving the region which includes the seat of government (and usually the largest city) so that it serves as a base for the bulk of the work for the Ministry in addition to the work for the region. This may also help in the organisation of training of staff, which is considered in a later section.
129. As regards the daily work of health-care provision, structure comprising the regional centre together with its satellite centres should be self-sufficient for most purposes. It is assumed that the major hospitals in a region are sufficiently close to the regional centre that staff could travel from centre to hospital to perform work, collect or deliver equipment within a day (ideally to return also). During the stage of development of the HCTS it is possible to provide much of the routine service to hospitals from the regional centre, developing the satellite centres as resources become available.

130. Although it is desirable that the regional centre should be close to the region's administrative health authority, it is of great importance that it be in or close to the major hospital (or one of them). The acceptability of HCTS to the hospital staff is much more easily achieved and the motivation of the engineering staff is higher if the service is based in a hospital rather than in an isolated location. An exception to this rule may be encountered where the service is given to two or more establishments of comparable size between which is a spirit of rivalry or antagonism, when it may be wiser to be on an independent, neutral site.

131. The primary purpose of having a regional centre with satellite centres in the region's hospitals is to improve the efficiency and economy of the service by ensuring that expensive equipment and facilities and expensive staff with specialised expertise are fully used on work which necessitates that equipment or expertise. It is foolish to install in each hospital a large lathe which may be required infrequently; better one which receives work from a number of hospitals. It is expensive to maintain a member of staff with the expertise needed to repair a biochemistry analyser if he is called upon to do so three times a year, and it is also difficult for a man to retain his expertise if he is used so infrequently. Better that he serve four such hospitals, tackling similar problems every month. Obviously it is also better that one centre holds a full range of spares for the machine, rather than each hospital.

132. Even a degree of centralisation which allows one man to be well-used as a specialist is not fully satisfactory, for the man will sometimes be ill, on holiday or will leave for other employment, so that expertise and local knowledge will be unavailable. Better a small team to provide cover and continuity - but for this to be economical requires an even larger number of equipments to be served. These considerations point to the largest possible degree of centralisation of services, up to the point where disadvantages of travelling time and costs begin to outweigh the economies of scale.

133. Regional centres will normally contain well-equipped mechanical and electronics workshops for general work and specialised workshops for teams maintaining X-ray, medical laboratory equipment, renal dialysis equipment, sterilisation equipment, radiotherapy equipment. They will provide office accommodation for managerial staff and clerical staff concerned with financial accounting, inventories, etc. There will be library and data-bases. It is likely that in-service training will be concentrated here, both for junior HCTS staff and other staff using equipment. There will be logistic support - stores, transport.

134. It is possible that for political reasons a country will need to have several regional centres but for financial reasons these cannot all be as large as is necessary for technical efficiency. A possible approach to this problem is to make each self-sufficient for dealing with the commoner, less specialised equipment but to distribute the specialised teams between the regions, although each serves several or all regions. For example, only region 1 has a radiotherapy team, regions 2 and 4 have renal dialysis teams, regions 1 and 3 have X-ray teams, etc. This solution requires close scrutiny with respect to travelling time: an engineer who spends half of his paid time travelling will gain no more specialised experience and contribute less than one who spends half of his time on specialised work but is static and therefore spends half of his time on some other specialised or non-specialised work.
135. In addition to the task of providing specialist services to hospitals, the regional centre should be the base of senior staff who will manage and monitor the work done by HCTS teams in hospitals. The level of detailed management will clearly vary: a large hospital will have a larger HCTS team with more self management than in a small hospital where much of the management may depend on the regional centre. But it is envisaged that personnel management (recruitment, training, career development, etc.) will be a regional function.

136. The contribution of a regional centre should not be confined to the routine servicing of equipment, where the health-care is administered by a regional authority, but should include advice and assistance to that authority, comparable to that recommended at Ministry level, to the extent that the functions are devolved to the regional, state or governorate tier. This will probably exclude quality control, equipment standards for performance and safety, etc, major matters of financial policy, staffing structures, etc, which the national or federal authority will wish to be uniform throughout the country. But there may be reasons for diversity in relation to equipment policies, brand-reduction, maintenance contracts, etc. Since the detailed provision of facilities, planning and equipping of premises will almost certainly be undertaken at regional level, the administration should have advice from the regional HCTS centre. It will not be feasible to maintain a comprehensive data-bank at several centres in the country, but data should be transmitted from the national centre through the regional centre; a computer terminal linked to the national centre would be ideal for a large regional centre. Certainly there should be a regional inventory of equipment, used for planning a replacement programme, for ensuring adequate maintenance, etc.

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THE HCTS - ITS RELATIONSHIPS AND LINKS WITH OTHER DEPARTMENTS

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137. The emphasis in this paper is strongly placed upon the management of technical equipment used in health-care, the perceived need in most countries. It would be unfortunate if this concentration of thought on the equipment completely concealed the importance of managing the intellectual aspects of the technology - in modern jargon, the 'software' as opposed to the 'hardware'. Ideal equipment kept in pristine condition will not ensure good care of the patient: it is necessary to have wise and able staff who understand the technology and who employ the best, proven techniques. When the technology becomes complex and is changing rapidly, a team-approach is often advantageous, the team members drawn from several disciplines or staff categories, e.g. radiology requires medical radiologists, nurses, X-ray technicians and scientists or engineers. Often the characteristics of, and expertise required from, the supporting staff - technicians and scientists - is very similar to that required from HCTS staff. There is a great advantage in integrating as closely as possible the staff providing the regular support for the clinical application of the technology with the staff providing the HCTS.
Figure 2(2)
138. Although the staff permanently attached to the clinical department would not wish to undertake time-consuming repairs, their continuous presence in the department and their knowledge of the equipment places them in an ideal position to carry out preventive maintenance, first-line servicing and several of the other necessary parts of the HCTS. In fact, the ideal support for any department employing a large amount of advanced technology is given when the supporting team is permanently based in the department and committed to its regular work. This is always better than the intrusion of 'outsiders' when problems occur, but it is obviously too expensive to be possible in the majority of departments.

139. Where the workload justifies the permanent presence of staff members within a department to give technical support (e.g. a large radiotherapy department), this is the best option and they should undertake as many aspects of the work as they can efficiently perform. But this team should be a part of the regional HCTS or of the hospital HCTS, and not an isolated, separately managed team, for it will need access to expertise and equipment which could not economically be justified within the department, and also benefit from the administrative managerial and logistic support from the higher level of the Service.

140. In the formative years of a country's health services it would be valuable to consider the whole subject of the support required by medical staff in the provision of care which involves technology. The tendency is to copy the systems established in the developed countries with several different categories of staff (e.g. doctors, nurses, paramedical technicians, aids to paramedical technicians, equipment maintenance technicians, etc). The reason for this diversity of staff often lies in the circumstances existing half-a-century ago, and only the entrenched professional interests explain their continued use in the changed circumstances now pertaining. There are some paramedical staff who carry out essential routine procedures on patients, under the general control of doctors, who have achieved a professional status involving lengthy education and training in anatomy, physiology, physics, electronics and who are therefore rare and expensive. But closer work analysis will show that for the regular patient-care the knowledge of those subjects is not required. When, exceptionally, more expertise would be useful for a complex procedure or when equipment is faulty, the education and training has been too superficial, or the expertise lost by lack of use. In other words, by the advance of technology the regular task has been de-skilled (perhaps by computerisation) but the irregular tasks, often related to equipment management, have been super-skilled. In this situation the continuation of traditional staffing policies results in an increasingly expensive and inefficient service.

141. A modern approach which broke free from tradition would suggest that the bulk of the work should be done by less technically qualified staff, with only a small number of other staff who possess the higher qualifications and expertise needed to manage the equipment. This is no doubt a contentious suggestion, but if it is valuable to urge the adoption of appropriate technology, it is surely worth considering the provision of appropriate technologists.

**SECTION 9**

**STAFFING A HCTS**

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142. A key issue is the types of staff needed to provide the service previously described. The common approach to this issue is to use the labels familiar to those who have worked in a developed country - labels such as Engineer, Technician, Technician-Engineer, Biomedical Equipment Technician, etc. This may prove extremely delusory in a country at a stage of development when, although a label can be attached, there is no realistic possibility of creating sufficient staff members who can perform the duties which are associated with that label in a country which is at a later stage of development. Nor is it sensible to try to establish a uniform structure which can be applied to "a developing country". Countries are different one from another in many aspects which affect the potential for creation of a technical workforce and although the goals of equipment management may be common, the steps necessary or the timescale of achievement may be very different.

143. But with this warning against a universal plan or unrealistic expectations of achievement based on replicating foreign practices, it is nevertheless suggested that a country will require staff who can be described in three broad categories. Rather than label these with a term which may evoke different images in different readers, they will be designated by code letters: for each the expectations of achievement will be outlined. Of course, not all the achievements may be realised by every individual, and certainly they will be reached at different stages of the career.

144. Type A.

Will be able to acquire a high level of craft skills of hand and eye involving the use of mechanical hand and powered tools to fabricate parts in metal, plastic, etc. from instructions given verbally or written in native language, or following a pattern. Will recognise and appreciate the properties of common materials used in equipment. Will be able to recognise defects, breakages, weaknesses or signs of wear in equipment and to undertake repair involving welding, machining of parts, renewal of driving chains, filters, bearings, lubricants. Will be competent to carry out functional checks and maintenance on mechanical equipment according to prescribed schedules and
to inspect and recognise the state of serviceability of mechanical equipment such as simple anaesthetic machines, suction pumps, operating tables, lamps, X-ray tube stands, manometers, steriliser seals.

Or/and

will be able to solder/desolder electrical and electronic connections in plant and equipment using appropriate tools, to fit mains or transducer connectors efficiently and safely, choosing appropriate cables, fuses, and understanding the safety aspects. To use multimeters to measure current, voltages, resistance, to recognise electrical and electronic components and read values and ratings, to test for failure, to select appropriate types and ratings for replacement. Will understand the use of batteries as power sources, rechargeable sources, testing and replacement. Will understand mains supplies, single and three phase supplies sufficiently to make proper connection to and use of them, recognising variations or faults which will affect equipment.

Will recognise the various pieces of common electromedical equipment and have a broad understanding of their purpose and method of use: will recognise common defects and calibration faults, be able to read displays, charts, records.

Will be able to carry out simple safety-checks, calibration, performance checks and preventive maintenance on common electromedical equipment, following prescribed schedules.

Will be able to keep records of work done and write short and meaningful reports in native language.

Will experience self-fulfilment by achieving the skills and abilities described above.

145. Type B.

Will have acquired skill at the level described above for A, but will not feel satisfied by working wholly at this level.

Will be able to design and construct simple equipment to meet a defined need, without previous experience of such equipment. Will be able to construct moderately complex equipment from engineering drawings or and from a circuit diagram. Will be able to modify common equipment to use components different from those originally fitted. Will be able to understand instructions, manuals, diagrams, catalogues, etc. written in the international language(s) commonly encountered.

Given drawings/circuit diagrams and manuals, will be able to find faults in most types of equipment, and effect replacements or repairs.

Will be able to operate and check the performance of most types of medical equipment, to devise and to carry out maintenance schedules.

Will be able to estimate the costs of maintenance or repair and to give good advice on the economies of repair or replacement.

Will understand the factors relating to the clinical usefulness and safety of the equipment, to devise safety and performance checks and advise the user of their significance.

Will be competent to install and commission equipment.

Will be able to instruct the users in the proper use and care of equipment and to report user-faults.

Will be able to organise his own work schedule and that of subordinates, setting
priorities wisely.

Will be able to relate effectively to plant engineers, representatives of agents or manufacturers attending to their equipment, all users of equipment, staff in charge of stores, transport.

Will be trustworthy to order parts and supplies needed for the work.

Will be able to write detailed technical reports.

Will be able to train subordinates or others in the same staff category in the application of technology to health care.

Will be aware of the point at which tasks exceed abilities and will then seek help.

Will be fulfilled by working at this level.

146. Type C.

Will be able to undertake any of the work of categories A and B although unlikely to be sufficiently motivated to acquire high skills at level A, or to be fully fulfilled by working for prolonged periods at level B.

Will be able to specify and design equipment for medical use, make major modifications to existing equipment, develop and improve it. Will be able to write necessary computer programs. Will be competent to identify design defects in commercial equipment and to discuss problems with the manufacturers engineers at a peer level. Will be able to read, write and communicate freely in the international language(s) generally used in the country.

Will be able to devise fault-finding procedures for most types of equipment, when necessary.

Will be able to devise policies for the establishment, operation and development of HCTS.

Will be able to discuss policies and practices with staff at all levels in any tier, from clinic to Ministry.

Will be able to recruit and train staff at all levels.

Will be able to design and specify all facilities required by the service.

Will be able to budget and to control the finances of the service.

Will generally be able to manage all aspects of the service.

Will be able to educate and train staff in basic technology, in addition to specific medical applications.

Will recognise and will work to overcome any limitations to his abilities which impede his professional work.

Will act as, and will earn the status of, a professional person equal to all the other professionals involved in health-care.

147. The HCTS outlined earlier will require staff at each of these levels. In all teams there will be staff of level B and in some teams staff of level A. Where there is only one or two in a team, the appropriate category will be B, since B can do all that
A can, but A is severely limited in capacity. There will be relatively few persons in category C, but these will be the key personnel for the establishment of the service and its efficient continuation: they will be most numerous in the higher tiers of the service.

148. The failure of many attempts at establishing a service may be attributed to the taking of persons appropriate to A, attempting to train them to work at level B, without providing any staff at level C.

149. Of course, the list of achievements could be regarded as a continuum, or divided up into more (or perhaps less) strata. The system used was chosen as it seems to fit a number and range of countries. Also, the specifications stated are the maximum achievements expected from staff in each category. Those with least experience will be working at lower levels of achievement and there may be an overlap between the expectations of achievement of the most experienced in one category with the least experienced in a higher category. It is for this reason that it is recommended that small teams could be effective with all staff in category B, if there is a range of experience as will be normal. The least experienced will initially be appropriate for work at level A, the most experienced for some work which in a larger team would be appropriate for category C.

150. Ideally, if the cultural and educational environment permit, it should be possible for individuals to move from one category to another as their capabilities were expanded and demonstrated. But it is envisaged that there will normally be direct recruitment into the three categories.

151. It is of great importance that before making detailed plans for courses and curricula, based on foreign models, countries should make an honest assessment of the chances that the proposed scheme will turn the entrant recruits or students into persons capable of reaching the necessary levels of achievement within the timescale and with the manpower and financial resources available.

152. Further, the question must be asked, will the person produced by the scheme be given the status, respect, authority and, of course, payment to motivate and permit him to work at this level?

153. In the past schemes have been started and have had no appreciable success or have quickly decayed; this outcome could have been predicted from the simple considerations outlined in the previous paragraph. Even if the trainees could have been given the necessary technical ability - and this hope may have had little foundation - the trained persons would predictably have been unable to create and maintain the conditions necessary to apply their knowledge, to tell a doctor when the equipment was repairable and when it is not, to argue with the administrator for the funds to obtain parts, to make the user adopt better practices, to make the wheels of bureaucracy move faster, get currency, import licences, chase the deliveries through customs. The common consequence - trained persons sitting hopelessly in the midst of a confusion they are too junior to tackle - is an inevitable outcome of lack of realism at the beginning of the project.

154. In looking at the practices of the developed, industrialised countries it is important to understand that many of the routes to careers in technology were established more than a century ago and depend for success on a cultural attitude to technology which was built up over a long period of time, which was very much dependent on the age of innovation and which is once again changing. The application of technology evident in the steam engine, etc., was not in general a product of the professionals emanating from the universities with degrees in engineering, but of a new class of 'mechanics' who started as apprenticed craftsmen, were motivated by the widely-acclaimed successes of railway transport, etc. and who organised the body of technical knowledge, as it was uncovered, and passed it on to those anxious to possess it, in their 'own spare time' at evening classes in institutions distinct from the universities. These
mechanics were not only rewarded by their chance to share in the exciting developments but also were accorded great public respect, and were able to earn relatively good incomes. They were the "astronauts" of their day.

155. The situation has changed, and is changing rapidly: in some countries old patterns of technical training have vanished and in others may soon be swallowed up in a widened system of higher education. But some of the characteristics still remain and cause problems in countries which try to import those established systems into a cultural environment which is completely different.

156. One important facet of the environment which still remains in the industrialised countries is the persistence of technical interest through all strata of society. A fraction of the population, irrespective of class, occupation, income will engage, however unprofessionally, in activities such as repairing their own cars, wiring the electrical supplies in their own houses, etc.

157. Consequently, the recruitment of personnel into scientific, engineering or technical education, whether at or below university level, will largely utilise this fraction of the population. Before there is any serious education or training, the entrant is likely to have dismantled and rebuilt a motor cycle or car engine, or to have made electronic devices, to have written computer programs, etc. In education, from the primary years onward, there will have been ample access to practical equipment. Toys will have been of a technical "educational" nature.

158. The methods and time required to produce "engineers", "technologists" or "technicians" from such recruits cannot be transposed unchanged to a country where a boy who is rich enough to possess a bicycle will take it to a craftsman in a shop if the driving chain becomes disengaged from the gears; where a boy who is poor will have had little access to technical devices and certainly not permitted to "play" with them, where a boy from a professional family, like his father, would lose face if he were to crawl under the car, where the technical equipment in most schools and even colleges is sparse and obsolescent - where, above all, the possession of technology evokes pride of purchasing power but not pride of productive or inventive power. This describes a country which has adopted the benefits of the industrial revolution but has not passed through it.

159. In such a country, it will be difficult to impart enough practical skill to do a useful task at level B or C. And even if this can be done, the monetary reward is likely to be so low, for an individual who has not received a university education, that he will leave as soon as he can to find another type of employment or can practise his acquired abilities in a country which pays more adequately.

160. There are, of course, some countries in which there seems to be a natural national aptitude for technology. Even although the process may have started in the last few decades, industrialisation has proceeded rapidly. In such countries there is unlikely to be any problem in the education and training of staff for an HCTS.

161. Developing countries which do not display this ability to assimilate technology should consider very seriously whether there is any real benefit in attempting to set up training establishments to produce the essential staff for HCTS, unless they form part of the university system or take in students at the postgraduate level.

162. Such training will be costly, whereas the training of school-leavers is cheap. But this is a further argument for great caution. There is no cheap way of staffing or operating an HCTS service. It is possible to get good value for the money by wise planning, but it is not possible to get good value for little money.

163. There should be a continuous progression of expertise and experience throughout the staff: each person should be able to look to his immediate superior for practical help with a technical problem. Also, there should be a continuous expansion of
managerial activities throughout the ranks or grades. The system of ‘serfs and princes’, where many lowly-qualified, lowly-paid workers do practical work and a few highly-qualified, highly-paid managers occupy paper-strewn offices, is totally unsuitable for a modern technological service.

164. The payment of staff should attract able entrants, provide rewards for achievement, avoid ‘moonlighting’, keep staff in the service for extended periods and attract experienced staff from other sectors. It should reflect the scarcity of high quality staff: this will often mean a reversal of accepted values, e.g. a highly-trained, high-achieving engineer may be more valuable and much rarer than a highly-trained medical specialist.

165. Where the economy of the country requires the generation of financial incentives, e.g. by providing services from a public sector HCTs to private sector hospitals, every possible step should be taken to ensure that the incentives reward the persons who supply the technical expertise, and are not misappropriated by administrative or Ministry staff.

166. The staffing policy should favour expertise rather than high numbers. Given well qualified, well trained, well motivated and well paid staff, the number required may be remarkably small. Most ‘experts’ who have not personally managed a practical service overestimate the number required.
ANNEX IV

Working Paper No. 3*

THE MANAGEMENT OF HEALTH-CARE TECHNOLOGY

Index

For easy reference, sections and paragraphs are numbered consecutively throughout the three linked working papers, 1, 2, 3.

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SECTION 10

THE EDUCATION AND TRAINING OF HCTS STAFF

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* Working paper No. 3 was prepared for the meeting by Professor J McKie, Director, West of Scotland Health Boards' Department of Clinical Physics and Bio-Engineering and Professor of Clinical Physics, University of Glasgow.
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Type C staff

167. Category C staff, as defined in section 9, will be the predominant category in the Ministry HCTS, will manage the regional service and have the key role in staff training schemes. There can be no doubt that the production of these senior staff, which is essential to the success of an HCTS, must start with university graduates. It is almost certain that in a developing country these will have to be graduates in engineering. In some developed countries it is equally satisfactory to start with graduates in physics, which is a common route to careers in applied science or engineering - but these are graduates who will have had ample exposure to practical technology. This may not apply in the developing country, where physics students can graduate but remain unfamiliar with practical technology.
168. Unfortunately, this will often be true of engineering graduates also. The course will probably have been very deficient in practical work, and when provided this will have involved use of equipment but seldom any construction or intimate experience with equipment. The educational course may also be deficient in innovative work or lateral problem-solving, having concentrated on the imparting of knowledge and on practical examples designed only to reinforce theory.

169. The worst effect of such deficiencies is not that it fails to impart the skills necessary to do useful work, but that it fails to impart the desire to do so. The degree may be desired as a guarantee of escape from menial work or assurance of a place in an intellectual elite.

170. The education and training must therefore impart motivation to provide a practical service to health-care, an understanding of what this service can contribute and an idea of the self-fulfilment which can be derived, in addition to supplementing the entrant's theoretical knowledge with the practical techniques of application. It is necessary to teach the entrant the basic skills of staff management, but also to teach the basic craft skills so that he will be able to lead the teams and teach, guide and support each of its members.

171. The lack of trainers to start the process of providing class C staff is the greatest problem in the initiation of a useful HCTS.

172. At present the only practical method is to select likely engineers and send them abroad to receive on-the-job training and experience and perhaps some type of course. However, the environment of work in a developed country, with all the major difficulties already overcome, is often poor training for the situation to be faced in the homeland. The staffing schemes, administrative arrangements and divisions of work may have evolved over many years and be confusing and very different to those recommended for a newly-established service in a developing country. The relationship with manufacturers and the use of their services will certainly be different. And courses are seldom designed with an intimate knowledge of the background of the students and the cultural, educational, financial and work difficulties of their countries. They usually concentrate on the technology (which is certainly important) but fail to deal with the policies, managerial and administrative issues which will be equally important to the first recruits who will often have to occupy the key positions in the newly-established service.

173. This is not the type of training which can be given in an educational establishment remote from hospitals where the practical problems occur - at this level simulation is useless: the student must learn to deal with the problems of health care in context, as they occur, whether soluble or not. Nor is such experience likely to be available in a very small country. Until such a training facility can be established in a country - and the project cannot succeed unless it is integrated with a well-established HCTS where a wide range of work can be experienced - it would seem necessary for suitable training facilities to be identified or, more probably, to be built up in developed countries. The requirements are different to those for the training of the nationals for service in the developed country, and so the resources will require to be provided as a form of aid, either from national or international sources.

174. Once the first stages in the creation of an HCTS are in progress, and some type C staff are in post, it is certain that these will become involved in the training of type B and A staff. They will therefore need to be taught to teach and train others. However, it is likely that this teacher-training can be found within the country.

Type B staff

175. The birth and survival of an HCTS depends on the production of a small number of type C staff, but the growth and health of the service requires the continuous input of
type B staff. The richest developing countries may be able to rely on staff already produced in the developed, industrialised countries but the great majority will have to rely on their own national training schemes or make use of WHO or other international training centres.

176. The details of schemes will vary, depending on the level of intake, but can be classified very broadly as follows:

Class 1 schemes will take students from schools (secondary) and Class 2 schemes will take students from institutes of higher (tertiary) education (universities, polytechnics, colleges of technology, etc.).

Class 1 schemes

177. In the previous section of this paper it was pointed out that many developing countries will fail to develop and maintain an HCTES unless they recruit from the higher (tertiary) education sector, for cultural reasons such as pay and status. In this section it is necessary also to warn that most developing countries will find it difficult, formidable and expensive to produce type B staff, starting with school-leavers. Some of the reasons have already been discussed, and so are reiterated briefly, with additional reasons.

178. The level of technical knowledge and understanding to be achieved by Category B staff presents intellectual difficulty not greatly different from that required of a graduate with a degree; the main difference is more in width of studies rather than depth. But if school-leavers are recruited, these will inevitably be of lesser ability, on average, than those who have entered university. So the teaching will have to be at least as good – or better, if less time is allowed. It is unlikely that the health sector can afford this quality of teaching, or that teaching staff of the right calibre will be obtainable.

179. Specific teaching on, and experience of, medical applications will have to await acquisition of basic technical understanding, so extending the course: it may be that the limited width makes the course cheaper to provide than a university course, but if the educational sector is reasonably efficient it is hard to argue that basic technical education should be done in the health sector, which is likely to be less efficient when working on a small scale. Realistically, it may seem unreasonable to utilise health sector resources for work for which the education sector is funded.

180. There is also a language problem in many countries. To operate at the class B level the individual must be able to work in an international language. When the training is being given in specific health-care technology, study materials will be in the international languages. So, in a country where the secondary education is not in this or these languages, the course will have to include substantial language study. Again, this will add to expense and difficulty. Here too the fact that the students are going to be chosen from the academically-weaker strata of school-leavers will add to these difficulties.

181. In most developing countries it will be difficult to ensure that a class 2 course does not produce a person of lower technical status than those who are employed in commerce, industry, in technical support of education, or in the armed services. Indeed, it may not be unduly cynical to speculate that this depression of status may be one of the reasons for Ministries of Health choosing to produce staff by this method: it will make it less likely that staff will leave for employment outside the health sector, and enable low salaries to be paid. This must not be allowed to happen: it initiates a circle of depression which will lead back to a situation of poor equipment management and a technologically impoverished service. The ideal situation is one where there is a free movement of personnel to and from the health sector, with dynamic equilibrium of numbers. This keeps the health sector technology at a realistic level and allows mutual stimulation between sectors. It is essential
for the encouragement of an indigenous medical equipment industry.

182. In practice in the developing country the early years are likely to see a net outflow from the health sector to the commercial and manufacturing sector, or to other countries. This phase has to be endured; it should not be allowed to distort proper policies. In fact, if a sufficiently detached view is taken it will be seen to be a contribution to national development which will bring long term benefit, for as the commercial sector, the manufacturing sector and the "invisible exports" are strengthened, so the more buoyant economy will result in improved financing for the health sector.

183. It is suggested that this class of training be attempted if, and only if there is a substantial section of the school student population who have a practical technical aptitude which motivates them to find practical applications ahead of their theoretical organisation of knowledge.

the community gives an equal status to practical and academic achievement

this equality of status is expressed both in the self- and community esteem and also in the salaries paid

as a result, the learning ability of the entrant to this course will equal that to a university or college course

the entrant to the course has already acquired sufficient fluency in an international language to use text books and study technical literature in that language.

184. Most of the course syllabus which deals with specific medical applications will be common to class 1 and class 2 courses. The extra components of a class 1 course will be

- core subjects in - mechanical engineering and workshop practice
- physics and applied physics
- mathematics
- computing
- electricity, electrical and electronic engineering
- chemistry and chemical engineering
- languages

- specialised subjects in - mechanical engineering drawing
- mechanical engineering workshop practice

or - electrical engineering
- electronics.

and these will be broadly the same as studied for degrees or diplomas in technical universities or colleges.

Class 2 schemes

185. If the decision is to produce these members of staff by a class 2 scheme, as is generally to be recommended, the entry to the course will be a first (bachelors) degree or an equivalent technical diploma involving 3 or more years of technical education reaching a level comparable with a degree. It is not easy to define the criteria for judging equivalence in this context but they should be similar to those used in judging equivalence for the purpose of admission to a higher degree - e.g. an M.Sc. - of the university.
186. The subjects studied should be those which impart knowledge of engineering sciences or applied physical sciences, broadly as detailed for class 1 courses. The most numerous entrants will probably be those who have studied electronic engineering as a substantial part of their course.

187. If the first degree studies have been confined to a narrow branch of engineering, the course may have to include bridge courses which will broaden the understanding of necessary subjects not included (e.g., mechanical engineering for electronics engineers, and vice versa). Alternatively, optional material can be added to the obligatory practical courses.

188. All entrants should learn the basic craft skills involved in mechanical and electronic workshop and laboratory practice, for 3 reasons:

a) So that they can work independently whenever necessary, and have all of the skills needed to service, maintain or construct equipment;

b) So that they can provide good, detailed management of junior staff and instruct them when required;

c) So that from the very beginning of the course they accept that their personal work will involve a combination of mind and hand, intellectual and practical.

189. These basic craft skills will include mechanical bench fitting with hand-tools (filing, drilling, tapping and sawing), use of powered tools for turning, screw-cutting, milling, sawing, boring, jig-sawing, with metals, plastics and wood, sheet metal working, soldering, brazing and welding of ferrous and non-ferrous metals, use of adhesives, methods of cleaning, painting, use of gauges. Soldering and unsoldering of electrical connections (from mains supplies to printed circuit boards), other methods of connecting, production of printed circuit boards, fitting of connectors (plugs and sockets) and fuses, recognition of resistors, capacitors, inductors, semi-conductors, integrated circuits, transformers, use of meters, oscilloscopes, signal generators.

190. Since it is probable that the entrant will have learned a great deal of textbook theory but will have difficulty in relating this to practical equipment, there should be a general course designed to teach (or revise) the basis of the technology by practical work, choosing the practical illustrations from commonly-encountered equipment. The student should, if possible, construct the practical devices or, at least, assemble them. The use of demonstration equipment sold by educational supplies companies and used in school and university laboratories is not recommended: the student who has little practical background has difficulty in relating the teaching equipment to the realities of the equipment used in the outside world.

191. In electronics this course would cover

- Series and parallel RLC circuits, time-constants; relays, diodes, voltage regulator, transistor switch, relay oscillator; semi-conductor devices, characteristic curves, local lines, power dissipation, H-parameters, biasing, audio amplifiers, phase inverters, push-pull power amplifiers, multivibrators, phase-shift oscillator, unijunction transistor, FET, SCR, thermistors. Operational amplifier, differential amplifier, integrators, voltage comparator, low-pass filter, waveform generator, voltage-controlled oscillator, timers, sine-cosine oscillator, peak-pulsing and sample hold circuits, A-D converters; digital codes and decodes AND, OR, NOT, NAND, NOR, AND-OR-INVERT gates, De Morgan's theorem, Exclusive OR gate, R-S Latch, D Latch and flip-flop, J-K flip-flop, Shift registers, asynchronous and synchronous counters, decoders and encoders.
192. In electrical engineering

Series and parallel RLC circuits, power, resonance; 3 phase voltage, sequencing, connections, reactive circuits, power measurement; transformer ratios, exciting current, regulation and efficiency, distribution transformers, open delta and 4 wave connections, wattmeters, split-phase motors, DC motors, electrical installation standards, diversity factors and cable sizing, safety testing, earthing and testing, emergency power supplies, lighting practice, refrigeration and air-conditioning practices.

193. In mechanical engineering

An extended workshop course involving design, drawing and construction of basic mechanisms in metal and plastics, stripping and assembly of gearboxes, pumps, studies of seals, lubricants, gas control valves, sensors and gauges, recorders, etc.

194. Turning to the training for specific medical technology, there will be a need for a medical orientation course. This should commence with a simple introduction to human biology - anatomy, physiology, biochemistry, pathology: the problem will be to keep this simple enough, as lecturers from the medical profession tend towards excessive detail and specialised terminology. But the student should get an all-round knowledge of the organs and systems of the body and the common diseases, with emphasis on those where the diagnosis or treatment involves physical equipment. He should also be introduced to medical terminology at an elementary level.

195. There should be an introduction to the health-care system of the country, with particular reference to the organisation of hospital practice - what the different specialities do, what the professional groups are, how the administration is arranged, what are the conventions of etiquette for the visiting HCTS staff.

196. There will be a number of courses dealing with specific categories of equipment -

Clinical or physiological measurement (ECG, EEG, EMG, blood pressure, blood flow, respiratory tests, hearing, sight, urodynamics) which may be divided into general purpose (what is measured and why), general principles (amplifiers, recorders, transducers), and specific equipment, including calibration, testing, preventive maintenance, fault-finding.

197. Similar approaches would be used for -

Anaesthetic and medical gas equipment.

Theatre and intensive care equipment (e.g. diathermy, lamps, suction, tables, pacemakers, defibrillators).

Medical laboratory equipment.
Renal dialysis equipment.
Sterilising equipment.
Refrigeration equipment.

Radiological imaging equipment (X-ray, ultrasound, nuclear medicine).

Physiotherapy equipment.
Radiotherapy equipment.

These courses will vary in length and some will require a lengthy theoretical introduction, e.g. radiological equipment.
198. An important subject is Safety: the student would study

- Electrical safety in relation to staff, patients, fires, thermostats.
- Medical gas safety - anaesthetic gas inhalation, electrostatic hazards, gas identification, purity, pipeline hazards, cylinder hazards.
- Bacteriological hazards - sterility in theatres, etc., hazards of contaminated equipment and of laboratory samples, failure of sterilisers and of refrigerators, etc.
- Mechanical hazards - patients and staff at risk from heavy apparatus, unstable or weak supports, slippery floors, etc.

199. Service management must be taught. Students should learn how to schedule work, keep records, prepare reports, estimate and cost work, order supplies, organize stores, operate bonus or incentive schemes. Many teams which have achieved reasonable technical competence have been made inefficient by failure to appreciate the need for systematic organization and management, or lack of training in these aspects.

200. Staff management must also be taught, at least at a basic level. Again, this has been a weakness in places where an RATS has been introduced. All staff should be taught how to communicate with their subordinates, to monitor their performance, to give help, encouragement or criticism, to relate to superiors.

201. Although it is envisaged that structured courses will cover these subjects, the most important learning situation will be in practical experience working alongside service staff. Classroom or laboratory cannot impart the ability to deal with the typical hospital problem which may be confused, inadequately reported, perhaps never previously encountered, and with inadequate information available. The ability to deal with real problems does not come automatically from the systematic study of presented problems in the classroom whose nature and solution can be inferred by the student. Also, the number of items of equipment and the range of equipment which can be held for teaching purposes is likely to be very limited; the use of old equipment is satisfactory for some teaching but the vital preparation of the student should involve exposure to state-of-the-art equipment of as many types as possible. In a developing country it is quite unrealistic to think that a teaching facility isolated from a major hospital will be able to obtain and maintain enough equipment to provide adequate practical training. So the facility should be associated with at least one major, well-equipped hospital which is within a practicable travelling distance.

202. The practical work should be partly structured, i.e., the student should be attached to specialized teams and should complete a work-book covering specific tasks, and partly unstructured, dealing personally with tasks which arise in a particular situation, under the supervision of an experienced and reliable staff member. Subject to the limitations of clinical requirements, he should be allowed to make mistakes and learn from their correction.

203. This insistence on true work experience, which may not be agreeable to some college-based participants, arises from observation of the difficulties which students from existing courses experience in trying to cope with the working stresses, adopt a satisfactory working discipline and form a satisfactory self-image as they discover their inadequacies. If the self-confidence of the new staff member is lost in their first weeks, it may never be adequately recovered and the years of preparation will be wasted.

204. The syllabus will appear to be too full for a two-year course, which is the maximum realistic duration for a graduate. But it is not necessary that every module is studied by every student. Some may be omitted, some divided into an elementary stage which should be compulsory and an advanced stage which can be an option. Some may be
taken as "refresher" or additional courses as in-service training. This will be appropriate in the initial stages of development of an HCTS, for the service may not be dealing with the complete range of equipment in its early years.

**Type A staff**

205. Type A staff will work under the supervision of higher grades on simpler tasks requiring less intellectual ability. The production of type A staff would appear to present less difficulties, but again it is worth thinking of the options available in the country. The main component will be the acquisition, by teaching and practice, of craft skills, which are common to many applications: the specific medical application knowledge is a lesser component. Ought the craft skill to be imparted in a health-service institution? In a number of developing countries there are good craft training schools. Why duplicate their facilities and expertise? Can they serve for part of the required course? The basic craft skills were outlined in a previous section and do not differ substantially for this class, but a great deal more practice will be needed.

206. In addition to the basic skills, the students will require a medical orientation which will be a simplified, shortened version of the course for class B staff: although it is not envisaged that class A staff will work unsupervised, they will have to move in and around hospitals, clinics and rural health centres and must be very carefully and safely.

207. They will require a shortened safety course, on the lines previously described.

208. There should also be formalised instruction, generally in the form of workshop instruction, on the working, maintenance and repair of simple equipment or parts of equipment — sphygmomanometers, weighing apparatus, calorimeters, simple microscopes, suction apparatus, mains connectors, cables, transducer leads, trolleys, lamps, etc.

209. Towards the end of training the practical experience should be gained in the hospital teams, under experienced instructors.

210. A typical timescale would be one year in college or in formal training, followed by one year in apprenticeship training in a hospital team approved for this training, before the student was passed for general service outside the training environment.

**Assessment of trainees**

211. The assessment of the achievement of students in these courses presents difficulties. The number of facts stored in the mind of the student, or the ability to present the theories taught is of little importance to the HCTS which the student will enter. The course is not primarily educational but rather vocational.

212. So written examinations alone are not a satisfactory method of assessment, although they may be a necessary component of the teaching and learning process. Systematic, continuous assessment will be the mainstay, and much weight will be given to assessment of performance during the practical 'apprenticeship' stage of training.

213. But such assessment is no more reliable than the persons doing the assessment, and it is not possible to maintain consistent and objective standards as easily as for written examinations — there cannot be an external assessor in each situation. This will present problems in the early stages of the training scheme when those who supervise the training, both in the college and in the hospitals, may be inexperienced and uncertain not only in judging trainees but also in self-assessment. A person who lacks confidence about their own ability and performance is unlikely to make reliable judgements about the performance or potential of others.
214. It is nevertheless important that the assessment should be strongly biased towards practical performance in the working environment, and this is a further argument against training colleges which are not closely associated with a major HCTs. Not only do they have difficulties in giving useful training, but also they will have problems in ensuring that their assessments are useful and reliable to the prospective employers. Certainly, their certificates or diplomas may indicate the extent to which the student has taken advantage of the instruction given, but they cannot indicate how the student will perform in employment. Of course this is a characteristic of educational establishments, and not a deficiency within the context of such establishments.

215. But this is not what the Health-Care sector needs. The facilities under discussion are not intended to produce well-educated persons who may or may not be useful in health-care, but persons who are trained and certified to have demonstrated their usefulness as potential employees.

Qualification awards

216. It is a fact of modern life (which is not worth either defending or deploring) that no training scheme can be successful in producing the right quality and quantity of staff unless the assessment of merit leads to the conferment of a sufficiently prestigious degree, diploma or certificate. The conventions will differ from country to country but it is important that an appropriate award is made.

217. If there is a University connection, and if the regulations are sufficiently flexible, the courses suggested for type C, and perhaps also type B, staff (if they have required a first degree as an entrance qualification) might allow the award of a higher degree or diploma. There is a close parallel between these courses and some taught Masters degree courses, if the practical training is regarded as equivalent to the project-work.

218. Where this is not a possibility, the Health Ministry should ensure, in collaboration with the Education Ministry, that there is an appropriate award which is meaningful in the national context. Most countries have methods of recognising the acquisition of the craft skills which can be used for type A staff.

219. Although it may seem immoral or offensive to the academic community, the important considerations determining these awards should be

a) will they ensure the recruitment of staff of the required quality?

b) will they enable the staff to be paid sufficiently to retain them?

SECTION 11

RETAINING STAFF IN THE HCTs

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220. There is little value in producing staff if they are quickly lost from the service. Some loss is inevitable where the individual is free to choose, but a crippling exodus is evidence of bad management.

221. There is one particular cause of loss which is particularly wasteful. In many countries the students emerging from training for an HCTS are immediately required to do a period of national service in the armed forces. This results in a serious loss of expertise, in two ways. Experience shows that a substantial fraction do not subsequently return to take health-care posts. Worse is the loss of technical expertise between the end of training and the eventual commencement of duties in those who do return.

222. Of course it might appear invidious if graduates from one particular course gained exemption which was not available to others. Even so, a strong government with a genuine commitment to improvement of health-care and an understanding of the importance of this particular group of staff might consider doing so. But there is another approach to the problem.

223. This is to ensure that the graduates undertake this military service in the medical core, using the skills which they have learned. Where there is universal military service there is likely to be a medical core of substantial size, with a number of military hospitals which will require HCTS. There should be good liaison between civilian and military HCTS to ensure this automatic transfer of trained staff.

224. It is suggested that there should be no support provided by WHO or other international agencies to HCTS training unless there is a clear undertaking by the government that trained staff will not be diverted into the armed forces except in work which uses their training and adds to their experience of health-care.

225. Some countries provide training on condition that the trainee practises in the public service for a specified period, and this may be a necessary precaution against early loss of trained persons. But it is sometimes the most intelligent and enterprising individuals who find ways of evading such restrictions.

226. Excessive loss of trained and experienced staff may be due to a number of causes: amongst them are lack of immediate job-satisfaction or lack of prospects for career advancement. But the most likely is lack of financial reward.

227. It has been suggested earlier that the details of the HCTS must be arranged in such a way that it is possible to pay staff well enough to compete with alternative employment. For example, by ensuring that they will have the status which the country rewards with a good income, by concentrating on quality rather than quantity,
by putting a realistic fraction of equipment-funding towards maintenance rather than procurement.

228. However, in most countries it is unrealistic to expect that the problem can be solved without the help of a well-organised scheme of incentive payments. It is not an exaggeration to suggest that the details of the incentive scheme may be more important than the details of education, training, staff deployment, etc, in getting an HCTS established and working satisfactorily.

229. An incentive scheme must be well-planned and practicable. It must generate a worthwhile addition to the income of a successful team. But, above all, it must be honest and fair to all members of the HCTS team. If not, it will generate animosity, impair the service and cause loss of staff.

230. Given adequate salaries, the work in HCTS should prove intrinsically satisfactory to a competent person. If it does not, it will generally indicate that the facilities or resources required to carry out the work are poor or inadequate, or that the management is incompetent.

231. The providing of career advancement is important. HCTS staff should be continually expanding their abilities: this will be necessary to cope with expanding technology in health-care, but necessary also for the self-satisfaction of a good technologist.

232. Within the general types of staff there should be a structure of at least four grades for types B and C: two may suffice for type A. Promotion from grade to grade should be possible for all staff, but should not be automatic: it should be regulated by clear criteria which require evidence of increased ability, or the assumption of greater responsibilities, or a mixture of these, for advancement to the next grade.

233. The successful completion of further education and training should be the main way of demonstrating increased ability, and this should be available to each member of staff who exhibits competence.

234. In an HCTS it is a mistake to base the grade of a post (or person) on the number of subordinate staff. The effect of such a scheme is to push the most able persons into posts with the greatest managerial content. Of course, it is desirable that persons of high ability should be chosen for top managerial posts. But in an HCTS it will often happen that some innovative development is undertaken (e.g. undertaking maintenance of a type of complex equipment for the first time) which, to be done successfully, requires the best possible technical ability, and so the post should carry a high grading. But it is likely that the work will initially require only one or two persons. If the grading is tied to the number in the team it will prove impossible to recruit the best staff.

SECTION 12

NUMBER OF HCTS STAFF REQUIRED

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235. To suggest the number of staff who will be required and the number to be trained is as easy as answering the question "How long a piece of string is needed to secure a parcel?". It depends on the size of the parcel and the quality of the string - and perhaps on whether the string is attached as a gesture or in a genuine desire to secure the contents.

236. Analogous to asking the dimensions of the parcel we might ask:

What amount of equipment does the country possess, and in how many establishments?

To what extent will the HCTS provide repair and maintenance; will any major category, e.g. X-ray, be left to manufacturers?

With such information it would be possible to compare the proposed service with well-established services in a developed country and suggest a staffing level. But this would be meaningless, for the environment is so different.

237. Analogous to asking the strength of the string we might ask what quality of staff are to be provided: if the answer is (as often at present) that it is intended to do no more than give school-leavers a short course to make them 'polyvalent technicians' then the number required can be confidently stated as any number between 0 and infinity, for the end result will be no different.

238. Also, if the intention is to make a gesture towards doing something to appease the dissatisfaction with the Ministry inactivity, but to spend as little as possible, then the number is unimportant.

239. If the recommendations given previously about the quality of staff are implemented, a small number of staff will have an enormous impact on the situation where they work. If the administrative machinery is capable of measuring the impact in terms of financial savings, the growth of the service will follow without precise planning.

240. But the need to establish training centres does require a more precise plan, for there is a minimum level of output which will be worthwhile. A scheme to train type B and C staff on the lines suggested earlier would require a minimum of about 12 professional staff (full-time) and should have about 60 students, indicating a potential output of 25 per annum. (This assumes an existing HCTS providing practical training outside the centre).

241. This training output would sustain an HCTS service with a staff complement of 50 which was expanding at 20% per annum but losing 30% per annum. This would staff a small Ministry team, and about four regional centres each supporting one major and several minor hospitals, clinics, in addition to helping the training scheme.

242. This would be the minimum worthwhile training activity which most advisers would consider economically worthwhile. Of course, a large country would find a larger centre more efficient and also more useful. A smaller country, or a country wishing to set lower objectives, would either have to fund a relatively costly training establishment or combine with other countries under a multilateral or international scheme.
ANNEX V

Working Paper No. 4*

DEVELOPMENT AND STRENGTHENING OF MANPOWER TRAINING

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*Working Paper No. 4 was prepared for the meeting by Dr A. Malloupas, Head, WHO/EMRO Regional Training Centre for Maintenance and Repair of Medical Equipment, Higher Technical Institute, Nicosia, Cyprus
Summary

In any national or international policy concerning maintenance and repair, manpower training should form an important factor of a larger interacting and interrelated health technology cycle, and thus should necessarily constitute one of its major system inputs. As a consequence, it requires its own planning, infrastructure, objectives and specialists so that it can programme and implement training policies, which can deliver the required results, but always within and in relation to the overall policies of the health care system it is designed to serve. The major system factors are given, such as identifying the types of personnel to be trained, assessment of the suitability of available training courses and proper selection of candidates, taking into account their experience and background but always in relation to the needs and infrastructure of the service.

Another important aspect related to manpower mentioned is the availability of qualified, experienced staff at all levels, including high level management, who will form the necessary infrastructure and ensure that coordination, planning, budgeting, training and intersectoral liaison are effectively implemented and realized. The multidisciplinary nature of the system and the necessity for teamwork is emphasized.

Collaboration with other sectors or agencies should be established and maintained in order to facilitate future planning, identify common needs, maximise resources and implement collaborative action. Particular attention is drawn to the need for close collaboration and information exchange between existing national and regional training centres and the need for joint concerted action and policy towards future planning and sharing of experiences, including common efforts in related areas of research and development.

Recommendations are made and questions raised with the aim of stimulating discussion on these aspects which it is hoped will result in the adoption of policy decisions, resulting in decisive action being taken in the field of maintenance and repair. Proper operation and service of equipment is a vital contributor for the correct and effective standards of health care service being offered and thus an area that should function constructively if the goal of HFA is to be attained.

1. Introduction

Many factors and variables should be considered by planners of national policy concerning the training of personnel involved in service or operation of equipment. As can be seen from Figure 1 the health technology cycle, 1,2, is a large, complicated and interacting system with various inputs of different specializations whose final aim is to satisfy the health needs at national or international level. It is obvious that in order for such a system to function efficiently and correctly there must be coordinated planning and identifiable and committed policy at the correct time in the cycle in order to ensure that the different inputs are fed into the system at the right moment and in adequate proportions. It is obvious that without a dedicated and planned policy with committed funds and clear, efficient and coordinated action at the beginning of the cycle, then all the other actions would fall short of their targets, irrespective of the planning and expertise with which they are formulated and carried out.

The above situation must always be borne in mind when considering the particular needs outlined below that are required for developing and strengthening manpower training in this field.
As a consequence of the above, when planning manpower training due consideration must be taken of the other requirements in the cycle, and in particular:

- Procedures for equipment selection
- Financing and procurement for equipment, facilities, tools and spares
- Local market supply and manufacturer backing
- Existence of an inventory of equipment, technical library and associated administrative back-up
- Medical stores and logistics support
- Presence of a health care technical service*, HCTS, its infrastructure, facilities and available expertise
- Existence of routine maintenance, calibration and testing procedures and facilities
- Availability and suitability of training establishments

Invariably the technical personnel involved with maintenance and repair should belong to a health care technical service*, HCTS, which, as can be seen from Figure 2, interacts between the various inputs and needs of the overall health needs policy and delivers the specific specialized outputs for which it is responsible. Such a service should, in collaboration with the other departments of the Ministry of Health and through intersectoral liaison, identify its manpower training needs based on the realities of their situation.

Hence in identifying manpower training programmes the HCTS must take into consideration the following factors:

- Priority targets set in health care and the necessary equipment required to meet them;
- Availability and sources of financing for training;
- Academic and professional background of the technical candidates for training, as well as those of the operating personnel;
- Graduating level and expertise of the trainees;
- Post-graduation professional standing, needs and incentives of the trainees;
- Long-term incentives, infrastructure, career prospects of personnel;
- Identification and assessment of suitability of courses and training institutions;
- Assessment and methodology for candidate selection;
- Evaluation of course syllabi;
- Post graduation practical training (on-the-job) under suitable supervision.

Thus in determining manpower training needs certain aspects need to be considered such as type of personnel requiring training, availability and suitability of training courses, procedure for selecting candidates and the setting-up of training courses. The above aspects are discussed in the paper and some suggestions are made which it is hoped will stimulate discussion of the above topics during the workshop groups.

* Health care technical service: Service which deals with all aspects of maintenance and repair of hospital and medical equipment
2. Identification of Training Needs

The inter-disciplinary nature of the equipment situation makes it necessary to consider training of staff involved with the use, service and general planning and administration of equipment.

Thus consideration should be given to training:

1. Health care personnel responsible for operating the equipment.

2. Service personnel responsible for the service, maintenance, repair and installation of equipment.

3. Technical management personnel (equipment) responsible for policy planning, procurement and training.

2.1 Health care personnel

This category should include all the medical, paramedical and other personnel such as laboratory technicians, medical physicists, etc., who operate equipment, which are directly or indirectly related to diagnosis or cure. It is imperative that at the stage of equipment selection, the needs in operating personnel should also be assessed and due consideration of their training requirements, at the manufacturers or training institutions, be identified well in advance of the installation and commissioning of the equipment.

Such planned provision would ensure that when the equipment becomes operational, the right calibre personnel is available so that the maximum use, efficiency and benefit is obtained from the equipment. The form of training adopted should be carefully considered taking into account the prevalent national conditions and limitations.

2.2 Service personnel

Under this category should fall the engineers and technicians of a HCTS responsible for servicing and maintaining the equipment. In today's ever-changing technological world, particularly in the electronics field, it is of paramount importance that suitable training for these personnel should be identified and implemented well in advance of the selection stage. This would ensure that they are able to participate in the advance planning of facilities, determine spare parts requirements, be involved in the installation and commissioning of the equipment and hence ensure that the wastage of resources encountered so often due to unsuitable buildings, locations, back-up services as well as mal-operation and service of equipment is avoided.

The establishment of a HCTS with suitably qualified personnel should thus be considered and training adopted to the national conditions and constraints.

2.3 Technical management personnel

Due to the highly inter-disciplinary nature of the health technology cycle management personnel involved in equipment planning, coordination and policy at ministerial level should be competent so as to appreciate technical needs and communicate effectively with specialists from the various other disciplines. Annex I shows the typical terms of reference for technical managers at ministry of health level.
Technical managers may be trained from existing managerial personnel, who should be given technical appreciation courses, or from technical personnel, who should be given managerial courses. The second course may be more realistic. Guidance on formulating such training may be based on similar experiences by other bodies such as those given by the WHO 'kit' on training, research and practice in health facilities planning.10

2.4 Identification and availability of training courses

Before commencing any form of training consideration should be given to securing adequate financial resources and the corresponding policy to support it. It is therefore essential that national ministries, at the planning stage, secure the necessary financing either through local funds or through collaboration agreements with external agencies. Hence the means and mechanisms for obtaining this precondition should be considered at national and international level.

Having the necessary policy backing, identification of suitable training should be made well in advance. This may take the form of institutionalized training at home or abroad or training at manufacturers, preferably as part of the sale agreements or service contracts. A number of training centres at regional level exist which may be used. It is however important to realise that national authorities should be in a position to technically assess the suitability of the various courses and to select the appropriate candidates. Otherwise, even if use is made of the training available, this will not have maximum benefit for the countries.

3. Selection of suitable trainees

Identification and assessment of suitable candidates should be made by managerial personnel in the ministry of health and HCTS, who should be in a position to evaluate the needs of the service, the capability of the candidates and the suitability of the courses being offered.

3.1 Needs of the service

It is thus necessary to set out the technical requirements of the service, based on the available inventory, the resultant efficiency and output potential of the equipment, their downtime* and take account of future procurement and needs of the service. From the above considerations and the technical complexity of the equipment (available or to be ordered), qualified technical managers may identify the needs in training for the following classes of technical personnel.

- engineers (electrical, electronic, mechanical);
- technician engineers (electrical, electronic, mechanical);
- specialized technicians: (of various equipment disciplines, i.e., such as: x-ray, dental, electro-medical, operating theatre, clinical laboratory, hospital plant equipment, etc.
- general (polyvalent) technicians: first line technicians able to carry out simple routine repairs and maintenance).

Annex II gives the job descriptions for the above personnel. Depending on the background and infrastructure of the HCTS and academic qualifications and experience of the available candidates, the appropriate classes of technical personnel may be chosen.

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* Down time: Time equipment remains completely unused, e.g., due to undergoing repair, maintenance or awaiting spare parts, etc.
3.2 Career Infrastructure, Incentives and Service Contracts

It is important for anyone offering or supporting training to realize that once personnel are trained they require to be placed in a suitable working environment with a career structure and adequate incentives, salaries and career prospects. It is a fact, and it has been encountered in visits to students' home countries, that the employers not only should offer the above conditions to their employees but should also safeguard their own investment by some post-training service agreement (or contract), so that the services of trained personnel are not immediately lost to more lucrative private enterprises at home or abroad.

3.3 Post-graduation training

Although in most institutionalized courses there is usually an element of practical or on-the-job training in a hospital or other workshop, this form of training may be regarded as part of the academic training. The most valuable experience gained by graduates is in the real on-the-job training they receive when returning back to their own workshops and working environment. Post graduation experience training is most valuable and consolidates the academic work. However a necessary pre-condition for this form of practical training by experience is the existence of adequate workshop facilities, fully equipped and staffed, where possible, by experienced personnel who will be in a position to supervise and train the graduates.

It can be seen that in countries where such an environment does not exist or is lacking then the academic training is by far less effective and may be totally lost with time. It is therefore absolutely necessary for governments to establish and commit themselves to the creation of HCTS and particularly of hospital workshops, whether based (a) in a large hospital and serving satellite units or (b) in a central location.

4. Use of Regional/Interregional Training Centres

In all WHO regions training institutions exist, as shown in Annex III. The experience and extent of the courses varies between each centre, but between them they should cover a wide spectrum of courses and specializations, which interested governments may take advantage of requesting sponsorships through their respective regional offices.

Almost all countries have bilateral repair and maintenance agreements with their respective WHO regional offices and these agreements usually always include a fellowships provision, which countries may use in order to benefit from these regional training courses.

4.1 Collaboration between training centres

It is therefore important that the various regional training centres establish regular and coordinated collaboration between them in order to exchange information, identify needs and plan for new courses. Annex IV gives the typical terms of reference required for establishing new courses. As can be seen a knowledge of the situation in the countries of the regions is necessary in order to formulate courses which will respond to the needs at country level. However the problem will always be faced by course designers of inter-country variations and different needs, resulting in classes with a large non-homogeneity of students. It is therefore important to ensure that the right quality and calibre of candidates are nominated for regional courses.

From the EMRO regional training centre's experience since 1978, the solution lies in establishing at country level national foundation training centres which will then ensure a minimum, common standard for all students studying abroad.
The regional training centres may then be used to offer the higher level, more expensive training, which may not be financially and technically feasible at country level, and can be undertaken at regional or interregional level. This situation will result in the following advantages:

- establishing a training infrastructure and expertise at country level;
- saving of funds both for countries and sponsoring agencies;
- upgrading the available training at regional level.

However, such a network of training systems involves a high degree of coordination, collaboration and information exchange. It will therefore necessarily require one or several regional or interregional focal points in order to carry out the coordination needed. Governments and international agencies should commit funds for such an undertaking so that the scheme is given adequate backing and the means to carry out its mission.

The type of courses that may be undertaken by regional centres are the training of hospital engineers, medical electronics (leading up to advanced digital electronics and microprocessors) and various fields of specialized equipment courses. Annex V shows the objectives of the above courses. Such courses may be run by one or several centres individually or jointly.

4.2 Establishing training facilities at national level

Many countries have locally the infrastructure and capability to organize foundation courses. They may require guidance and coordination to set them up initially, however they should be able to train nationals at first line technician level (general or polyvalent technician).

Already in the Eastern Mediterranean region, in Syria, Somalia, Bahrain, Egypt and other countries such attempts have begun. These centres should be assisted to consolidate their efforts and even upgrade them where possible.

The possibility that such centres should be related to a technical institution and if possible have close ties with a paramedical or medical school should be investigated. However invariably some investment should be made to create specialized laboratories dedicated to this form of training.

4.3 Curriculum content and training needs

The planning and preparation for any course content requires knowledge of certain inputs before the actual academic syllabus can be prepared. The format followed by the regional training centre, Cyprus, is that of an academic board and syllabus and curriculum committees.

The academic board is a body composed of representatives from the various bodies involved in the training, such as the academic, health care technical service, ministry of health administration and planning and hospital directors. The board determines the overall policy, actions and needs of the training centre. It operates within the framework of the initial terms of reference which set up the centre. In this case the bilateral agreement with WHO and the Government of Cyprus.

When dealing with matters concerning a new course the board authorizes the setting up of a syllabus and curriculum committee on which specialists from all sides concerned with the particular specialization of the course are co-opted to participate in the committee. The usual composition of such a committee is made up of trainers, operators and service engineers of equipment and where appropriate representatives from the private sector or ministry of health.
Annex IV shows the typical considerations which such a committee investigates before setting the input requirements and output level of the course. A detailed draft syllabus content, with a breakdown of topics and time allocation is also submitted by the centre and discussed by the committee. A report is then prepared and submitted to the academic board for final approval and comments.

The training needs for any courses are:
- availability of trained staff for the particular course;
- adequate laboratory space
- training equipment needs

If any of the above needs are considered not to be satisfactory then the committee identifies the required inputs, with a time schedule, so that when the course actually begins all of the above should be available.

4.4 Teaching aids and materials

The major problem facing any trainers in this field is that it is a new discipline with very little background information and references. The form of training is practically oriented but requires theoretical back-up. The student as a rule has either little theoretical background or insufficient experience in the field and in many cases of language and communications problems during training. In all situations means have to be identified by which teaching aids should be carefully developed to present the message visually. Also required are practical training manuals using hands-on experience for use by trainers and trainees.

5. Training of Health Care Personnel working at Primary Health Care Level

Consideration should also be given to training health care personnel, local technicians and others who are working at primary health care (PHC) level and are usually using low level technology equipment but due to the nature of their location are usually isolated or far away from a main service centre. It has often been encountered at PHC level that even minor equipment faults cannot be repaired or simple routine maintenance not implemented. From workers in the field and experiences over a considerable period of time a solution to this problem may be found in giving training on 'technical or equipment appreciation' and very rudimentary maintenance and repair to medical, paramedical and auxiliary staff involved with PHC centres.

Since the personnel for which training is proposed do not have a technical background, such training should be formulated very carefully by experienced trainers at national or regional level and should definitely identify the limitations and extent to which such personnel should engage in maintenance and repair (i.e., include what not to do with equipment).

Due to the distances involved unavoidably such training should also include aspects of routine repair and maintenance for vehicles.

Various avenues of action should be explored in formulating collaboration and exchange of experiences with other sectors involved in similar training in order to prepare a suitable plan of action for this type of training taking into account the HPA goals and PHC approach.

After establishing guidelines for interested parties the various policy-making bodies of training centres should consider adopting this form of training in their technical courses as well as recommending the inclusion of a subject on 'equipment appreciation' for medical schools and nurse's training.
6. **Conclusions**

From the above presentation it is evident that for any input of the health technology cycle there must be predetermined and committed policy and funds, and manpower training is no exception. Another obvious aspect in that of the interdisciplinary and intersectoral nature of the cycle, in which efficient, coordinated action by specialist and well-trained personnel is essential.

The specific problem of training personnel for maintenance and repair is that due consideration must be made to train all the categories of personnel involved, i.e., operators, service personnel and technical managers. However, before specific training requirements are made, identification of equipment needs, staff capability and experience, availability and assessment of course offered, must be made. Such action, to be successful, requires the necessary infrastructure and coordinated action by all concerned.

Adequate post-training environment, career structure and service infrastructure are an essential element to the success of any training programme and to the effectiveness of meeting the health needs and objectives of any policy action.

It is therefore essential to tackle the different aspects of establishing policy, coordination, health care technical service, manpower development, logistics support, etc., in a unified manner, since any attempts at solving problems in isolation will not meet the desired goals.

Training centres at regional or national level must be strengthened or created. However, it is evident from present experience, that use to the fullest extent of existing establishments is not made by all concerned. Collaboration, exchanges and collective planning between centres is essential if unnecessary duplication is to be avoided, identification of future training needs established and benefits are uniformly distributed.

7. **Recommendations**

The following recommendations in key areas are given below, for consideration with the aim of establishing such actions which will enhance the benefits of training:

- establish mechanisms for formulating policy and action, which will consider all the aspects involved in meeting health needs;
- determine training requirements in relation to equipment available and future procurement;
- training needs of all personnel involved with equipment selection, procurement, operation and service should be considered;
- secure and commit appropriate funds for the identified training requirements;
- investigate policy for the establishment or strengthening of national health care technical services, offering infrastructure, career prospects and suitable working environment;
- create pilot hospital or central workshops in which post-graduation training may be made;
- enforce service contract agreements with trainees in order to safeguard the availability of trained staff;
- collaboration among existing regional training centres must be established with the aim of determining future training needs and courses, establish information and staff exchanges, etc;
- identify and nominate regional focal point(s) or collaborating centre(s) to undertake the coordination and background work involved in inter-centre collaboration;
- carry out country surveys of situation concerning training needs;
- encourage development of curricula, teaching aids and materials for use by national or regional centres;
- encourage the development of 'equipment appreciation' curricula for use by medical and paramedical schools;
- develop training for FHC health care personnel and auxiliary staff on simple repair and maintenance procedures.
ANNEX I

Terms of Reference for Technical Managers

The main role of technical managers posts at ministries of health are to:

i. Liaise between health care technical services and high-level ministry management;

ii. Coordinate national or district action in selection and procurement, training, logistics, etc., and act as focal reference points for the various agencies involved (i.e., engineering, medical stores, building services);

iii. Estimate and submit budgets for approval;

iv. Formulate policy for planning, training, spare parts and logistics support;

v. Determine medium and long-term needs and programming, etc.

Suitable courses may be run at selected collaborative centres for engineers requiring management experience or for managers requiring technical background. The former may be a more suitable candidate.

The level of the post should be that of a middle management grade, and be suitably ranked according to national grading policies.
ANNEX II

Job Description of various classes of Hospital Engineering Personnel

The following typical schemes of service for various levels and specialities of hospital engineering personnel are given below.

1. Hospital engineer

To apply theories and techniques concerning the use of technology in health care as follows: advise, coordinate, supervise work concerning the installation, operation, calibration, testing, safety standards, repair and maintenance of hospital and medical equipment. Prepare and submit budget needs for spare parts, tools, staff posts, training and facilities for the engineering and technical service involved. Liaise with medical and paramedical staff in implementing routine maintenance of hospital, medical equipment and hospital buildings. Participate in the planning, selection and specification of tenders of equipment and advice on relevant requirements for buildings, spare parts, training of operating and maintenance staff. Collaborate with medical staff, architects, civil and other engineers in the planning and layout of hospital buildings. Provide technological support and participate with staff involved in research and development work. Liaise with chemists and laboratory staff in the planning, costing and specifications concerning the layout, safety, operation and equipment needs of clinical laboratories.

2. Specialized equipment technicians

Technicians should be capable of appreciating the principle of operation of the standard equipment of their specialisation and perform calibrations, routine maintenance, identify malfunctions and faults and carry out basic repairs. Under the supervision and guidance of a hospital engineer or assistant engineer they should be capable of tackling more complicated faults. Specialized technicians should be based at a large hospital or central workshop. Individually, or with the superintendent of the workshop, they should cater for the needs of satellite health units under their jurisdiction.

Specialized equipment technicians may be categorized as follows:

- Medical electronics
- Diagnostic X-Ray
- Operating theatre
- Clinical laboratory
- Dental
- Electro-medical

3. General (or polyvalent) technicians

First line technicians capable of undertaking simple routine maintenance and front line repairs of hospital and medical equipment under the guidance of specialized technicians or engineers. Such technicians may be based in rural health clinics or be part of major hospital workshops.
A typical organogramme for the various positions of the above personnel is shown below: (its aim is to illustrate the job descriptions described above and should not be taken as the level or infrastructure that must exist in countries, since this would take into account many factors and namely the existing system and infrastructure, the country's specific needs and size and national grading policies).

**Typical organogramme of a R & M workshop serving a district**

The proposed workshop assumes that it receives specialist support from a central workshop and that medical stores, policy and other required backing exists.

The typical district consists of:

- Population: 100-150,000
- General hospital: 200 beds
- Rural health centres: 5 (with some beds)
- Sub-centres: (dispensaries): 20
- Health posts: 60

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**Diagram:**

- **Director of hospital**
  - Med. equip.
  - Technician
  - 2 x-ray spec. tech.
  - 2 dental
  - 1 hosp. lab.
  - 2 electro-med.
  - 1 oper. theatre

- **Director HCTS**
  - Hosp. plant
  - Craftsman
  - 1 foreman
  - 2 electricians
  - 1 boilerman
  - 1 carpenter

- **Medical stores**
  - Hosp. build.
  - Craftsman
  - 1 foreman
  - 1 plumber
  - 1 mason

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**Visits on routine or call basis:**

- Visits on routine or call basis by building craftsmen or electricians for maintenance of buildings and basic supplies.
ANNEX III

Regional Training Centres*

At present training centres operating on a regional or national basis exist in:

- Sierra Leone
- Togo
- Nigeria
- Swaziland (Commonwealth)
- Brazil
- Cyprus
- Iraq
- Syria
- Bahrain
- Egypt
- Pakistan
- Lyon, France
- Compiègne, France
- Falfield, UK
- Bangladesh
- India
- New Zealand
- Philippines

* Due to lack of information this list is incomplete
ANNEX IV

Typical Terms of Reference for Establishing New Courses

The following guidelines are typical of the issues which must be taken into account when considering the running of a new course:

i. Aims and objectives of course

The field of specialization of the course and its scope must be identified and its general objectives investigated in relation to the role and need of such personnel and training for the particular health care service or private health care it is envisaged to cover.

ii. Professional standing of course graduates

It is necessary to ascertain the professional grade of such personnel, always in relation to item (i), and particularly matters concerning:

- their superior and subordinate grades and position in the existing infrastructure;
- their salary scale, job classification;
- the degree of specialization required for the field under consideration;
- the need for any other related or back-up training of existing or new personnel.

iii. Academic level of graduates (student output)

Having considered and agreed on the above then the corresponding status and academic level of the graduates must be set, i.e., the student output, which is their:

- final academic level
- type of certificate or diploma to be issued (related to existing professional norms and standards)

iv. Course duration

The duration of the course is determined mainly by financial considerations and the type of professional level and recognition it is required to have.

v. Level of student input (intake)

Having set the output levels and objectives for the course and its duration the student input needs must be set, in order to realize the objectives set. It is required to particularly examine the following:

- educational background and level;
- practical experience of candidates;
- availability of candidates
- knowledge of course language
vi. Guidelines of syllabus content

Having considered and agreed on the above, syllabus content guidelines must be prepared based on the following:

- General topic headings which must be included in the course, identified and based on the aims, objectives and academic level decided for the course;
- Entrance examination topics and syllabus;
- Candidates entrance requirements to the course.

vii. Detailed syllabus content and breakdown

A detailed syllabus content both for the course and entrance examinations must be prepared and discussed by the members of the syllabus committee, including a topic by topic time allocation.

viii. Equipment needs and facilities

Having set the syllabus content, the training equipment needs in test equipment, tools, spares and medical equipment must be ascertained, with estimated costs in order that unavailable equipment can be purchased in time for the commencement of the course. The adequacy of the training facilities in laboratories, stores, offices, etc., must also be ascertained. Again building additions must be identified and implemented in time for the course.

ix. Teaching staff training needs

The existing expertise and capability of the teaching staff to undertake the particular course must be assessed and any upgrading, or retraining must be identified and implemented in time for the course.

x. Teaching process

Courses should be extensively practically (hands-on) biased with a 50-50 breakdown between practical and theoretical teaching. Due to the nature of the courses and the background of the students emphasis should be placed on demonstration and extensive use of visual aids culminating in practical work on actual medical equipment. Mini constructional projects should be used extensively to familiarize students with principles and practical techniques.

xi. Assessment of performance

A system of continuous assessment (short tests) and final examinations should form the basis of evaluation of the students. Short tests may be both theoretical or practical depending on the subject matter to be examined. Final examinations should include a practical examination in fault-finding and repair.
ANNEX V

Objectives of Various Courses which may be run at Regional Level

The following courses could be run at regional level since they require higher academic standard and degree of teaching expertise, which may not always be available nationally. Also for smaller nations the numbers of personnel may make the running of such courses financially and/or organisationally unfeasible.

1. Hospital engineer

The aims of such a course would be to produce graduates who will be able to:
- Lead a large hospital workshop and carry out its administrative and technical supervision;
- Train lower level technicians;
- Keep inventory and spare parts records needed by the workshop and medical equipment under his jurisdiction;
- Liaise with medical and non-medical staff in planning, layout of equipment and hospital buildings;
- Estimate staff budget needs, facilities, tools and test equipment requirements for the workshop;
- Participate in select committees on general planning, tendering, selection and procurement of equipment;
- Report and advise the director of the hospital technical service;
- Carry out installation, commissioning, testing, maintenance and repair of sophisticated equipment, etc.

2. Technical manager

Such a course will train personnel for technical manager posts, at middle management grade, mainly at ministries of health in order to:
- Liaise between health care technical services and high-level ministry management;
- Coordinate national or district action in selection, procurement, logistics, etc., and act as focal reference points for the various agencies involved (i.e., engineering, medical stores, building services, etc.);
- Participate in budget preparation and submit them for approval;
- Formulate policy for planning, training, spare parts and logistics support;
- Determine medium and long-term needs and programming, etc.

3. Logistics Support Courses

Logistics support courses (mainly dealing with the function of medical stores) have mainly been dealt with on a national basis (SHS/85.6 Report on Logistics Support to PHC including Communications and Transport). Countries which have had good experiences in this field or other centres may be used to running courses on logistics support which should include the following (based on SHS/85.6 report findings). The aim of such a course should be to train graduates who will be able to:
- Carry out planning and budgeting for medical stores requirements and other related logistics support;
- Participate and formulate drawing up tender and procurement documents and submitting them to manufacturers;
- Administer receipt and inspection procedures concerning equipment, supplies and spare parts, including customs, clearance and insurance cover;
- Plan and administer storage and warehousing facilities and supervise subordinate staff;
- Plan, administer and update inventory control of equipment;
- Liaise with interested parties concerning delivery, installation and transport of equipment;
- Evaluate, assess and implement policy concerning medical stores staff infrastructure;
- Carry out environmental control and management of storage systems at health facilities;
- Determine staff training needs and supervise training of staff;
- Identify, evaluate and assess research and development programmes concerning operation, efficiency and modern methods of work of medical stores.

4. **Medical electronics specialized technicians**

This course is aimed at higher level technicians and its objective is to introduce students to the new micro-electronics technology which is now available in almost all equipment. Paradoxically, although this technology has meant simpler operating procedures it is technically more complicated or at least different from orthodox electronics technology, requiring special skills and background.

The duration of the course is ten months.

Candidates attending such a course should be able to:

- Work in a team of hospital workshop technicians under the supervision of an engineer;
- Understand the principles and operation of medical electronics circuits comprising of analogue and advanced digital circuits commonly found in medical equipment;
- Appreciate and have a working knowledge of equipment using microprocessor circuits;
- Carry out unsupervised repair and maintenance of non-microprocessor equipment;
- Locate areas of faults in microprocessor equipment and under suitable supervision carry out their repairs;
- Undertake routine calibration and testing of electronic equipment.

5. **Specialized technician courses**

The following specializations of equipment may be covered by courses dealing with the following equipment areas:

- Electro-medical
- Dental
- Operating theatre
- Clinical laboratory
- Diagnostic X-Ray

Candidates graduating from the above courses should acquire such expertise in their specialisation so as to be capable of:
- Collaborating with other technicians of a hospital workshop in carrying out the service work required in a large hospital or satellite clinics;
- Appreciating the function of standard equipment of their specialization;
- Undertaking without supervision routine maintenance and repair of standard low and middle level technology equipment;
- Carrying out routine calibration and testing;
- Working under the supervision of an engineer to carry out more complicated repair and maintenance work.
References

1. Malloupas A. WHO Programme for Support to Countries in the Field of Repair and Maintenance of Hospital and Medical Equipment. Background document for reference and use by personnel dealing with this field. WHO/HQ Geneva, SHS/86.5.


Figure 1: The Place of Maintenance and Repair of Equipment in the Health Technology Cycle
Figure 2: Main system inputs and outputs of a health care technical service
ANNEX VI

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16. Okoye, Dr Goddy Chuba, Lecturer, Department of Medical Rehabilitation, Faculty of Health Sciences and Technology, College of Medicine, University of Nigeria, Enugu, Nigeria.
17. Porter, Dr David, (also representing UKODA), Principal Physicist, Overseas Project Support Group, Consultant, UK Overseas Development Administration, West of Scotland Health Boards, Department of Clinical Physics and Bioengineering, Glasgow G4 9LF, United Kingdom.

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IFMBE

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Coulter International

31. Barton, Mr Leslie C., Area Manager, East Africa, Coultronics France SA, 29 Avenue Georges Pompidou, 95580 Margency, France.

32. Hutchinson, Mr William J., Regional Service Manager, Coulter Electronics UK, Ltd., Regional Office for Middle East, PO Box 4831, Dubai, UAE.

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Medicor Co.

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Siemens AG

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38. Issakov, Dr Andrei, Medical Officer, Logistics of Health Services, Division of Strengthening of Health Services, Avenue Appia, 1211 Geneva 27, Switzerland (Secretary).

39. Tarimo, Dr E., Director, Division of Strengthening of Health Services, Avenue Appia, 1211 Geneva 27, Switzerland.

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Dr A. Issakov, SHS/LHS, WHO, Geneva
Miss J. Harwood, SHS/LHS, WHO, Geneva
Dr A. Mallouppas, WHO/EMRO RTC; Nicosia, Cyprus
Prof. J. McKie, SHS/LHS, WHO, Geneva (Temporary Adviser)
Mrs E. Papa, WHO/EMRO RTC, Nicosia, Cyprus
Dr D. Porter, WSHB, Glasgow, UK
Mr J. Riha, WHO/AFRO, Freetown, Sierra Leone
Dr E. Tarimo, Director, SHS, WHO, Geneva
Mr P. Vogt, Leysin, Switzerland.
ANNEX VII

Programme of Work

Sunday, 23 November 1986

18.00 - 19.00 Meeting of the secretariat

Monday, 24 November 1986

08.00 - 09.00 Registration of participants

09.00 - 09.30 Opening session
Welcome address by Dr A. Mallouppas, Head, WHO/EMRO
Regional Training Centre for Maintenance and Repair of
Medical Equipment, Nicosia, Cyprus
Statement by Dr E. Tarimo, Director, Division of
Strengthening of Health Services, WHO, Geneva
Opening address by Dr T. Pelekanos, His Excellency the
Minister of Health, the Republic of Cyprus

09.30 - 10.00 Coffee break

10.00 - 10.30 Plenary session
Introduction of participants
Election of chairman, vice-chairman and rapporteur
Composition of working groups, election of chairpersons and
rapporteurs

10.30 - 13.00 Plenary session
Presentation and discussion of situational reports

13.00 - 14.00 Lunch break

14.00 - 15.45 Plenary session
Presentation and discussion of situation reports (continued)

15.45 - 16.00 Coffee break

16.00 - 18.45 Plenary session
Presentation and discussion of situation reports (continued)

19.00 - 21.00 Evening reception by the Ministry of Health, the Republic of
Cyprus

Tuesday, 25 November 1986

08.00 - 10.00 Visit to WHO/EMRO Regional Training Centre for Maintenance
and Repair of Medical Equipment, Nicosia, Cyprus

10.00 - 10.15 Coffee break

Topic 1 - National Policy on the Maintenance and Repair of
Health Care Equipment
10.15 - 11.00  Plenary session
              Introduction by Prof. J. McKie
              Discussion

11.00 - 12.30  Working groups
              Group discussions

12.30 - 14.00  Lunch break

14.00 - 15.30  Working groups
              Group discussions (continued)

15.30 - 15.45  Coffee break

15.45 - 17.45  Plenary session

15.45 - 15.55  Introduction by the chairman

15.55 - 16.05  Report of working group no. 1

16.05 - 16.15  Report of working group no. 2

16.15 - 16.25  Report of working group no. 3

16.25 - 17.45  Discussion

Evening  Secretariat - editing, typing and distribution of working
groups' conclusions

Wednesday, 26 November 1986

Topic 2 - National infrastructure for the maintenance and
repair of health care equipment

08.00 - 08.45  Plenary session
              Introduction by Prof. J. McKie
              Discussion

08.45 - 10.15  Working groups
              Group discussions

10.15 - 10.30  Coffee break

10.30 - 12.00  Working groups
              Group discussions (continued)

12.00 - 13.00  Lunch break

13.00 - 13.10  Plenary session

13.00 - 13.10  Introduction by the chairman

13.10 - 13.20  Report of working group no. 1

13.20 - 13.30  Report of working group no. 2

13.30 - 13.40  Report of working group no. 3

13.40 - 15.00  Discussion

15.00 - 15.15  Coffee break

15.15  Sightseeing tour of Nicosia

Evening  Secretariat - editing, typing and distribution of working
groups' conclusions
Thursday, 27 November 1986

Additional agenda item - Use of computer database systems in health care equipment management

08.00 - 09.00
Plenary session
Introduction by the chairman
Discussion

Additional agenda item - Collaboration with other agencies and bilateral donors

09.00 - 10.00
Plenary session
Introduction by the chairman
Discussion

Topic 3 - Development and strengthening of manpower training for management, maintenance and repair

10.00 - 10.45
Plenary session
Introduction by Dr A. Malloupas
Discussion

10.45 - 11.00
Coffee break

11.00 - 12.30
Working groups
Group discussions

12.30 - 14.00
Lunch break

14.00 - 15.30
Working groups
Group discussions (continued)

15.30 - 16.10
Plenary session

15.30 - 15.40
Introduction by the chairman

15.40 - 15.50
Report of working group no. 1

15.50 - 16.00
Report of working group no. 2

16.00 - 16.10
Report of working group no. 3

16.10 - 16.25
Coffee break

16.25 - 17.45
Plenary session
Discussion

19.00 - 20.30
Cocktail party offered by the Ledra hotel management

Evening
Secretariat - Drafting, typing and distribution of the report of the meeting
Friday, 28 November 1986

09.00 - 10.30  Plenary session
09.00 - 09.15  Introduction by the chairman
09.15 - 09.45  Presentation of the draft report of the meeting by the rapporteur
09.45 - 10.30  Discussion on the draft report and recommendations for follow-up action by countries, WHO and other agencies

10.30 - 10.45  Coffee break
10.45 - 12.45  Plenary session
10.45 - 12.30  Continuation of discussion and adoption of the draft report and recommendations
12.30 - 12.45  Closure of the meeting
12.45 - 14.00  Lunch break
14.00 - 15.00  Meeting of the secretariat
ANNEX VIII

Composition of Working Groups

Working Group No. 1
Aarnio, Mr E.
Azmeh, Mr B. el
Barzai, Mr J.
Bracale, Prof. M.
Donadey, Mr A.
Herrera, Mr A.
Killini, Mr F.
Mokhtar, Mr N. bin
Okoys, Dr C.C.
Porter, Dr D.
Redeker, Mr H.
Savvides, Dr L.
Tarimo, Dr E.
Vogt, Mr F.

Tuesday, 25 November 1986 - Chairman: Mr Mokhtar; Rapporteur: Mr Azmeh
Wednesday, 26 November 1986 - Chairman: Mr Redeker; Rapporteur: Dr Okoys
Thursday, 27 November 1986 - Chairman: Mr Barzai; Rapporteur: Dr Savvides

Working Group No. 2
Baron, Mr L.
Biles, Mr J.
Chaplin, Mr D.
Cheng, Mr M.
Deria, Mr A.M.
Kress, Mr H.
Liestrump, Mr G.
Marcel, Mr J.-C.
Massara, Dr B.
Mckie, Prof. J.
Rahman, Mr M.B.
Sarbolirwan, Mr G.
Syprou, Mr S.
Wang, Dr B.

Tuesday, 25 November 1986 - Chairman: Mr Marcel; Rapporteur: Dr Wang
Wednesday, 26 November 1986 - Chairman: Dr Massara; Rapporteur: Mr Syprou
Thursday, 27 November 1986 - Chairman: Mr Rahman; Rapporteur: Mr Chaplin

Working Group No. 3
Areefiev, Dr I.
Gaber, Dr A.
Hutchinson, Mr W.
Issakov, Dr A.
Malloupatas, Dr A.
Newman, Mr P.
Rih, Mr J.
Sachot, Dr E.
Talusan, Mr I.
Thairu, Prof. K.
Yacoub, Mr E.

Tuesday, 25 November 1986 - Chairman: Mr Talusan; Rapporteur: Mr Hutchinson
Wednesday, 26 November 1986 - Chairman: Mr Rih; Rapporteur: Mr Yacoub
Thursday, 27 November 1986 - Chairman: Mr Newman; Rapporteur: Dr Gaber
ANNEX IX

Working group discussion outlines

Topic 1

The following objectives and questions are intended as guidelines to aid the working groups in their discussions on the topic. Recommendations on following action by countries, WHO and other international agencies should be developed.

National Policy on Maintenance and Repair of Health Care Equipment

Approaches to the formulation of appropriate national policies, based on intersectoral collaboration, in accordance with country's needs and resources.

- Identification and assessment of health care services needs and requirements for equipment (appropriate and inappropriate technology) based on the epidemiological situation and resources available.

- Programming, planning and budgeting for optimal use of available resources (finance, manpower, facilities, supplies).

- Financial resource allocation (cost of maintenance and cost of non-maintenance, division between purchasing and maintenance, etc.).

Q. Is there a policy commitment by your ministry on maintenance and repair? Is it adequate with the necessary advance planning, financing and intersectoral collaboration? If not, why not? What steps are needed to ensure an effective policy and who should take them? In which way can WHO help to establish and/or strengthen such a policy commitment?

Q. Is it possible to limit our technology to 'appropriate' equipment or must our practice become appropriate to a technology whose level is beyond our control?

Q. What proportion of our technological equipment can be controlled by our ministries, and how much is controlled by other agencies - private sector, aid-giving countries, international agencies?

Q. Do we agree that it is important to fund not only the purchase but also the maintenance of equipment as inseparable necessities? Can this be done in our health-care organization which we fund? Can it be done for equipment which we do not directly fund? Would an international convention on these policies be useful?

- Selection and procurement of equipment (importance of maintainability, effect of type and brand standardization and diversification, difference between purchase price and lifetime price, tendering procedures; maintenance provided in purchase contracts, training provided in purchase contracts, approval of supplier, approval of agents; availability of spare parts and supplies, availability of technical information).

- Policies on donated and bartered equipment.
Q. What procedure is followed in your country in the planning identification of needs, selection, tendering and procurement of equipment? Who participates in this effort and why? In what way do you think this may be improved?

Q. Do we/should we/can we control the acquisition of equipment to ensure maintainability, efficiency and safety by limitations of sources, brands, by contractual obligations for maintenance parts, support, supply of information and user training? Can this be done for donated equipment? Does this need international agreement?

Q. Is a national central purchasing agency a help or a hindrance; how can this be organized? Can we eliminate waste during transport and in customs?

- Distribution of equipment (adequacy of transport and communication systems) and adequacy of facilities for installation and storage.
- Inventories and replacement procedures.
- Safety, legislation, certification, testing, evaluation and approval procedures.
- Equipment advice and information databanks.
- Hazard and defects control.
- Importing, currency and customs problems.

Q. Is there a need for legislation governing safety and efficiency - are international standards adequate? Should we each undertake evaluation of equipment, and would the results affect our practice.

- Need for establishment of effective national infrastructure - national health-care technical service (HCTS), intersectoral collaboration at national level, relationship of facility planning to maintenance planning.

- Manpower resource training and management. Classes of manpower, estimating numbers required, educational sector implications, specialized training, career provision, setting pay and incentives, avoiding manpower loss, establishing priorities.

- Limitations of service in smaller countries, possibilities of international collaboration.

Q. Do we see the necessity for a health-care technical service which extends from ministry to local clinic in a co-ordinated way? Are the objectives suggested in the working paper broadly correct? How should HCTS relate to the management of hospital plant, services, 'hotel' equipment?

Q. What types of staff do we consider to be necessary in a HCTS in order that it shall fulfil its objectives?

Q. Can we provide enough staff of these types - how will we produce them; can we pay them sufficient to retain them? Do we require incentive schemes?

Q. Can a service be established without external aid? If not, what agencies should be involved and what should be done?
Topic 2

The following objectives and questions are intended as guidelines to aid the working groups in their discussions on the following topic. Recommendations on follow-up action by countries, WHO and other international agencies should be developed.

National Infrastructure for Maintenance and Repair of Health Care Equipment - National Health Care Technical Service (HCTS)

Approaches to establishing or strengthening of effective national health care technical service.

- Resumé of requirements of the service (established in Topic 1).
- Status and government control of service.
- Targets, goals at national, regional, district levels.
- Effective liaison with departments within the health sector and with other related sectors.

Q. Do we have a service comparable with the HCTS outlined?

Q. Can we organize a service with line management from ministry to clinic, or must it be divided? If divided, how can we ensure coordination and avoid isolation of segments, or friction between them?

Q. What should be the rank of the chief of the HCTS? How will the service relate to the ministry sectors controlling health service development, training, buildings and plant? How can its educational and training functions be arranged when they impinge on the Educational Ministry?

- Acceptance testing, commissioning, user-instruction, inventories, planned preventive maintenance, repair, spare parts stock, technical information.
- Appropriate choice of commercial maintenance, HCTS maintenance, user maintenance.
- Supervision and control of commercial maintenance and user maintenance.
- Relationship between plant maintenance and medical equipment maintenance.
- Workshops, equipment, logistics support.

Q. Are the duties (which have been listed) related to the care of equipment appropriate?

Q. With an HCTS in operation, what division of responsibility should there be between manufacturers' agents and the HCTS?

Q. Should the HCTS deal with all equipment and plant, from endoscopes and ECGs to elevators and steam generators, or should there be a division? If a division, where should it occur? Can the divided parts be coordinated?
Q. What facilities are needed in, say, a large general hospital (1,000 bed) and in a small town hospital (200 bed).

- Staffing (levels, expectation of achievements of technicians, engineers).
- Relationship between operational support (e.g., paramedical technicians) and HCTS.
- Staffing infrastructure (career structure, experience, motivation, incentives).
- Availability of adequate training, need for basic training, continuing in-service training, specialist training.

Q. What types and numbers of staff do you think should be provided at the various levels of the HCTS. What names should we use for these types?

Q. What are the relationships of your HCTS with medical, paramedical and administrative staff and medical stores? Are these really of importance? Are these adequate? In what way should they be improved?

Q. Are such staff already available in sufficient numbers? If not, do you think that they can be produced and retained by the schemes outlined?

Q. How will the service be financed?

Topic 3

The following objectives and questions are intended as guidelines to aid the working groups in their discussions on the following topic. Recommendations on following action by countries, WHO and other international agencies should be developed.

Development and Strengthening of Manpower Training for Management, Maintenance and Repair

- Identification and assessment of training needs in relation to the development of the HCTS.
- Programming, planning and budgetting for identified training needs. Usefulness of country surveys.
- Identification, assessment of available training institutions and suitability of courses.

Q. Do you agree with the general concept of providing HCTS staff by starting with high educational qualifications and adding a specific vocational training with strong practical bias?

Q. What educational levels in your country would be required for entry to training for each type of staff? What duration of training would be required?

Q. In what way and who carries out the evaluation of any training scheme or course? What experience should personnel involved with training assessment and candidate selection have? How should selection criteria be formulated?
Q. Do you agree with the emphasis on the need for practical experience within the hospital environment during the course, or do you think that the training can be completed entirely within a college or training centre?

- Need for national and regional training centres.

- Formulating objectives for curriculum and syllabus content.

- Establishment, staffing and equipping of pilot or central workshops in which post-graduation training may be made.

Q. How should syllabii and curricula for courses be produced? Who should be involved in the planning and formulation of courses? How should course objectives be set? Are WHO guidelines necessary?

Q. How can training centres be staffed in their initial years of development?

Q. Is there a need for collaboration and information exchange between existing training centres? How and by whom should future needs be established? What type of exchange of information is necessary? Should such centres do planning, development and other related work? Should more centres be established at national or regional level and by whom?

- Development of curricula, teaching aids and materials for use by training centres.

- Language problems.

- In-service training (including manufacturer training).

- Type of qualifications awarded and their assessment.

Q. Have you problems with language? Do you suffer from lack of training material in your national language(s)? Is there need for international or regional cooperation to produce such material?

Q. Do you see the need for continuous in-service training after the initial qualification is achieved? Should this be on more specialized topics, or general 'refresher' courses or both? Is this something which should be done in-country or is this a useful area for international action?

Q. Have you problems of loss of students between training and employment? How can these be solved?

Q. How should student progress and performance be assessed and certified?

- Identification and establishment of focal points and/or collaborating centres related to training and service by UN agencies.

- Collaboration and coordination by different agencies in establishing training and repair and maintenance services.

Q. Have you experience of duplication or lack of coordination of collaboration programmes? If yes, why is this so? How can situation be improved?
ANNEX X

Useful References


3. Background document for reference and use by Personnel dealing with the WHO program for Support to Countries in the Field of Maintenance and Repair of Hospital and Medical Equipment by A. Malloupas, WHO Geneva, SHS/86.5.


32. Specifications for Production and/or Assembly of Basic Laboratory Equipment, WHO Geneva, LAB/84.2.

33. Strategy and Proposed Action concerning Maintenance and Repair of Hospital and Medical Equipment by A. Mallouppas, WHO Geneva, SHS/86.4.


36. Test and Check Procedures, Booklets 1-7, West of Scotland Health Boards' Department of Clinical Physics and Bioengineering, Glasgow, UK.


The following reports were prepared by WHO regional offices during last years.


3. Assessment of two and a half years’ activities in the field of Maintenance of Medical and Hospital Equipment in seven countries of the Eastern Mediterranean region, January 1971 - July 1973, EM/RAD/66 by P. Vogt.


16. Assignment report, Survey of Actual Situation in the Field of Maintenance and Repair of Hospital Equipment and Assessment of Future Needs in the Somali Democratic Republic, by Dr D. Porter and Mr P. Spyrou, EM/RAD/115.


21. Assignment report, Development of Manpower and Services for Maintenance and Repair of Medical Equipment, Yemen Arab Republic, 9 July - 6 August and 10 September to 15 October 1984 by Dr D. Porter.


SEARO


WPRO


4. Assignment report by Mr M.J. Reeves, 1 August - 27 October 1982, Philippines, Maintenance of X-ray and other Medical Equipment, PHL/ATH/002.


6. Report on a Field Visit to the Philippines by Mr M.J. Reeves, 12-16 March 1984, ICP/PHC/003.


11. Report on a Field Visit to Vanuatu by Mr M.J. Reeves, 30 September - 7 October 1984, ICP/PHC/003.

12. Report on a Field Visit to Fiji by Mr M.J. Reeves, 7-15 October 1984, ICP/PHC/003.

13. Report on a Field Visit to Tuvalu by Mr M.J. Reeves, 15-19 October 1984, ICP/PHC/003.


15. Report on a Field Visit to Western Samoa by Mr M.J. Reeves, 24-28 October 1984, ICP/PHC/003.

16. Report on a Field Visit to Cook Islands by Mr M.J. Reeves, 28 October - 1 November 1984, ICP/PHC/003.

17. Report on a Field Visit to Laos by Mr M.J. Reeves, 5-16 July 1984, ICP/PHC/003.


20. Report on a Field Visit to Republic of Korea by Mr M.J. Reeves, 8-20 April 1985, ICP/PHC/003.

22. Assignment report by Mr M.J. Reeves and Mr Renato Ongcoy, Vanuatu, 16 June – 30 July 1985, Training course on electromedical equipment.


26. Assignment report by Dr Bengt-Inge Ruden, 5 March – 5 April 1985, Republic of Korea, KOR/CLR/001.
### ANNEX XI

#### Abbreviations Used

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AFRO</td>
<td>WHO Regional Office for Africa</td>
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<tr>
<td>AMRO/PAHO</td>
<td>WHO Regional Office for the Americas/Pan American Health Organization</td>
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<tr>
<td>CIDA</td>
<td>Canadian International Development Agency</td>
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<tr>
<td>CNMEA</td>
<td>Council for Mutual Economic Assistance</td>
</tr>
<tr>
<td>DANIDA</td>
<td>Danish International Development Agency</td>
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<td>DTH</td>
<td>Directorate of International Technical Aid, the Netherlands</td>
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<tr>
<td>DTR</td>
<td>Diagnostic, Therapeutic and Rehabilitative Technology Division, WHO Geneva</td>
</tr>
<tr>
<td>EMRO</td>
<td>WHO Regional Office for Eastern Mediterranean</td>
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<tr>
<td>EPI</td>
<td>Expanded Programme on Immunization, WHO, Geneva</td>
</tr>
<tr>
<td>EURO</td>
<td>WHO Regional Office for Europe</td>
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<tr>
<td>FINNIDA</td>
<td>Finnish International Development Agency</td>
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<td>GNP</td>
<td>Gross National Product</td>
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<td>GTZ</td>
<td>Germany Agency for Technical Cooperation</td>
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<tr>
<td>HCTS</td>
<td>Health Care Technical Service</td>
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<td>HIPA 2000</td>
<td>Health for All by the Year 2000</td>
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<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<td>IEC</td>
<td>International Electrotechnical Commission</td>
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<td>IFHE</td>
<td>International Federation of Hospital Engineering</td>
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<td>IFMBE</td>
<td>International Federation for Medical and Biological Engineering</td>
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<td>IGOs</td>
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<td>ILO</td>
<td>International Labour Office</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<td>LHS</td>
<td>Logistics of Health Services, WHO, Geneva</td>
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<td>Ministry of Health</td>
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<td>NARAD</td>
<td>Norwegian Agency for International Development</td>
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<td>OECD</td>
<td>Organization for Economic Cooperation and Development</td>
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<td>PHE</td>
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<td>PHC</td>
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<td>RTC</td>
<td>Regional Training Centre, WHO/EMRO, Nicosia, Cyprus</td>
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<td>SEARO</td>
<td>WHO Regional Office for South East Asia</td>
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<td>SHS</td>
<td>Strengthening of Health Services Division, WHO Geneva</td>
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<td>SIDA</td>
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<td>TCDRC/RCDC</td>
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<td>UKODA</td>
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<td>UNDP</td>
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<td>WSHB</td>
<td>West of Scotland Health Boards</td>
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ANNEX XII

Acknowledgements

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