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ABSTRACT

A biomedical engineering course at the University of Wisconsin is described. The course is a comprehensive survey designed to develop the student's ability to participate in the solution of medical problems, particularly in areas involving technology. Course objectives and lecture outlines are provided. (MLH)

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AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ANNUAL CONFERENCE, JUNE 16-19, 1975

COLORADO STATE UNIVERSITY

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A COURSE IN MEDICINE AND CLINICAL ENGINEERING FOR ENGINEERS

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1) The course should provide sufficient medical terminology so that the student can easily converse with medical personnel.

2) The course should provide sufficient basic science material, such as anatomy and physiology, so that the student is prepared to learn diagnosis, pathology and treatment.

3) The student should learn the organized process that the physician follows in making a diagnosis, such as the physical diagnosis and laboratory tests.

4) The student should learn the basics of medical and surgical treatment, with emphasis on technological aspects.

Course Organization

Most engineering courses are taught by a single teacher. In medical schools, the usual pattern for courses both in the basic and clinical sciences is for team teaching, with each area of the course taught by a specialist in that area. There are very few teachers who are knowledgable in all areas of medicine and also conversant in engineering. Such rare individuals are frequently heavily committed already and are not free nor willing to take on the task of teaching this type of course. Such was the case for us.

Therefore the author, as biomedical engineer organized the course, following the outline suggested by Bertil Jacobson, a Swedish physician-engineer who has taught a similar course to over 300 students. We followed the team teaching concept by inviting physician-specialists to give lectures in each subject area. Since our physicians were asked to provide only 1 to 3 lectures in their specialty area, all contacted either

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Text Objectives

The text provides several functions:

1) It provides comprehensive background reading for the student, who is asked to read the material prior to the lecture.

2) It checks student comprehension, since each section of the text is followed by a series of questions in a programmed learning format.

3) It provides direction to the physicians as to the desired level and extent of their lectures. This helps to prevent the course from just becoming a series of specialized topics. The physicians are requested to extend the material presented in the text.

4) It defines student objectives, since students are informed that 2/3 of exam material will be from the text and 1/3 from the lectures.

Lecture Content

The text provides a guide for the 40 lectures. These subject areas are listed below, together with examples of representative figures and programmed learning questions from the text.

MEDICAL TERMINOLOGY (6 lectures)

- General terminology, tissues, the cell
- Types of tissues, body fluids, pathology
- Organs, anatomy, skeletal, muscular system
- Digestive, respiratory, circulatory, excretory system
- Reproductive, skin, endocrine, nervous system
- Regulatory functions, organs of the senses

PHYSICAL DIAGNOSIS (2 lectures)

- Patient history (Fig. 1 shows the area of the body where the patient feels pain due to angina.)
- Physical examination (Fig. 2 shows a fiberoptic endoscope used for viewing inside the patient's intestines.)

CLINICAL PHYSIOLOGY (6 lectures)

- Respiration, lung function tests
- Catheterization, phonocardiography, pressure
- Blood flow, body fluid, tissue volumes (Fig. 3 shows the Fick principle for measuring cardiac output.) (Fig. 4 shows a programmed learning question, that deals with the indicator dilution method of measuring cardiac output.)
- Electrocardiography (Fig. 5 shows a programmed learning question, in which the student uses an abnormal ECG waveform to diagnose heart pathology.)
- Vectorcardiography, computer analysis of ECG
- Defibrillation, pacemaker, working capacity

CLINICAL NEUROPHYSIOLOGY (2 lectures).

- EEG, clinical applications (Fig. 6 shows a programmed learning question, in which the student uses an abnormal EEG waveform to diagnose brain pathology.)
- Electromyography, conduction velocity in nerves

CLINICAL CHEMISTRY (3 lectures)

- Blood plasma and serum
- Blood cells, coagulation, urine, gastric juices, CSF

- Chemical analysis, automatic analysis, isotope methods (Fig. 7 shows how electrophoresis is used to separate constituents of the plasma.) (Fig. 8 shows how an Autoanalyzer automates chemical analysis of plasma.)

CLINICAL MICROBIOLOGY & IMMUNOLOGY (3 lectures)

- Microbiological culture techniques (Fig. 9 shows an infectious agent is tested for sensitivity to various antibiotics.)
- Sterilization, disinfection, hospital hygiene
- Immunology, antigens, antibodies, serology

BLOOD & TRANSPLANTATION (1 lecture)

- Blood groups, transfusion, tissue typing, storage (Fig. 10 shows how blood is tested to determine its type in the ABO blood system.)

DIAGNOSTIC RADIOLOGY (6 lectures)

- Radiography, fluoroscopy, contrast media
- X-ray technology
- X-ray generators, image detection (Fig. 11 shows how subtraction techniques are used to improve detail in X-rays.) (Fig. 12 shows how the EMI scanner utilizes computer-assisted tomography to detect anomalies in the brain.)
- Information content of radiographic images
- Radioisotopes, thermography (Fig. 13 shows the basic construction of a thermograph for measuring skin temperature.)
- Ultrasonics, principles, applications, techniques

INTERNAL MEDICINE & TREATMENT (1 lecture)

- Principles, forms, pharmacology, examples

SURGERY (3 lectures)

- Asepsis, anesthesia, local, general (Fig. 14 shows basic construction of an anesthesia machine.)
- Incision, suturing, transplantation
- Prostheses, dressing techniques, treatment

INTENSIVE CARE (4 lectures)

- Artificial respiration, ventilators, oxygen (Fig. 15 shows the block diagram of a servo ventilator.)
- Cardiac arrest, shock, infarction, heart-lung machines
- Nutrition, fluid, electrolyte, acid-base balance
- Dialysis, monitoring, data analysis, drugs (Fig. 16 shows the system used for dialyzing patients using an artificial kidney.)

OBSTETRICS (1 lecture)

- Pregnancy, delivery, anesthesia, complications

RADIOTHERAPY & PHYSIOTHERAPY (1 lecture)

- Dose planning and measurement, physiotherapy (Fig. 17 shows the patient radiation dose contours, as used in treatment planning in radio therapy.)

HOSPITAL INFORMATION SYSTEM (1 lecture)

- Medical record, treatment planning, computer diagnosis (Fig. 18 shows questions from a flowchart, as used in a computerized patient history program.)

Course Evaluation

Of the course evaluation sheets distributed to the 32 students, 16 were returned. All students felt the course should be offered in the future, but they suggested several areas of change. Six students requested tours of the hospital areas and clinical labs. Seven students requested that the lectures provide them with more information regarding what engineers can do or design for physicians - how should engineers become involved and what is needed in hospital work.

Regarding course content, three students suggested less material on radiology and one suggested less on microbiology. Three students suggested more material on electrical safety and one student suggested more on medical economics, materials biocompatibility, radiation protection, orthopedics, rehabilitation, pharmacology, and geriatrics.

Exams were fill-in-the-answer type or multiple choice. Six students suggested less memorization and more essay-type explanation of techniques and general principles.

Seven students gave comments of a general nature, as follows:

1) The wide range of topics presented by different lecturers made the course lively and was for me a valuable learning experience. By listening to real experts in the various subjects, we have gained much more insight into medical practice and research than would be possible if the course were taught by one person.

2) Excellent introduction to overall hospital organization from technical aspects.

3) I am very pleased with this course. It is by far the most valuable I have taken this year.

4) It was a very useful course and excellently organized.

5) Good course. It is of value to me because I would like to work with medical personel and this helps to bridge the communication gap along with introducing to general principles & "philosophies" of medical practice and medicine. It has given me a better understanding of the role of an engineer in medicine and his potential for participation in the field, among other things.

6) I thought the course was a very good survey of a great deal of medical procedure. A very interesting course.

7) The course is great. Learned more in this course than any other this semester.

References

[1] Bertil Jacobson and John G. Webster, Medicine and Clinical Engineering, 660 pages, ~~1975.~~ Prentice-Hall, In press, 1976.

[2] Russell Pimmel and H. R. Weed, A course in medicine for engineers, Engineering Education 65, 250-251, 1974.

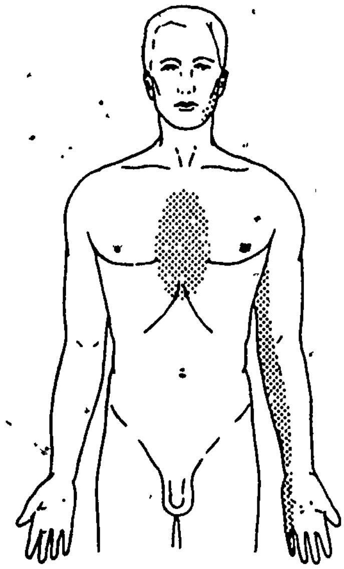


Fig. 1. Site of pain in angina pectoris.

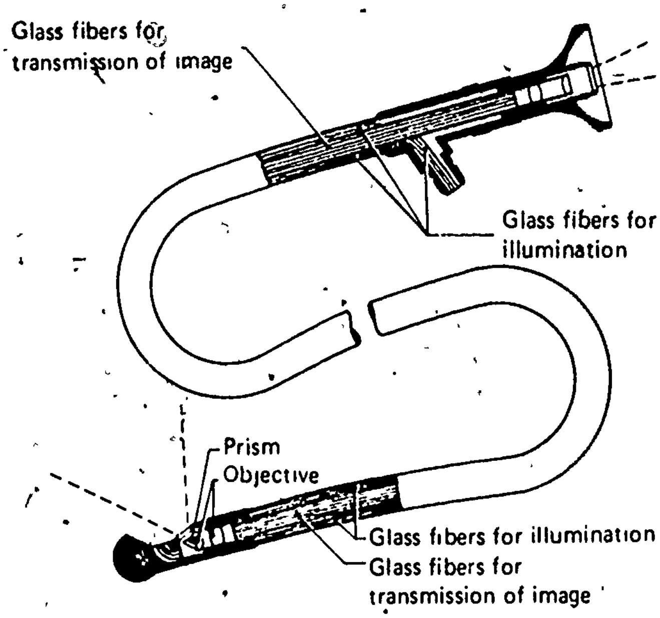
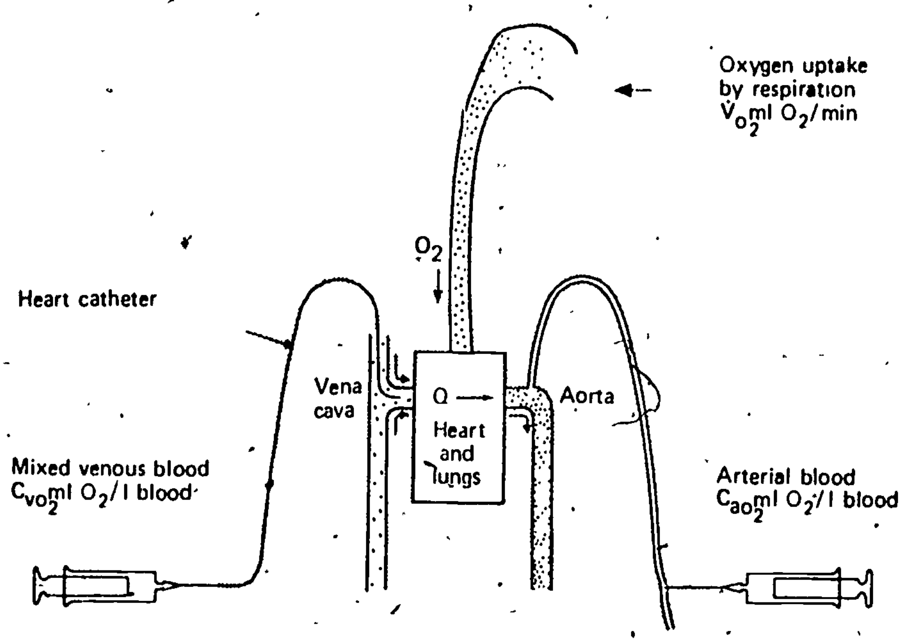


Fig. 2. Endoscope



Minute volume Q

$$Q = \frac{\dot{V}_{O_2}}{C_{aO_2} - C_{vO_2}} \text{ l blood/min}$$

Fig. 3. The Fick principle for determining the minute volume of the heart.

For an indicator dilution curve, M is the amount injected, and c is the instantaneous concentration. The flow Q is given by the equation ....

$Q = M / \int_0^t c\,dt$

Fig. 4.

The patient is referred to a specialist at a clinical physiological laboratory and a new ECG is taken, but with the same result. The illustrated exercise ECG was therefore taken using a bicycle ergometer. This shows .... and an .... which indicate ....

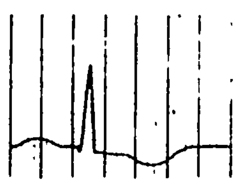
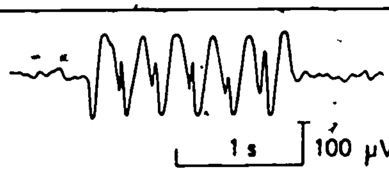


Fig. 5.

ST depression
inverted T wave
coronary insufficiency



The adjacent EEG changes are a sign of ....

Fig. 6.

epilepsy (petit mal)

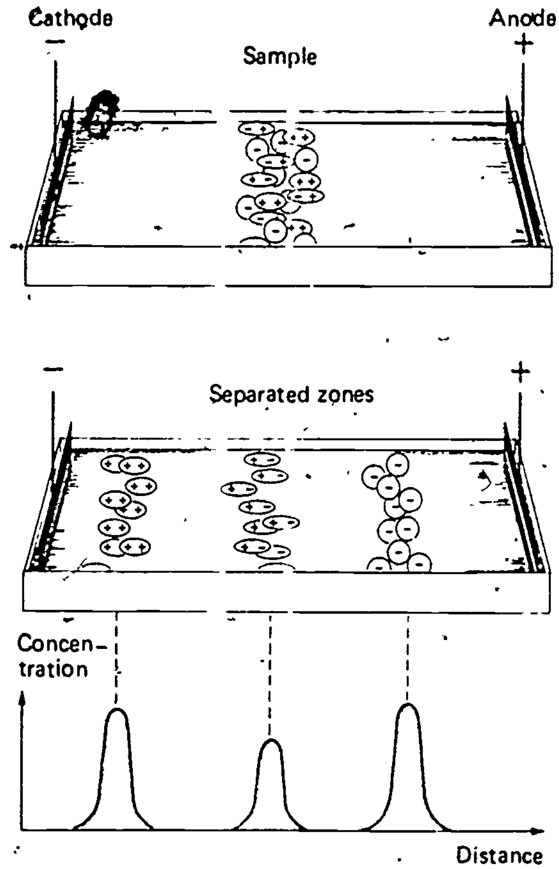


Fig. 7. Principle of zone electrophoresis.

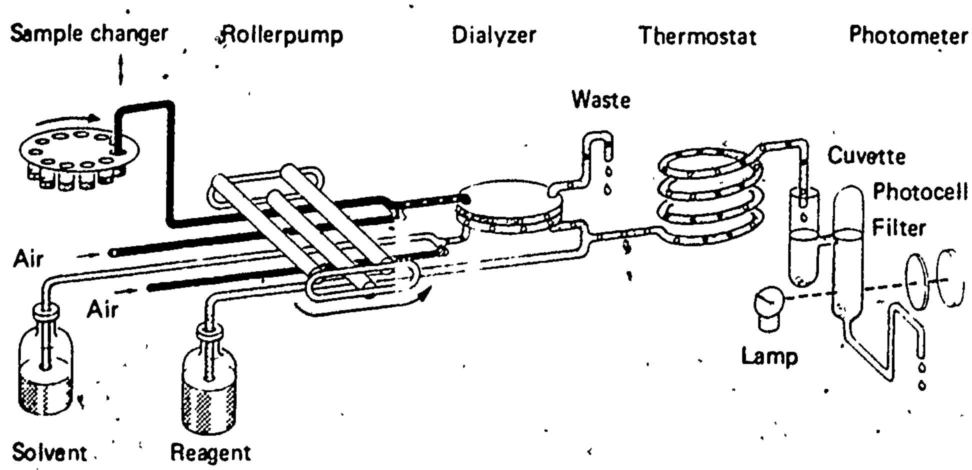


Fig. 8. Principle of the AutoAnalyzer.

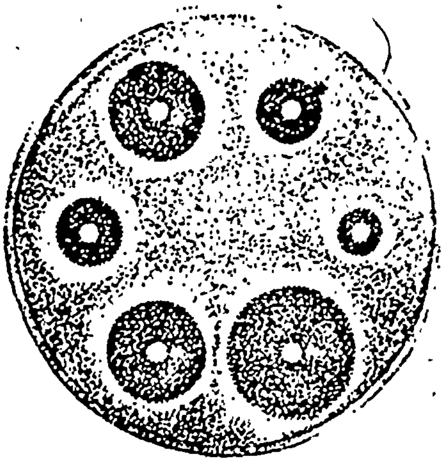


Fig. 9. Resistance determination with antibiotic test paper. The bacterial strain is most sensitive to the antibiotic in the bottom right area (5 o' clock).

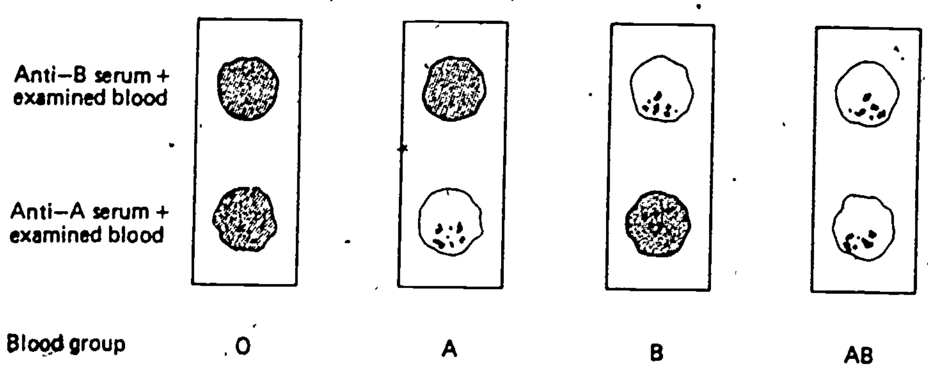


Fig. 10. Determination of ABO group using the microscope slide method. At the top of the slide is placed a drop of anti-B serum; that is, serum containing antibodies to the B antigen and no other antibodies, and at the bottom a drop of anti-A serum. Drops of a saline suspension of the red cells to be typed are added to the sera and mixed. The slide is rocked back and forth and observed for the appearance of agglutination, which usually begins within 30 seconds.

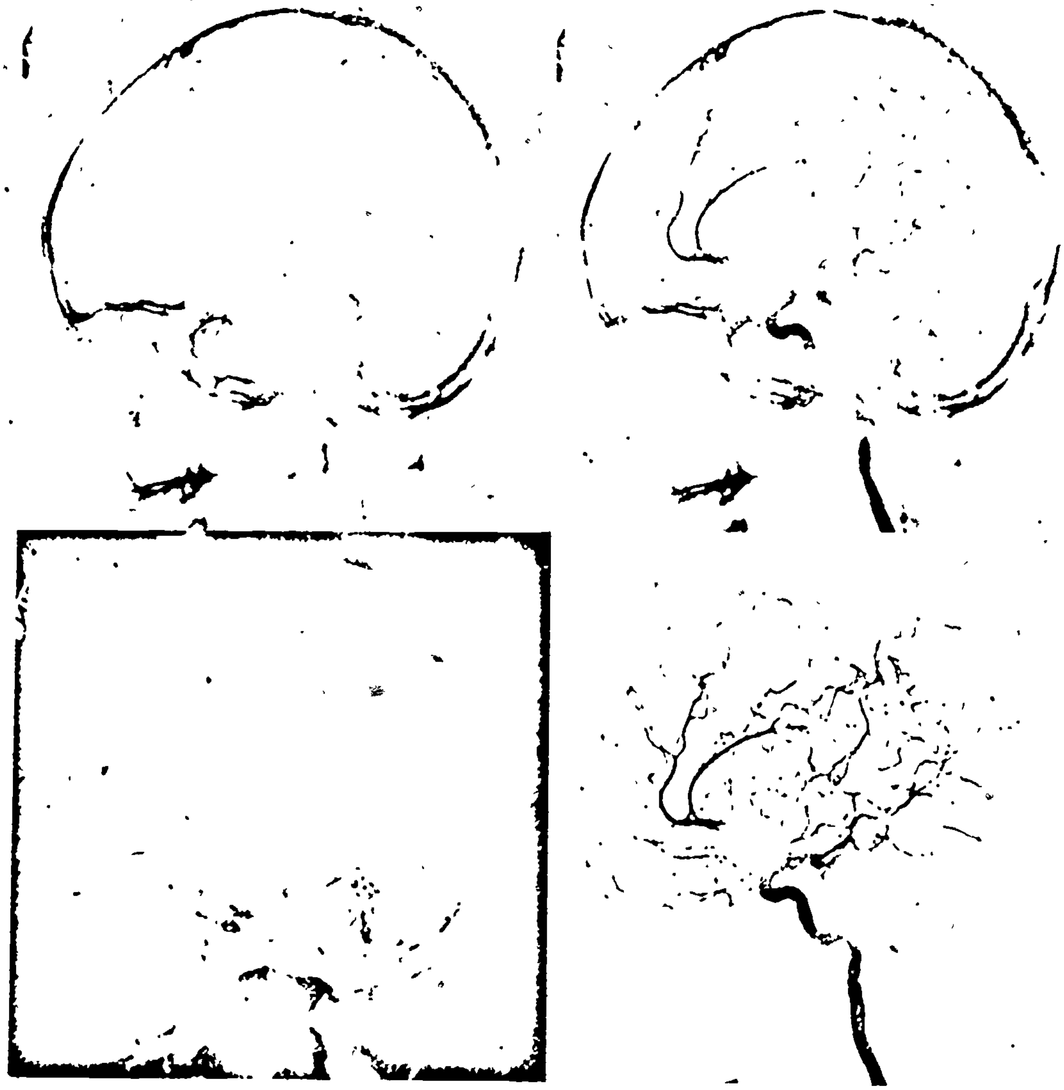


Fig. 11. Lower right: Subtraction image of cerebral angiography. Upper left and right: The two original films. Lower left: Image with reversed contrast used in the subtraction process.

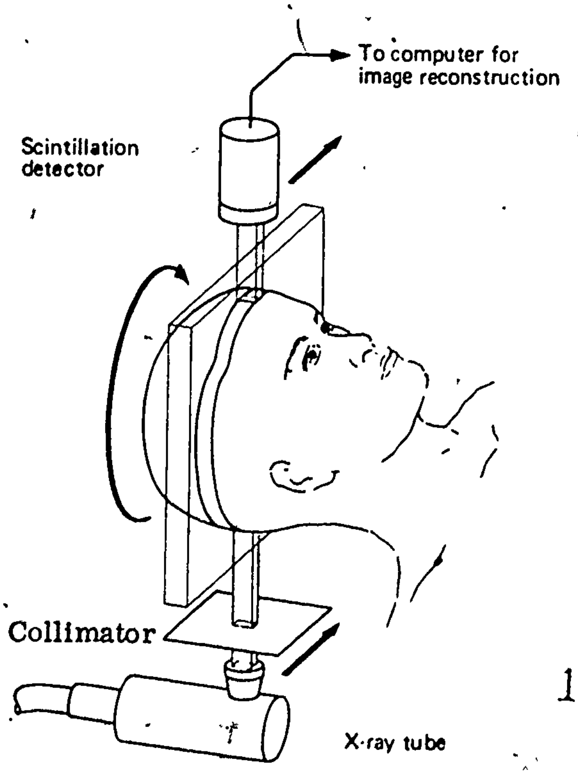


Fig. 12. Pencil beam arrangement for multiprojection scanning.

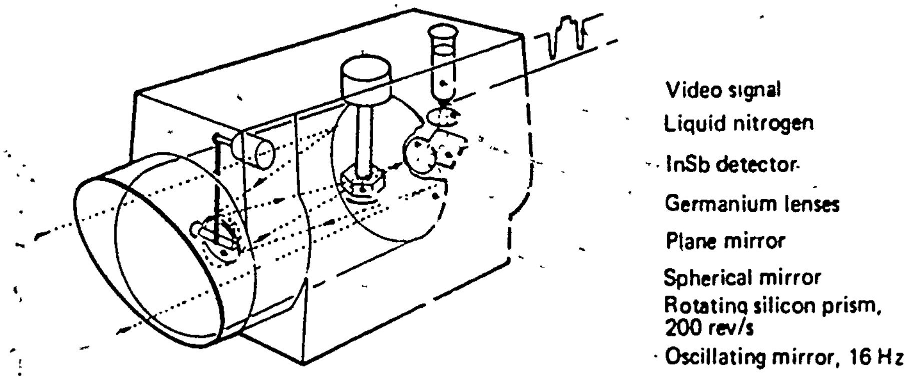


Fig. 13. Principle of the thermography camera (AGA).

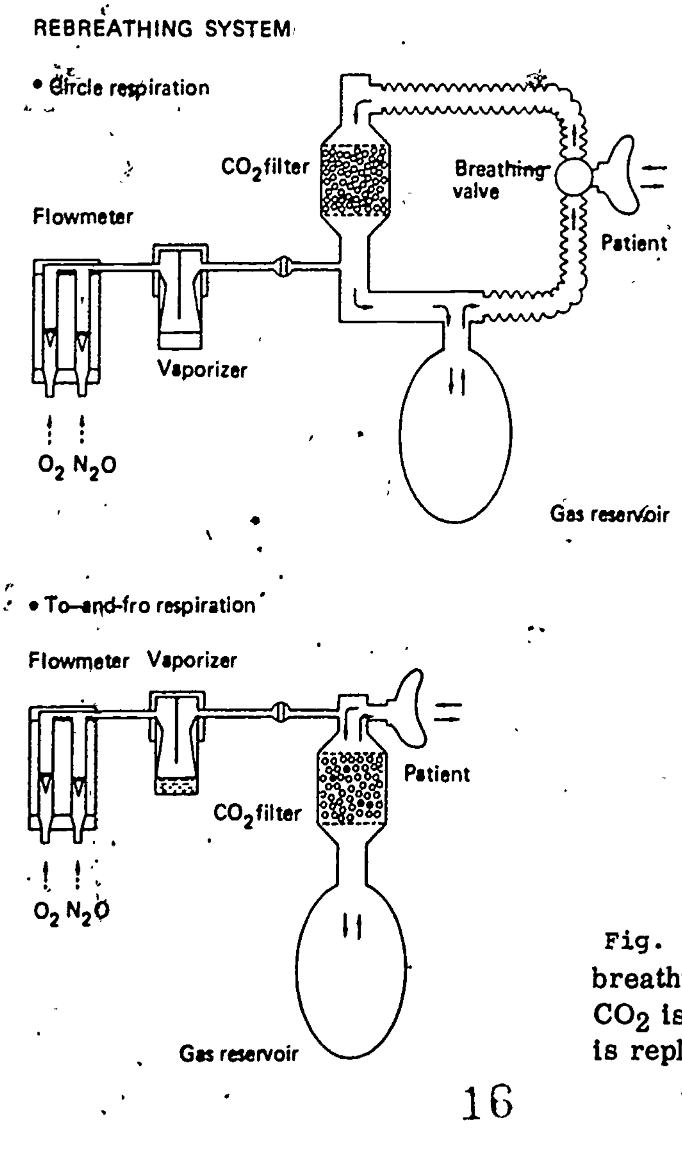


Fig. 14. Systems with complete rebreathing are entirely closed. Expired CO_2 is absorbed and consumed oxygen is replaced.

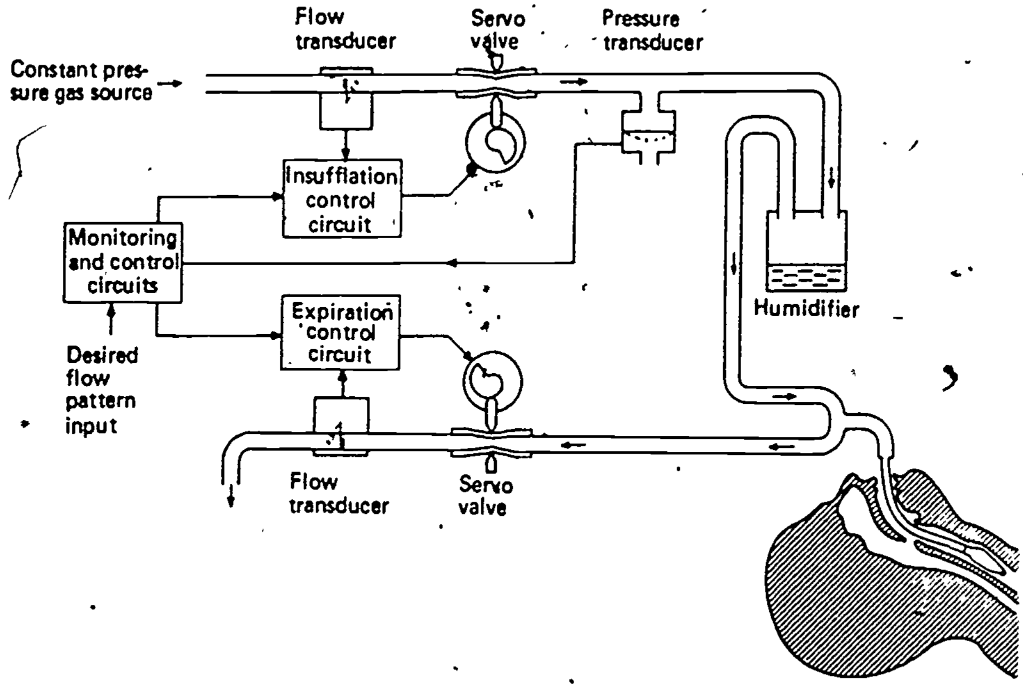


Fig. 15. Principle of servo-controlled ventilator. The flow to and from the patient is controlled by feedback circuits.

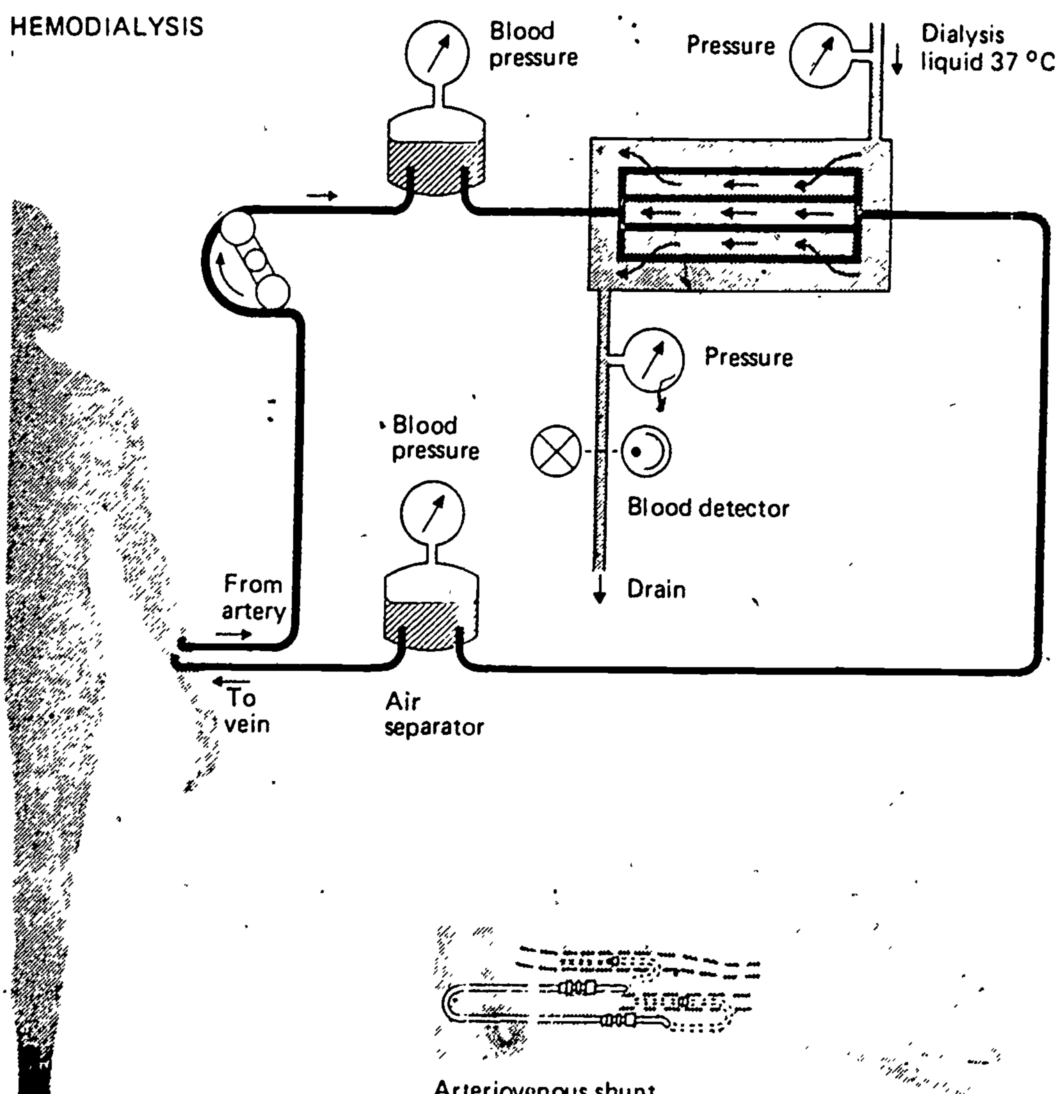


Fig. 16. Principle of hemodialysis.

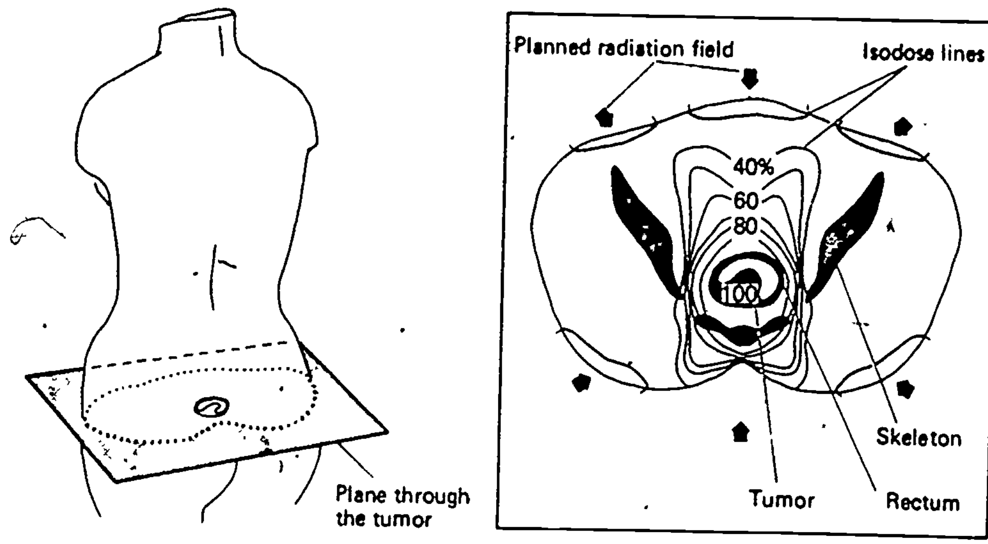


Fig. 17. Two dimensional isodose contour treatment plan in cobalt treatment of rectal cancer with six radiation fields.

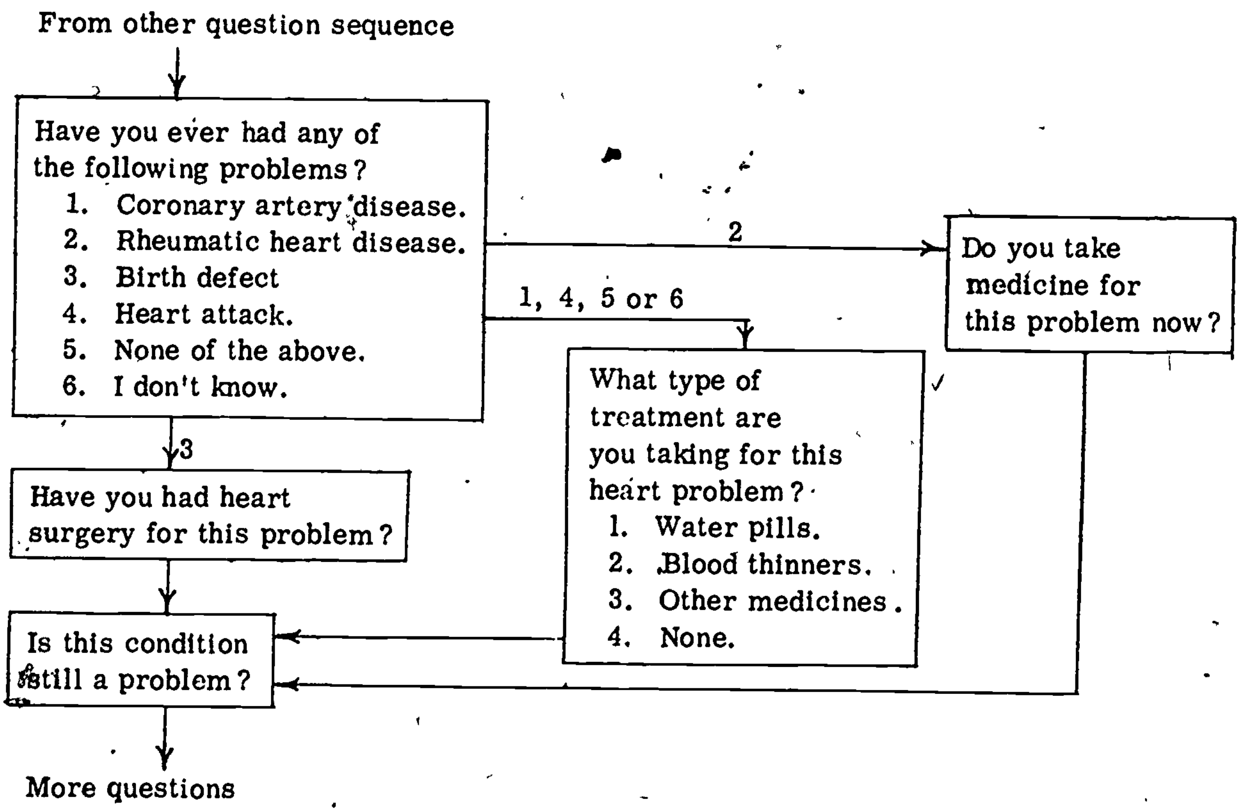


Fig. 18. Portion of a typical flow chart used for a computerized medical history interview.