The History of Cardiology

An Exhibition in

ome Institute of the History of Medicine

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The cover picture is taken from R. Quain's 'The Anatomy of the Arteries of the Human Body', London, 1844, plate 48, fig. 1.

Exhibition Catalogue No. 6

The History of Cardiology

An Exhibition in The Wellcome Institute of the History of Medicine

THE WELLCOME BUILDING,
183 EUSTON ROAD, LONDON N.W.1.
September, 1970

N.B. This Exhibition is open daily to the public (except Sundays and Bank Holidays) from 10 a.m. to 5 p.m. free of charge.
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PRINTED BY Unwin Brothers Limited
THE GRESHAM PRESS OLD WOKING SURREY ENGLAND

Produced by 'Uneoprint'

A member of the Staples Printing Group (SO8915)

FOREWORD

This exhibition illustrating important aspects of the history of cardiology has been prepared on the occasion of the Sixth World Congress of Cardiology meeting in London on 6-12 September 1970. Although it has been specially designed for cardiologists, the needs of other members of the medical profession as well as of the generally interested public have also been kept in view. Clearly divided into six sections, the exhibition shows us how knowledge of the heart and its function was developed from classical antiquity to the present day. It shows how the recognition of diseases of the heart and blood vessels grew with the advancing science of physiology and with the technical ability to invent instruments and machines for telling us how the heart is fulfilling its function and even to serve as a substitute for it while surgery is carried out. To emphasise merely the peaks of this development may suggest that knowledge grew inevitably and along a path that was unimpeded by concurrent ideas or by the want of specific technical means at crucial points. This brief guide to the exhibition is designed to correct such a view by drawing attention to some of the background to the material on view.

Dr. J. K. Crellin, who has prepared the guide, Dr. K. D. Keele, and Mr. E. Gaskell, the Institute's Librarian, have all made important contributions to the planning of this exhibition. Mr. Colin Sizer, the Curator of the Institute's Museum, has been entirely responsible for mounting the exhibition and has shown much enterprise in obtaining specimens or instruments to illustrate significant points in our original plan. The facsimiles of drawings by Leonardo da Vinci have been kindly lent by the Royal Library at Windsor, being reproduced by gracious permission of Her Majesty the Queen. Among others who have lent or given specimens are: The Atomic Energy Authority, Harwell; Dr. E. Besterman, St. Mary's Hospital; Cardiac Recorders Ltd.; Terence Cuss Esq.; Edwards Laboratories, California, U.S.A.; Genito-Urinary Manufacturing Co. Ltd.; Hammersmith Hospital; The Institute of Cardiology; London Hospital Medical College; The Royal College of Surgeons Museum; Sierex Ltd.; The Wellcome Museum of Medical Science.

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The exhibition, which is on display in one of the new galleries on the first floor of the Wellcome Building, will be open to the public from 9th September, daily except Sundays, from 10 a.m. to 5 p.m. and will remain open for about a year.

F. N. L. POYNTER
Director

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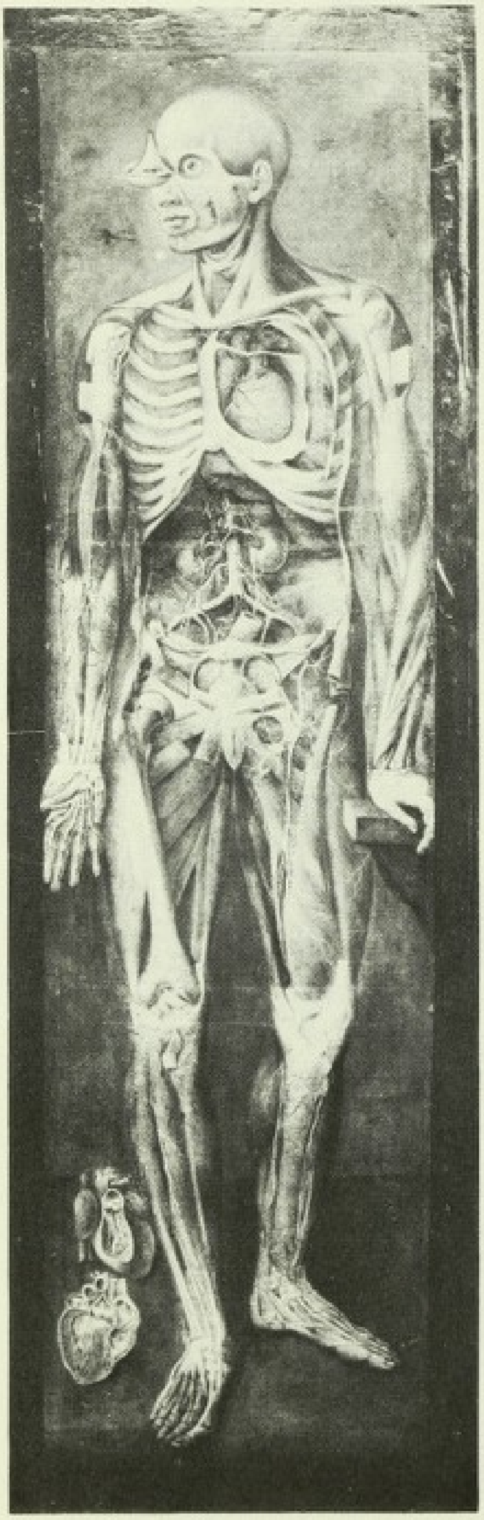
INTRODUCTION

The history of cardiology is one of repeated questioning of well established, and often well thought out concepts, of the introduction of new scientific ideas and of instruments based on them.

Illust. 1. Anatomical fugitive sheet, dated 1544.

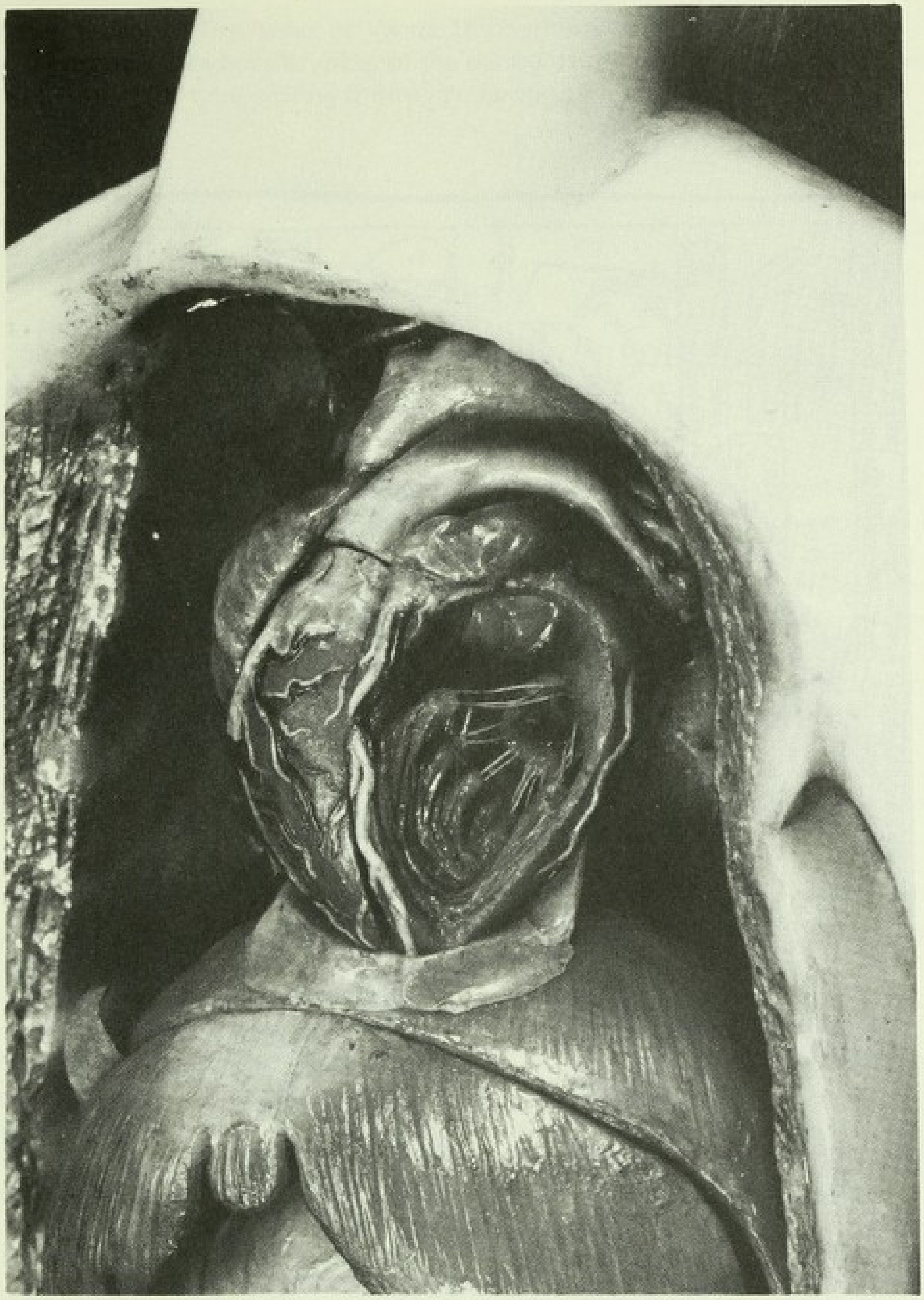
When we consider how the current views of the heart's structure have been presented in particular periods we may begin by looking at a picture which, although dated 1544, is pre-Vesalian and offers the traditional view which stemmed from classical antiquity. This is seen in the anatomical fugitive sheet which is one of less than a score of such specimens which have survived. These large broadsheets depicting the human figure, with flaps which lift to reveal the heart and other organs in position, were useful as aids to teaching at a time when the opportunities for the actual dissection of the body were strictly limited. Their publication at this time reflects the new interest in human anatomy which had begun among the Italian artists and which had been taken up by the physicians and surgeons. (Cornelius Cort's *A Studio for the Seven Visual Arts* (1578), which depicts artists drawing a suspended cadaver, emphasises this trend.)



Illust. 2. Oil painting by Jacques Gautier d'Agoty, c, 1750.

None of the surviving sheets, however, shows the professional skill or accuracy to be found in Vesalius's *De Humani Corporis Fabrica* (1543). This great book is the forerunner of countless superbly illustrated anatomy textbooks for students. The large oil painting (198 x 61 cms) by J. Gautier d'Agoty—one of twelve in the Wellcome collections—is of particular interest, for it is one of a series similar to those in *Myologie Complette* (1746-48) to give us one of the finest early examples of colour-printing in a medical book. In contrast, modern illustrations of the heart commonly have the character of a photograph, as the one from Grant's highly regarded *Atlas of Anatomy* (1962, 5th ed.).

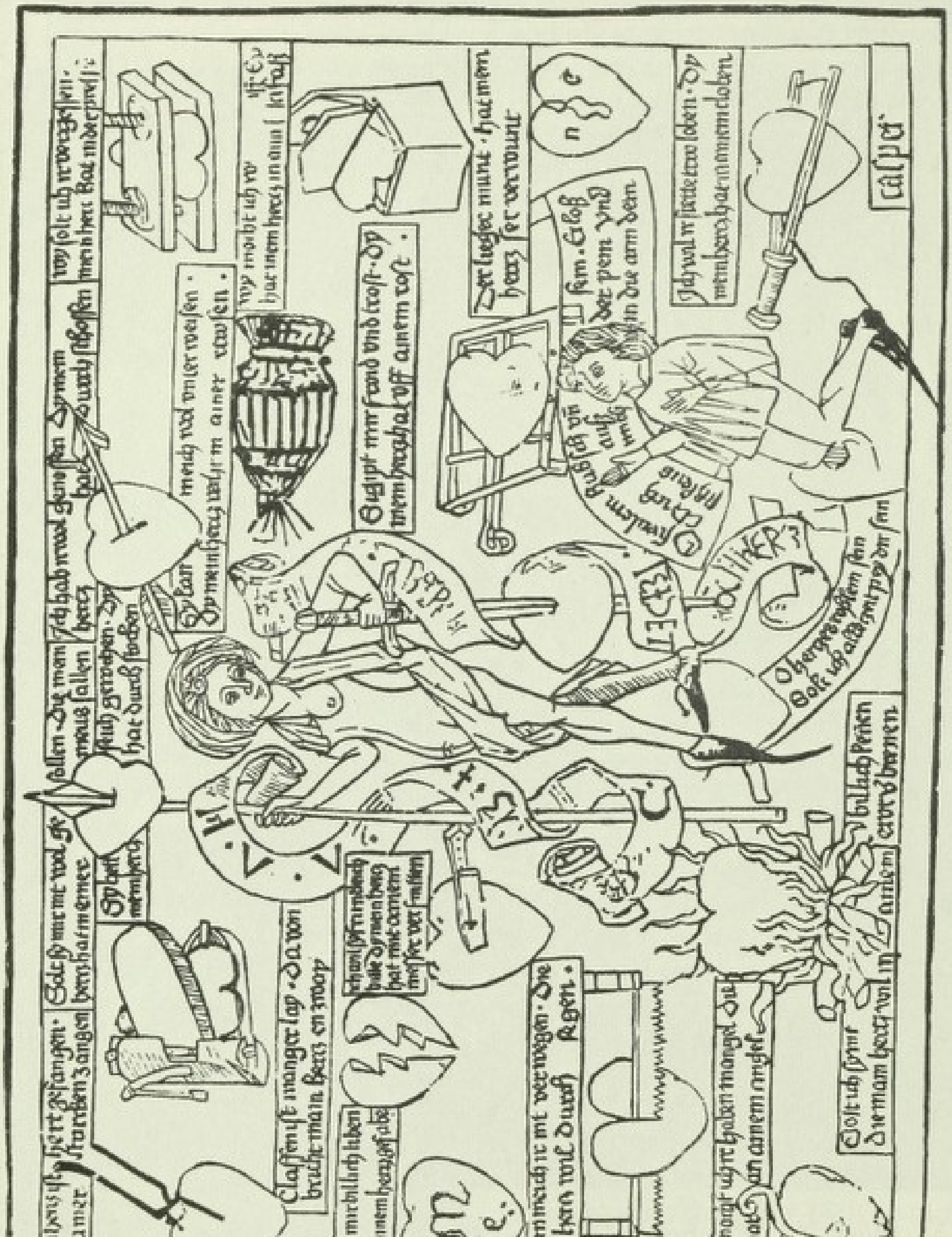
Model wax hearts have also played a conspicuous role in teaching anatomy since at least the early 18th century. At Bologna, for instance, Ercole Lelli prepared a celebrated series of wax anatomical models during the 1740s at the order of Pope Benedict XIV. The Wellcome figures (80 cms high) could have been inspired by Lelli, though no precise provenance and date can be given. Wax models are generally realistic and lifelike, and were an excellent way of overcoming the shortage of dissection material. They are certainly unmatched by the



Illust. 3. The heart; from an 18th century wax figure.

plaster and plastic models of the present day, which do no more than instruct—though excellently—the relations of the anatomical features.

Many of the wax anatomical models found their way into 18th-century 'cabinets of curiosities' and to natural history museums, rather than being used for the formal education of medical students, a reminder that interest in the heart is not restricted to the medical professions. The heart has been a symbol of countless peoples, and its use as a symbol of love and charity is still widespread. As a love symbol it became particularly popular in the Middle Ages, as exemplified by



Illust. 4. Caspar's 'The Power of Venus', 1470; from Lewinshon, R., *Eine Weltgeschichte des Herzens,* Hamburg: Rowohlt, 1959. (reproduced by kind permission of Dr. W. Göpel, Archiv für Kunst und Geschichte, Berlin).

Meister Caspar's *The Power of Venus.* Dating from 1470 this illustration has satirical overtones not untypical of the period. It shows numerous ways of destroying the heart, by cutting it through, burning, crushing, etc.

PART 1

WILLIAM HARVEY AND HIS PREDECESSORS

1. The Heart in Antiquity

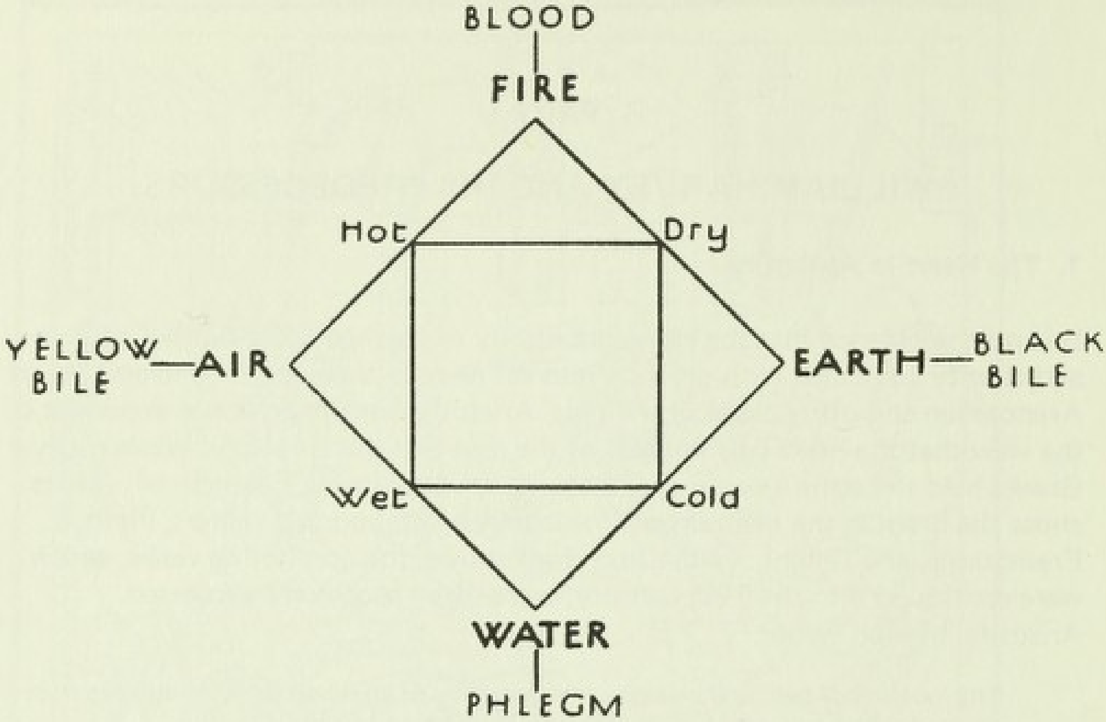
It is no coincidence that the rising popularity of the heart as a symbol of love and charity coincided with growing interest (largely through the universities) in Aristotelian and other classical writings. Aristotle was the principal exponent of the view that the heart was the seat of the soul and the emotions. While many Greeks held the same view (e.g., Democritus, Empedocles, Praxagoras), others chose the brain as the main organ (for instance, Hippocratic writers, Plato, Erasistratus, and Galen). As the first chart shows, the conflicting views, which were continued into the 17th century, were often succinctly expressed. Aristotle, himself wrote:

> The motions of pain and pleasure, and generally of all sensations plainly have their source in the heart, and find in it their ultimate termination.

Galen, Aristotle's most influential opponent over the primacy of the heart as the seat of emotions, regarded the heart principally as an organ of respiration and as the main place for the production of animal heat. Unlike Harvey and his followers, Galen did not consider the heart as a pump (although the analogy could have been made). The chart of Galen's physiology emphasises why the heart was considered a respiratory organ. It also demonstrates that the classical physiology of Aristotle and Galen, where explanatory concepts of qualities and spirits provided a ready link with cosmological and metaphysical ideas, is far removed from the chemical and physical explanations characteristic of modern physiology.

Galen believed that blood, after being formed in the liver, passed via the vena cava into the right ventricle. This occurred during diastole (the expansion of the heart), which also drew air (or its 'qualities') from the lungs (via the pulmonary vein) into the left ventricle. During systole (contraction of the heart) blood passed into the pulmonary artery (to nourish the lungs) *and* into the left ventricle via alleged invisible pores. In the left ventricle 'vital spirits' were formed during interaction of the blood with the air. The blood and vital spirit were then conveyed about the body via the arteries. A further task of the heart and lungs—again emphasising their respiratory unity—was to relieve the blood of its 'sooty' impurities. These passed along the pulmonary artery and were exhaled in the breath.

Another aspect of Galen's physiology of interest to the story of cardiology is his humoral theory of disease. In essence, Galen considered disease to result from an imbalance of humours, and their associated qualities. The four humours (blood, phlegm, yellow bile and black bile) and their qualities are shown in the following diagram; along with the four elements—earth, air, fire, and water—closely linked with the humours:



Illust. 5. Elements, humours, and qualities; from Singer, C., *A History of Biology.* London, New York: Abelard Schuman, 1959.

Thus cardiac conditions, rather than being arranged according to anatomical variations or physiological changes, were generally believed to result from an excess of watery phlegm.

Galen's humoral theory was also the most common argument for rationalising drug treatment until the 19th century. The action of drugs, it was believed, resulted from their effects on humours rather than on organs and tissues. Tournefort summarised this clearly in the early 18th century: 'Evacuating medicines are such as manifestly expel the Humours out of the Body, but altering medicines are such as change the Qualities of the Humours, and reduce them to their natural state'. For heart conditions (e.g. 'palpitations') cordials were recommended to raise the 'strength and cheerfulness . . . as comforting the heart'. Spiritous liquors were popular ingredients of cordials as the selection of 18th-century 'cordial' cabinets shows (see 6. Treatment).

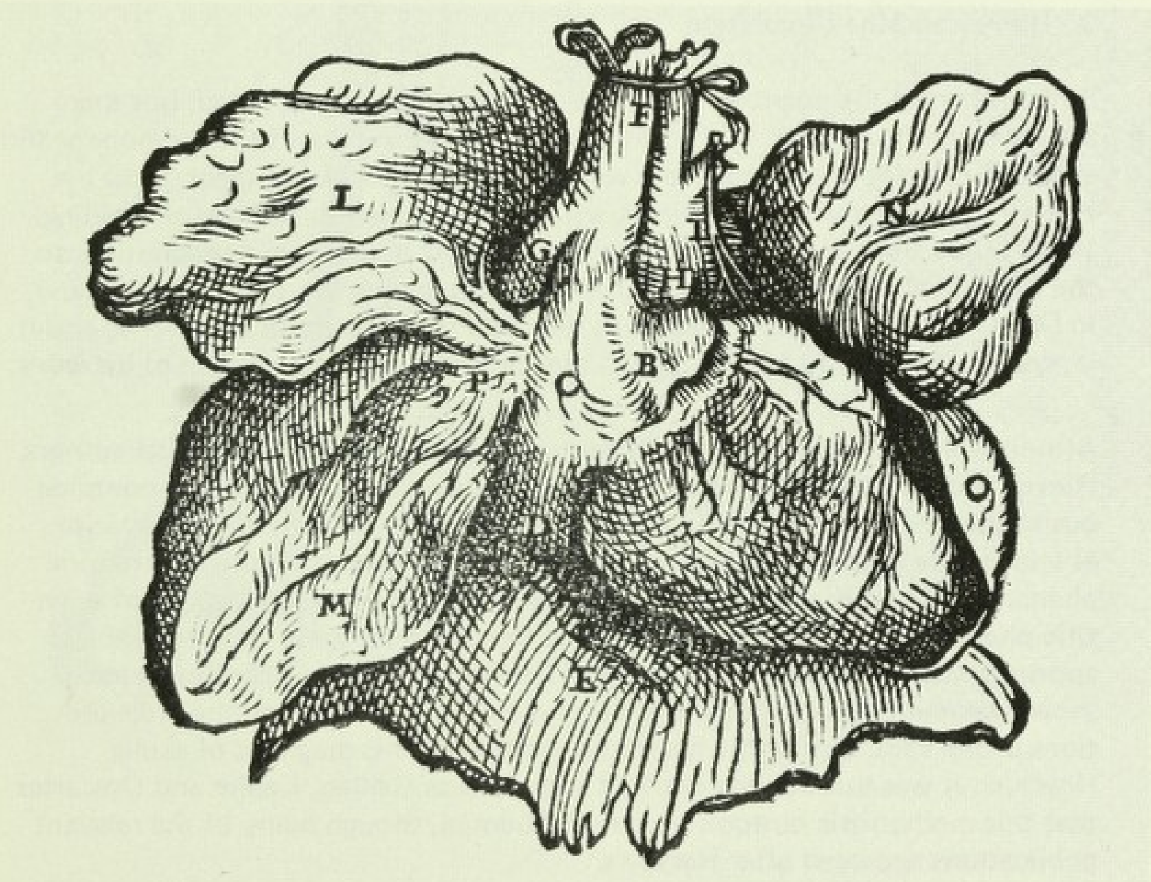
Also in this section of the exhibition is an illustration of Chinese physiological ideas taken from *Specimen Medicinae Sinicae* (1682), published by Andreas Cleyer from the manuscript of a Jesuit missionary, Father Michael Boym. Chinese physiology shows some kinship with certain classical views. For instance, that the heart was the seat of the intellect, and that two basic 'elements', yin and yang, were thought to interact with each other. When in harmony they produced health, when in conflict disease or old age.

2. Pre-Harveian Ideas on the Circulation of the Blood

The writings of Aristotle, Galen and other classical writers were the background for Harvey's celebrated work on the heart and blood circulation published in full detail in 1628. Scholars have long considered the various factors which helped Harvey to his discovery. One particular problem concerns the 16th-century forerunners of Harvey, notably Michael Servetus (1511?-1553), Realdus Columbus (1516?-1559) and Andreas Cesalpinus (1525?-1603). Also of interest is Ibn an-Nafis, for in the 13th century he questioned the existence of interventricular pores so crucial, in Galen's physiology, for the passage of blood from the right to the left ventricle. Ibn an-Nafis's disbelief in pores led to the idea of pulmonary transit, i.e., all the blood from the right ventricle passing through the lung before entering the left ventricle. In many ways, though, this was not particularly revolutionary—merely placing the mixing of the blood with air in the lungs, instead of in the heart.

While it is still undecided whether Ibn an-Nafis's views influenced Servetus, Columbus, and Cesalpinus, there is little doubt that Vesalius's scepticism of the pores was significant. In the 1543 edition of his *De Fabrica* Vesalius certainly seems to have had some doubts on interventricular pores.

In the 1555 revised edition, however, Vesalius was explicit that there were no pores, and it is intriguing that two years earlier, in 1553, Servetus's *Christianismi*



Illust. 6. Illustration of heart; from Vesalius's *De Humani Corporis Fabrica.* Basle, J. Oporinus, 1543.

Restitutio appeared. This is a large theological work, containing a short description of the passage of blood in a 'long course through the lungs' and not through the cardiac septum. Whether Servetus was stimulated by Vesalius's 1543 doubts on the septal pores, or whether Vesalius profited from Servetus's views when revising his *De Fabrica* remain unanswered questions. It can be added though, that Vesalius may not have had the chance to read Servetus's views, for Servetus was burned as a heretic in 1553, and his book destroyed. (Only three copies are known today, and even copies of the 1790 edition are rare.) Servetus, a fundamentalist, believed that blood was the seat of the soul and that this was breathed into man by God. Since air and blood are the material constituents of the soul, Servetus argued that perfection of the soul takes place in the lungs, allowing constant renewal of the vital spirit and distribution to all parts of the body.

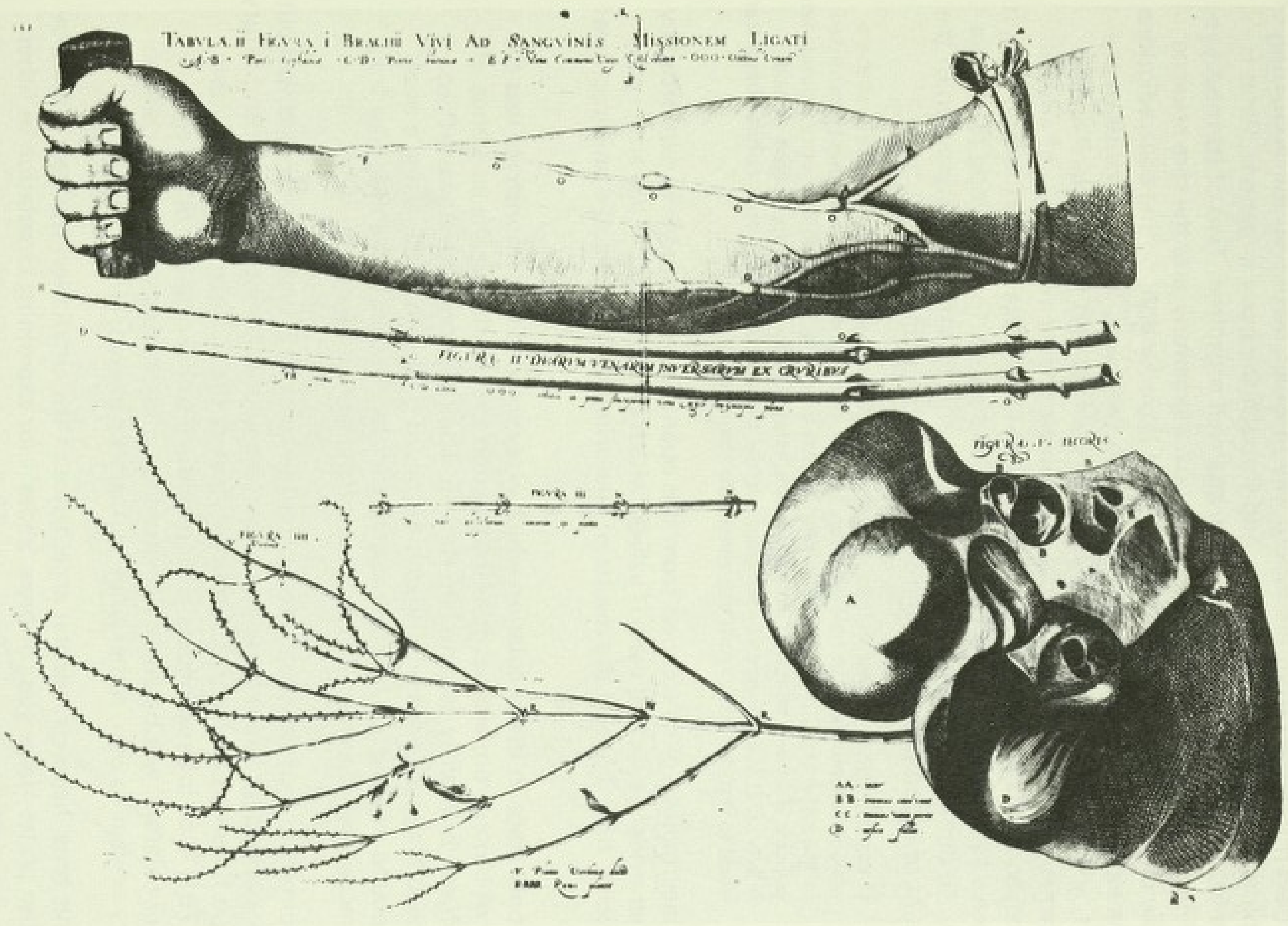
Realdus Columbus was undoubtedly more influential in promoting ideas on pulmonary circulation, for he gave a detailed denial of interventricular communication in his *De Re Anatomica* (1559). (The dissection scene on the title page of this book depicts an artist watching the scene, a link with Cort's picture already mentioned.) Harvey quotes Columbus a number of times in his classic *De Motu Cordis et Sanguinis,* but rather surprisingly makes no reference at all to Cesalpinus who also seems to have considered the idea of the circulation of the blood but made no attempt to demonstrate it scientifically.

3. Harvey and the Circulation

So far, some of the possible influences on Harvey have been noted, but there are other points relevant to the story of his discoveries about the pulmonary and systemic circulations, notably the venous valves (described in great detail by Harvey's Paduan teacher, Fabricius, in 1603) which led to the idea of unidirectional blood flow. Harvey himself told Boyle that it had been a meditation on the venous valves which prompted his new view and vision. On the other hand, in *De Motu* quantification appears as the main stimulus to his discoveries and it is probable that many factors helped the formation and completion of his work.

Although the new spirit of enquiry featured much criticism of classical authors, Harvey profited from the first hand observations and experiments so conspicuous in the writings of Aristotle and Galen. Part of the reason for the criticism, at least in the 17th century, was a growing commitment to explaining natural phenomena in mechanical terms, and an acceptance that explanations of scientific phenomena did not need answers to the question 'why'. The mechanical approach was foreshadowed in some of Leonardo da Vinci's studies which show a geometrical approach to anatomy. Examples of this are the cross-sections of the ventricles of the heart and, better still, his diagrams of skulls. However, it was through the work of such men as Galileo, Kepler and Descartes that this mechanistic outlook became influential, though many of the relevant publications appeared after Harvey's.

Nevertheless, the classical influence persisted: large numbers of works on natural philosophy continued to appear with a staunch Aristotelian outlook, and it is certainly possible that the Aristotelian concept of the macrocosm-microcosm



Illust. 7. Venous valves; from Fabricius's *De Venarum Ostiolis.* Padua: L. Pasquati, 1603.

influenced Harvey. This concept postulated that the phenomena in the sublunar world imitated the celestial pattern; the 17th-century interest in this view is illustrated by the frontispiece to Loewnheimb's *Oceanus macro-microcosmicus* (1664).

While Harvey's work is thus a reflection of many intellectual ideas of his time, this does not detract from the superb way in which he proved the circulation of the blood, both through the lungs, and through the body in general. What is more his *De Motu* is concisely written and well organised. Two of its most eye-catching features are the lack of theoretical digressions, and the rare reliance on the observations of others. After a brief introduction, noting contradictions in the existing literature, the book falls into two parts, the movements of the heart, and the circulation of the blood. In the first part Harvey clarifies the movements of systole and diastole, the corresponding movements of arterial pulses, and the movements of the atria. With knowledge of heart movements, it is then a logical step to consider the heart as a pump, forcing blood round the body. In doing this Harvey placed emphasis on a quantitative estimation of the amount of blood passed through the heart, commenting that:

> If the heart in one beat in man, the sheep, or the ox, emits one drachm, and there are a thousand beats in half an hour, ten pounds five ounces have been transmitted in the same time; if in one beat it emits two drachms, the total is twenty pounds ten ounces; if in one beat half an ounce, the total is forty one pounds eight ounces; finally, if it is an ounce at each beat, eighty three pounds four ounces have been transfused in half an hour from the veins into the arteries.

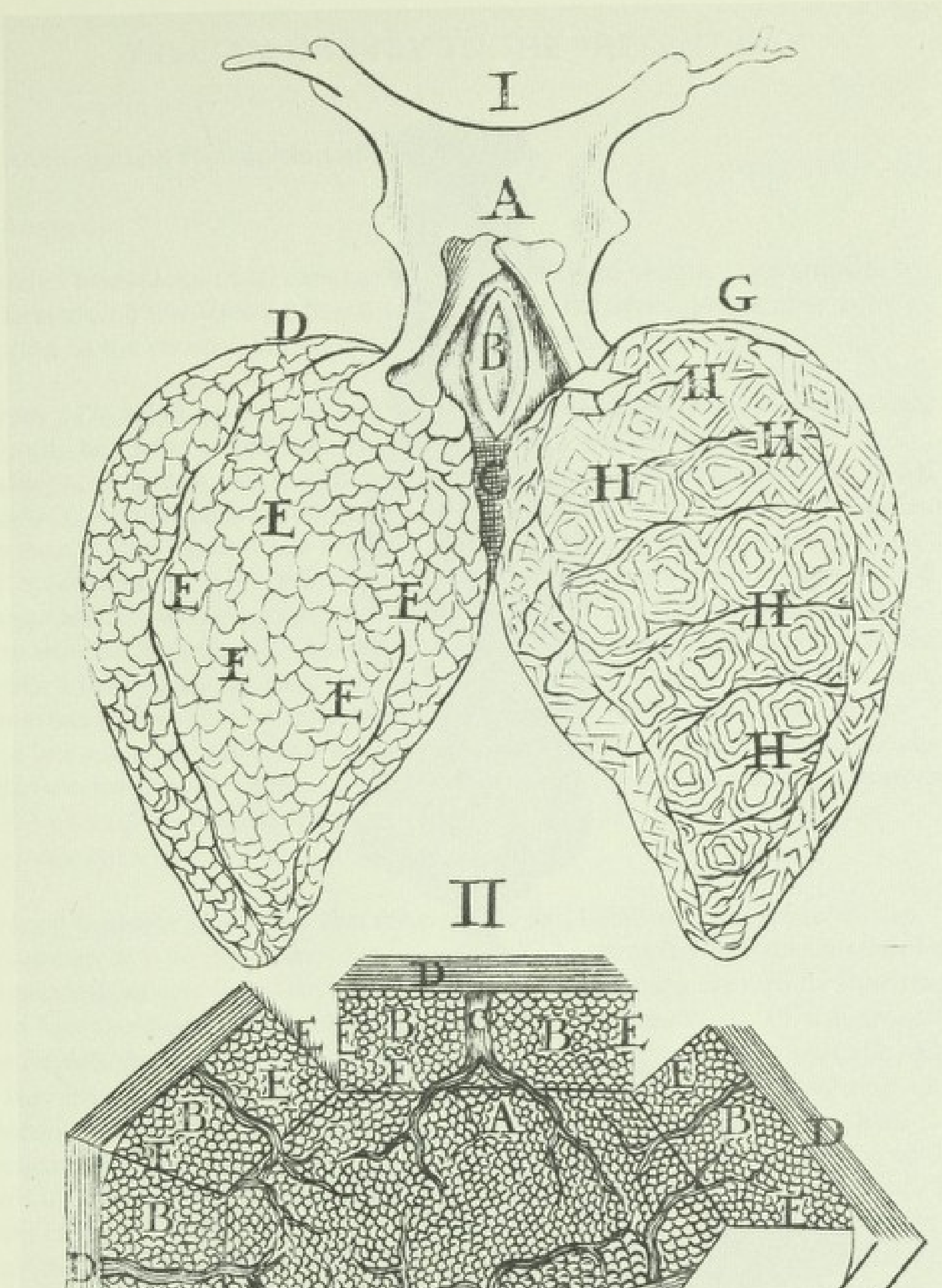
The inevitability of circulation from this quantitative approach is reinforced by further evidence such as venous valves (which he illustrated in the arm, using Fabricius' drawing) and the results of ligaturing, which indicated unidirectional flow.

The only stage in the circulation which Harvey failed to demonstrate was the flow of blood from arteries to veins through the capillaries, the existence of which was brilliantly assumed by Harvey. Their demonstration was left to Marcello Malpighi, who published his account of this in 1661. Using a small compound microscope he observed the capillary vessels in the lung of a frog, and recognised that they carried blood from the arteries to the veins.

The circulation of the blood, to us a self-evident fact, was not accepted without frank opposition and reasoned criticism, some of it lasting into the 18th century. Joseph Browne's *Lecture of Anatomy Against the Circulation of the Blood* (c. 1701) is an interesting late example. Much of Browne's criticism against the 'circulators' was based on his view that anastomoses were from artery to artery or vein to vein, rather than from artery to vein.

At this time, however, general acceptance of the circulation was being aided by the fish plates—large glass or brass 'slides'—for examining circulation in fishes. These became popular accessories to 18th-century microscopes (often as brass plates), one of the first accounts being by J. Harris in 1703:

> And one thing I ought not to omit...is, that I have often with this glass, seen the circulation of the blood in the fins of the tail of tadpoles; and indeed more conspicuously here than in any other creature: for the fins growing all round the tail, and coming back a little way out beyond the body of it, both the ejaculation of the blood out of the arteries, and its return again by the veins, is much quicker than in the tails of fishes.



Illust. 8. Malpighi's 1661 illustrations of frog lung and capillary circulation.

Illust. 9. 18th century Marshall microscope and brass holders for examining circulation in fish tails.

PART II

WILLIAM HARVEY TO THE PRESENT DAY

4. Anatomy and Recognition of Heart Disease

a. Anatomy

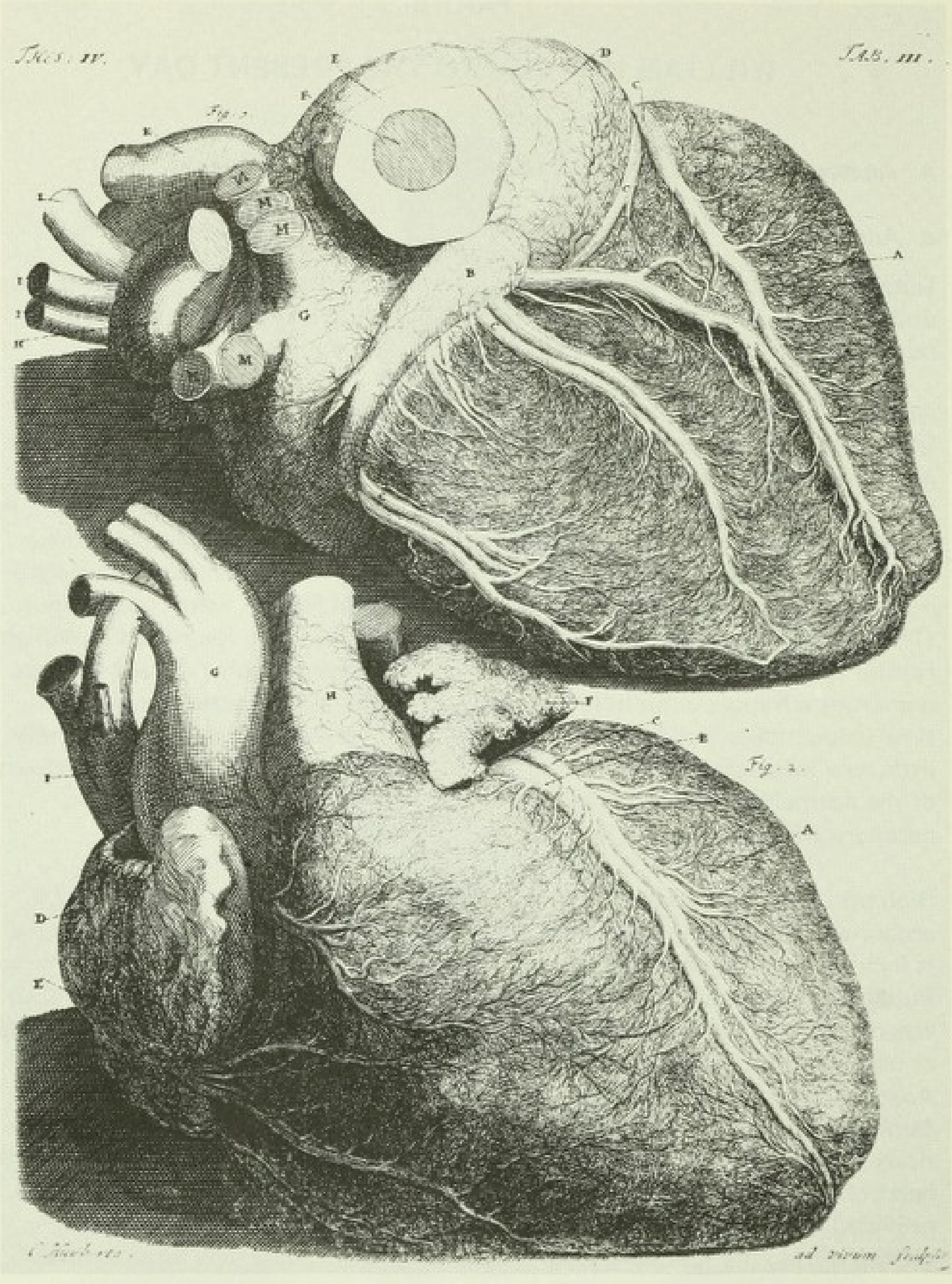
Detailed knowledge of the anatomy of the heart is of course a prerequisite to understanding the diseased heart, and this note, therefore, serves as an introduction to the recognition of some cardiac diseases.

Harvey's *De Motu* gave tremendous impetus to the study of the heart, though it should be remembered that there was, anyway, a growing interest in anatomy. In Britain alone, 230 anatomy books were published between 1651 and 1700, compared with 50 during the period 1600 to 1650. The 18th century saw even greater anatomical activity, if only because of the developing educational facilities, notably in Edinburgh and London where the names of Monro *primus* and Monro *secundus,* and William and John Hunter were conspicuous. (The Rowlandson scene of a dissection room, traditionally identified as William Hunter's, highlights the growing number of anatomy schools.) As will be seen, numerous advances in pathology and the recognition of disease came at this time (educational facilities were improving in all areas), though comparatively little new information came out of the fervour of activity on the gross anatomy of the normal heart. One exception, however, was in connection with the coronary circulation.

Richard Lower's celebrated *Tractatus de Corde* (1669) was a comprehensive account of the anatomy and physiology of the heart as it was then understood. It included new information about coronary anastomoses, derived by injecting fluid into the vessels, a technique devised by Christopher Wren. This approach was developed comprehensively by Fredrik Ruysch, who injected metallic salts or wax into blood vessels, the basis of superb illustrations in his *Thesaurus Anatomicus Quartus* (1704). A few years later A. C. Thebesius's *Dissertatio Medica de Circulo Sanguinis in Corde* (1708) gave an account of injecting solutions into the coronary veins of cadavers, and observing orifices opening into the heart chambers from the endocardium (hence Thebesian valves). Such studies provided basic information on the coronary circulation, which was gradually refined during the following 200 years, though arguments over anastomoses have continued into this century.

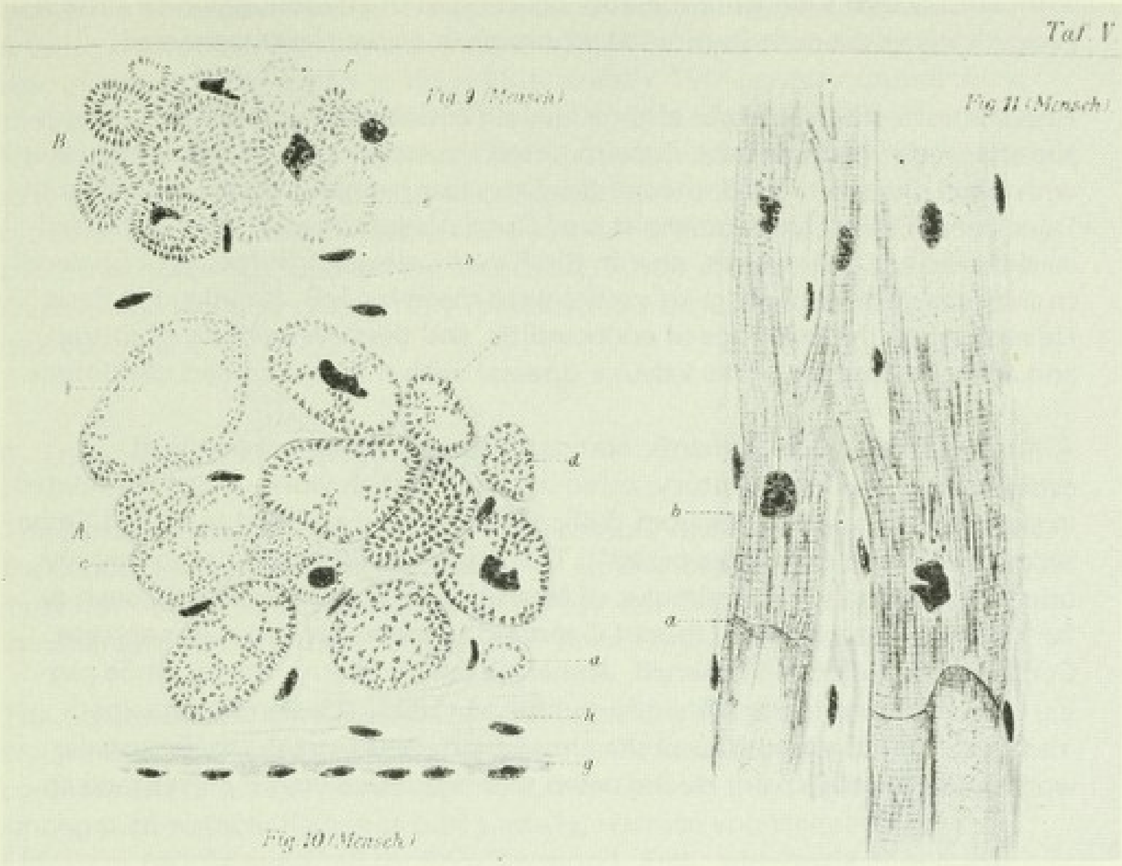
Another aspect of the heart anatomy still being discussed at the beginning of this century was the histology of the pathway of electrical depolarisation, which initiates and co-ordinates heart movements. Precise knowledge could, of course, only follow the 19th-century advances in microscopical techniques (improved optics from the 1830s and advances in staining and sectioning from the 1870s), though the recognition from the 1840s of the cellular nature of all tissues was also of inestimable value in interpreting microscopical preparations.

Thus, though the Purkinje fibres had been recorded in 1839, it was nearly fifty years later when Kent, and especially His, identified the A-V bundle (His-



Illust. 10. Heart, injected with red wax, showing the ramifications of the coronary vessels; from Ruysch, F., *Thesaurus Anatomicus Quartus.* Amsterdam: J. Woltens, 1704.

Kent bundle). In 1906 Tawara gave a classic and detailed account of the whole conducting network in many animals, leaving only the sino-auricular node to be recognised by Keith and Flack in 1908. As will be noted below these studies were concurrent with other investigations on the heart contractions, though it was not until the 1950s that artificial stimulation of the sino-auricular node (the pacemaker) was used to attain normal rhythm in certain patients.



Illust. 11. Histological drawings of human heart; from Tawara, S., *Das Reizleitungssystem des Säugetierherzens.* Jena: G. Fischer, 1906.

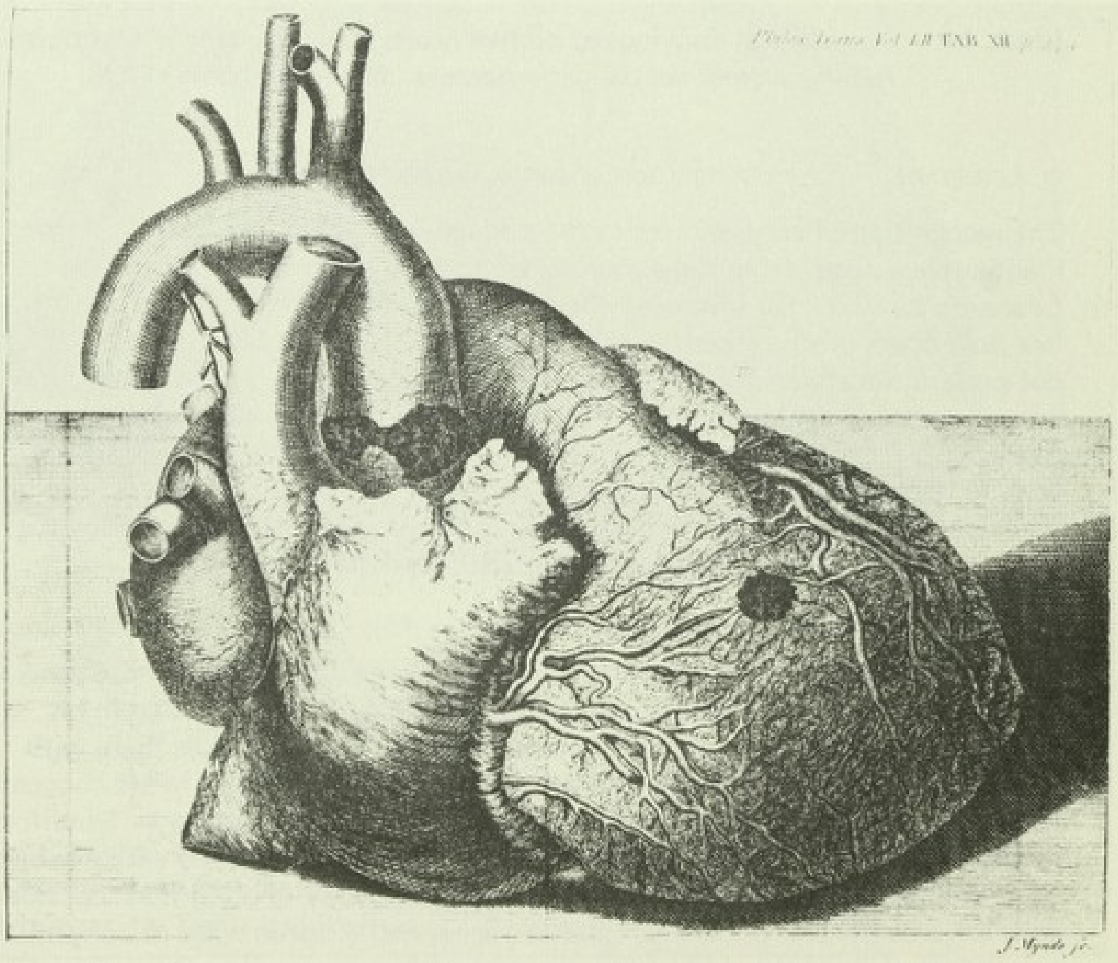
b. Landmarks in the Recognition of some Cardiac Diseases

The recognition of cardiac diseases has evolved by stages. First, cardiac abnormalities were noted from the abnormal anatomy that might be present. Leonardo da Vinci, for instance, when describing septal defects made a note: 'see how often this is present in other peoples' hearts'. But he could not get near our present understanding (cf. Galen's views) and discuss what the possibilities were in terms of abnormal physiology (the next stage in the recognition of heart disease). This could only come after Harvey's studies. For long, abnormalities were to remain as curiosities and monstrosities in museums, and it was only in the 18th century that a patho-physiological approach became noticeable. For instance, in 1705, Vieussens recognised circulation abnormalities in conditions like mitral stenosis.

In the 18th century, too, congenital cardiac abnormalities became more generally recognised. They were clearly appreciated by Morgagni (and included in his famous work *De Sedibus...* of 1761) when attempting to correlate them with pathology or symptomatology. But a more thorough attempt to relate congenital heart disease with pathological circulatory changes was soon made by Sandifort in his recognition (1771) of a case of Fallot's tetralogy. Later, the whole subject was developed by William Hunter. He made a long study of abnormal foetuses, and, towards the end of his life, collected some half a dozen cases of congenital heart disease, amongst which were examples of Fallot's tetralogy, ventricular septal defect, and atresia of the pulmonary artery. However, a full understanding of congenital defects only began with the rise of modern embryology (starting with J. F. Meckel's work) in the 19th century, in the middle of which (1858) Peacock's classical contribution, *Malformations of the Heart,* appeared.

Rheumatic heart disease was also recognised aetiologically in Britain towards the end of the 18th century. Pitcairn noted the association of rheumatic fever with heart disease in 1788, though the first clear recognition was published by Dundas in 1809. (The photograph is of Dundas's specimen of rheumatic pericarditis with mitral stenosis, now in the Royal College of Surgeons of England). In the early 19th century great strides were made by J. B. Bouillaud in Paris. He recognised the existence of endocarditis, and the development of mitral and aortic disease (or aortic valvular disease) with rheumatic heart conditions.

A third area of cardiac ailments, coronary disease, which became well established in the 18th century, owed much to British work. It was stimulated, in part, by a classical paper from William Heberden, published in 1772 ('Some account of a disorder of the breast'). The British studies were pathologically orientated, reflecting the stimulus of Morgagni, though other factors such as famous case histories (e.g., that of George II) were not without importance. Contributors included Fothergill, Jenner, Black and Parry. Burns, while paying special tribute to Parry's work, published (1809) the significant experiment of a tight ligature around the arm, which demonstrated that muscular work could produce pain. He indicated that this lesion would correspond to



Illust. 12. Ruptured heart of King George II; from *Phil. Trans.,* 1761, **52**, 274.

ischaemia of cardiac muscle, if the heart was functioning with the coronary arteries obstructed. As with other types of cardiac disease, much information has, of course, been added to these 18th-to early 19th-century foundations, though full recognition was slow. This was in spite of distinguished work by, for example, Richard Quain, who stated that acute localised fatty degeneration, as it was then called, was due to thrombosis in the coronary arteries. Recognition of the condition clinically was not made until the studies of Obrastzow and Straschesko (1910) and Herrick (1912). It was at this time, too, that the Wassermann reaction (1905) fully revealed the true incidence of syphilitic heart disease.

5. Diagnosis and Physiology

The contributions of 19th- to early 20th-century histology to knowledge of the conducting pathway in the heart have already been mentioned, but they must not be looked at in isolation. Histology was closely associated with innumerable contributions coming from an exciting era of physiology.

The expansion and development of 19th-century physiology is a complex story and only a couple of points can be mentioned. Conspicuous was a commitment to a biophysical approach, especially in the 1940s and '50s, among such notable figures as Carl Ludwig, Herman von Helmholtz, Ernst von Brucke and Emil du Bois-Reymond. Fick, who made important contributions to cardiac physiology, spelled out the philosophy of this group in the following words:

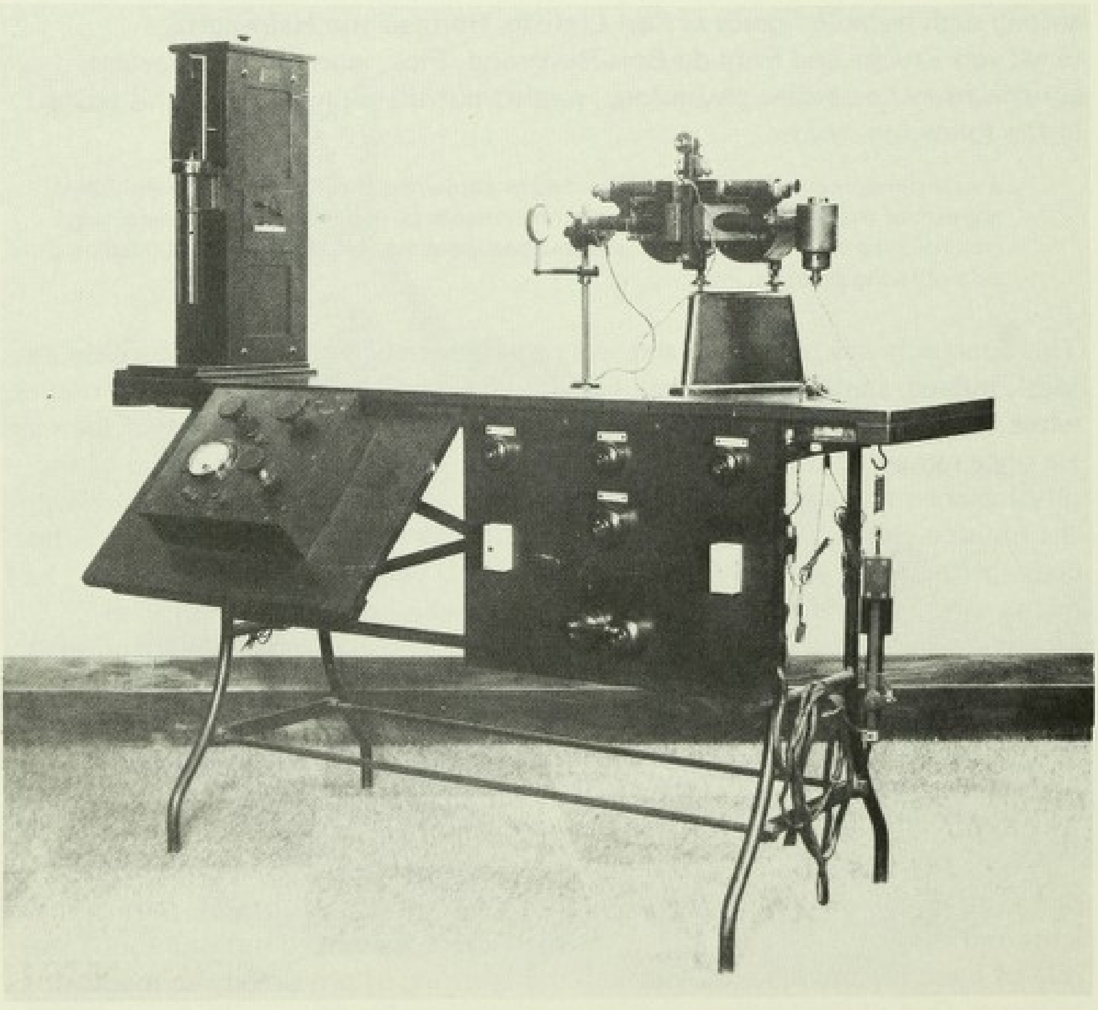
> a vital phenomena can only be regarded as explained if it has been proven that it appears as the result of the material components of living organisms interacting according to the laws which those same components follow in their interaction outside of living systems.

This approach was not novel, and was soon generally recognised to be only an ideal. Indeed, some workers were faithful to a 'vitalist' interpretation of nature, while the great French physiologist Claude Bernard took the middle of the road. He once remarked that biology must borrow the experimental method of the physico-chemical sciences, but keep its special phenomena and laws. Even so, the physico-chemical approach was an influential factor at the time, partly because of the remarkable growth in physiological research during the second half of the century. One indicator of this is the notable success of the British Physiological Society (founded in 1876). Many of the names to be mentioned below (Burdon Sanderson, Page, Waller, Martin and Starling) were members during its early years, and when the story of the achievement of British physiology in the second half of the 19th century comes to be written, this Society will feature prominently.

The growth of physiology undoubtedly helped it to become an independent scientific discipline divorced from its traditional role as an *integral* part of medicine and medical education. This, not unnaturally, raised questions about the role of basic research in medicine and the teaching of physiology to medical students. One of the leading modern cardiologists, Sir Thomas R. Lewis (1881-1945), was particularly worried over such questions. For instance, he urged that physiology for medical students should become more 'human', a comment on the animal experimentation which had become basic to physiology (and which had raised the wrath of the antivivisectionists). Lewis also questioned whether the new instruments, which were being introduced, such as the electrocardiograph machine, should become part of general practice, and he clearly differentiated the role of the general practitioner from the hospital specialist. The following sections, which cannot do justice to the tremendous amount of time and effort which was put into the separate lines of enquiry, show how these still debated questions came to the fore.

a. *Physiology of the heart; electrocardiography*

The period around 1880 to 1920, concurrently with histological studies on the conducting tissues, laid a firm foundation for understanding the functioning of the heart. Some of the enquiries had, however, started earlier. Electrophysiology had been a particularly active field of endeavour since around the 1840s, so that when the British physiologists Burdon Sanderson and Page published, in 1880, their long, detailed paper on time lags in the spread of conduction ('On the time-relations of the excitatory progress in the ventricle of the heart of the frog') they acknowledged the work of Helmholtz, Donders, von Kölliker and Müller, du Bois-Reymond and Engelmann. Only seven years later, A. D. Waller showed that



Illust. 13. Electrocardiograph made in 1933 by the Cambridge Instrument Company. The machine was used by Sir Thomas Lewis.

it was possible to register the electrical activity of the heart beat without opening the chest and exposing the heart as was generally done. Waller recorded the activity with a capillary electrometer, a difficult instrument to use, and demonstrated this to Willem Einthoven who then introduced the superior string galvanometer in the early 1900s. Illustrations of Einthoven's original, cumbersome apparatus, and equipment of the early 1930s and of the present day demonstrate the enormous advances in convenience.

When Einthoven first published his work in full in 1903 it created immediate interest, for once the normal tracing was understood abnormal variations could be correlated with diseased conditions. One of the most notable figures was Lewis, whose first major publication on the subject (*The Mechanism of the Heart Beat,* 1911) was dedicated to Einthoven (and James Mackenzie, who will be mentioned below). In his preface Lewis remarks:

> The records in themselves constitute the most exact signs of cardiac affections which we possess. The little strips of paper imprinted by the disease itself, form permanent and unquestionable testimony of events which have occurred, and may be placed in the balance, without disquietude, while experiences of a more subjective kind fill the opposing scale.

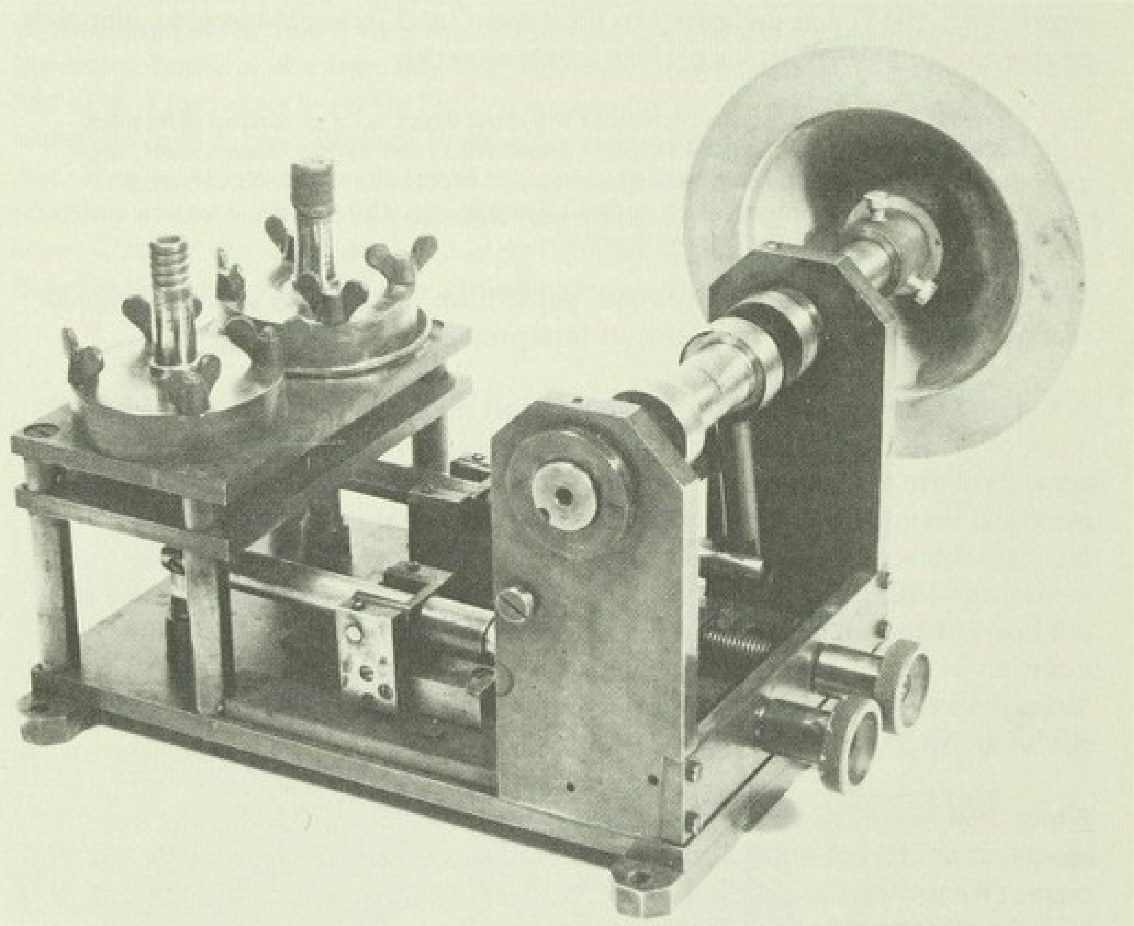
The little strips of 'disease imprinted' paper have since led to a mass of highly technical literature over problems of interpretation.

A full understanding of the functioning heart, however, owed much to the work of Gaskell and Starling. The late 19th century witnessed much controversy over the myogenic or neurogenic spread of conduction, i.e., whether the electrical impulses were controlled by nervous tissue, or whether it was an intrinsic characteristic of the muscle. For most people, Gaskell's classic memoir of 1883, 'On the innervation of the heart with especial reference to the heart of the tortoise' (supplementing important earlier work) settled the question in favour of the myogenic theory. The tortoise heart proved much easier than the frog heart for removing the nervous tissue, and hence for studying the properties of the heart muscle.

While Gaskell was carrying out his fundamental work, Sydney Ringer was reporting on the action of various electrolytes on isolated frog's heart. His paper, 'Regarding the action of hydrate of soda, hydrate of ammonia, and hydrate of potash on the ventricle of the frog's heart' (1881) contained a large number of tracings (obtained by using Roy's tonometer attached to the ventricle) recording the effects of these substances on the heart. Ringer's Solution, the first to be successfully used in physiological laboratories for examining many tissues under 'normal' environment, is a solution of five salts in balanced proportions.

However, the problem still remained of studying mammalian (i.e. warm blooded) hearts. The first person to overcome this difficulty was H. N. Martin, who, according to Sewall, acted on a flash of inspiration one evening. 'I could not sleep last night [said Martin] and the thought came to me that the problem of isolating the Mammalian heart might be solved by getting a return circulation through the coronary vessels'. The idea was thus developed of keeping the heart and lungs intact, and Martin perfected an experimental technique of the heart-lung preparation so that the study of the physiology of the mammalian heart was made possible to an extent never before attainable. The action of drugs and physiological factors affecting the heart action could be readily studied, and in the first two decades of this century Starling formulated his celebrated law of the heart: that the energy of contraction is a function of the length of muscle fibres.

Physiological research at the time was also concerned with perfusing blood through vessels and organs under controlled conditions, and in 1928 Dale and Schuster announced their double perfusion pump which could replace the heart in maintaining the pulmonary and systemic circulations. This pump, based on a principle already discussed in the literature, was of considerable influence in the development of heart lung machines used in surgery.

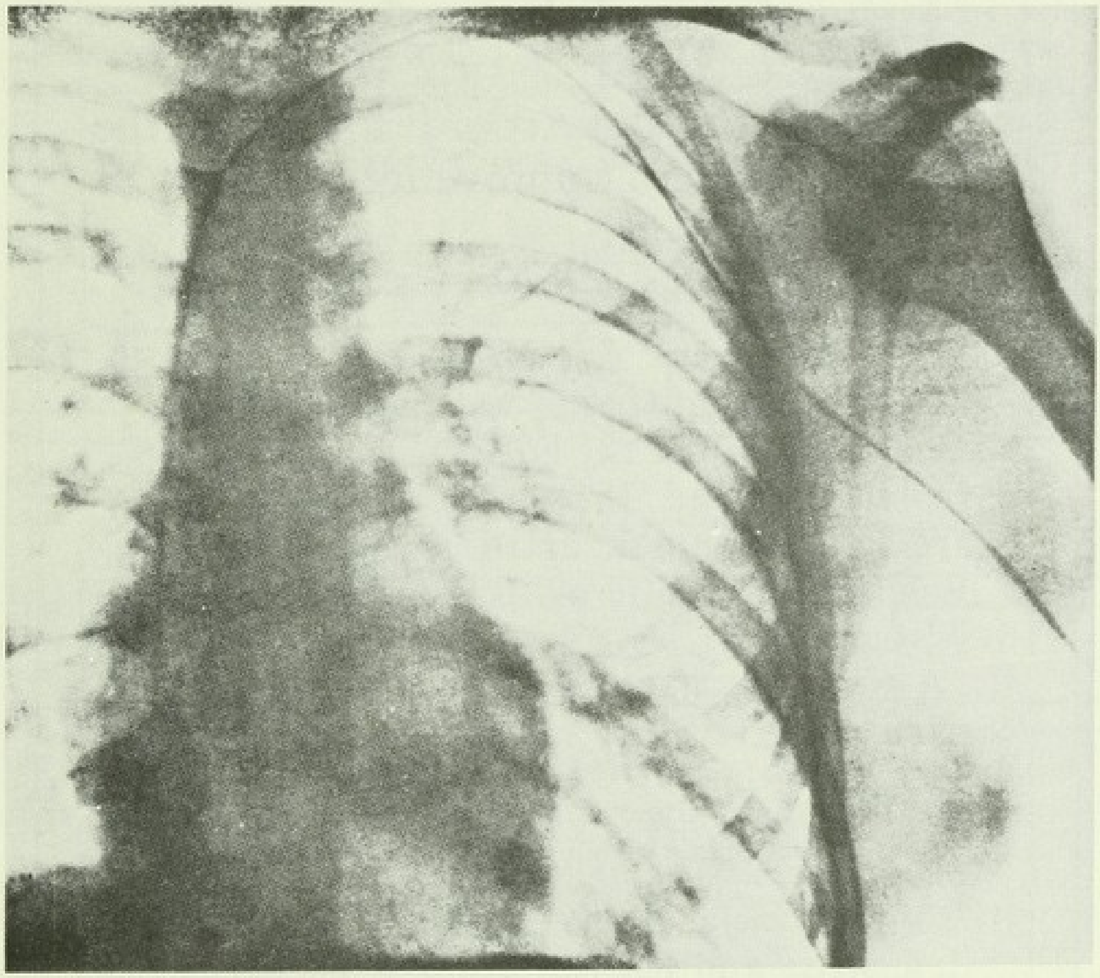


Illust. 14. Dale-Schuster double perfusion pump.

b. Blood pressure

Starling's Law of the Heart has helped to explain the relationship between pressure and cardiac failure, though only with the advent, during the last three decades, of catheterisation of the human heart in routine clinical medicine has detailed knowledge of pressure changes and heart conditions been ascertained. Werner Forssman was the pioneer in using a catheter in human hearts and he performed the first passage of a catheter on himself in 1929. Forssman has given an account of the origin of his ideas. One year after completing his medical studies (1922-27), he reflected on the many subjective elements in auscultation and percussion (see below) and considered a way of entering the heart without disturbing normal functions. His thoughts were helped by his early interest in 'old illustrations' from the works of Bernard, Chaveau and Marey: 'I never forgot them and decided to do in man what they had done in animals'. Chaveau and his colleagues (notably Marey) had, in the late 1850s and early '60s, correlated pressures with such factors as heart sounds.

The aetiology of high blood pressure still presents problems, and as the vascular system is not the principal concern of this exhibition, only brief mention will be made to the methods for its measurement. Poiseuille, in his striking thesis,



Illust. 15. X-ray of Forssman's self-catheterisation. The catheter is entering the right atrium via the superior vena cava.

Recherches sur la Force du Coeur Aortique (1828), could mention only Hales as a predecessor in measuring static blood pressure. On the other hand, others—Keill, Bernoulli, Haller and Sauvages—had been interested in the dynamics of circulation, as was Poiseuille, who made important contributions to its study. An interesting by-product of Poiseuille's own mercury manometer for determining blood pressure was Ludwig's modification, in 1841, of adding a float recorder and kymograph. The introduction of this recording tool into general physiology revolutionised experimental work. On display is a kymograph used by Sir Henry Dale (made by C. F. Palmer & Co. London).

The clinical measurement of blood pressure only developed during the second

THE

Phyſician's Pulſe-Watch;

OR, AN

ESSAY

To Explain the Old Art of FEELING the PULSE, and to Improve it by the help of a PULSE-WATCH.

In Three PARTS.

I. The Old *Galenic* Art of Feeling the Pulſe is deſcrib'd, and many of its Errors corrected: The true Uſe of the Pulſes, and their Cauſes, Differences and Prognoſtications by them, are fully explain'd, and Directions given for Feeling the Pulſe by the Pulſe-Watch, or Minute-Glaſs.

II. A New Mechanical Method is propos'd for preſerving Health, and prolonging Life, and for curing Diſeaſes by the help of the Pulſe-Watch, which ſhews the Pulſes when they exceed or are deficient from the natural.

III. The *Chineſe* Art of Feeling the Pulſe is deſcrib'd; and the Imitation of their Practice of Phyſick, which is grounded on the Obſervation of the Pulſe, is recommended.

To which is added,

An Extract out of *Andrew Cleyer*, concerning the *Chineſe* Art of Feeling the Pulſe.

By Sir JOHN FLOYER, Knight.

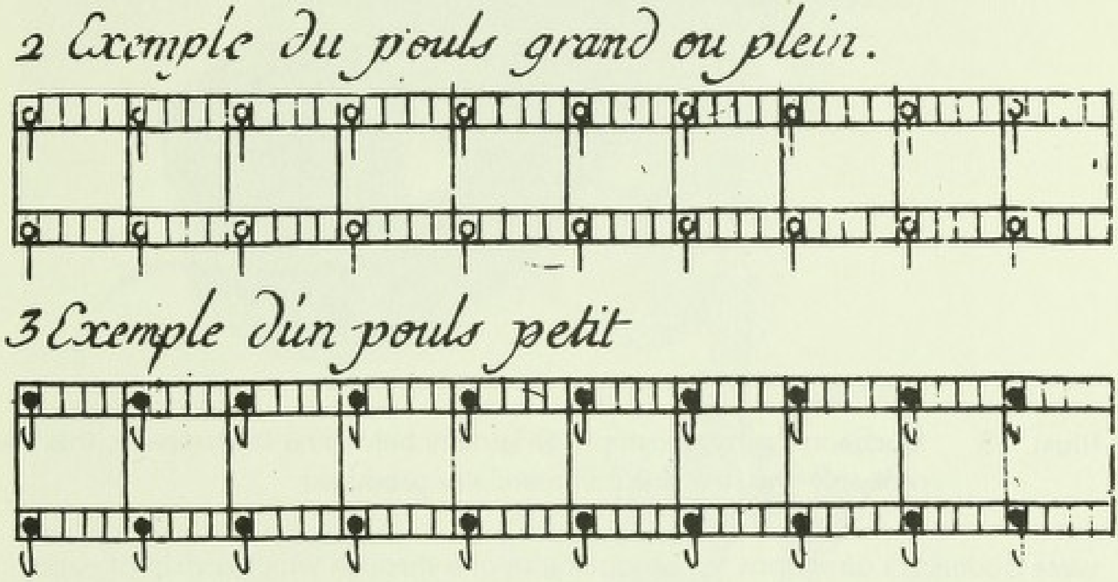
LONDON, Printed for *Sam. Smith* and *Benj. Walford*, at the *Prince's-Arms* in St. *Paul's Church-Yard*, 1707.

Illust. 16.

half of the 19th century, with the introduction of countless devices. Many examples are in the Wellcome Collection, some reflecting what has been termed Victorian inventiveness. Influential continental methods are those of Vierordt, von Basch, Potain and Riva Rocci. Also shown are techniques for measuring venous and capillary pressure.

c. The pulse

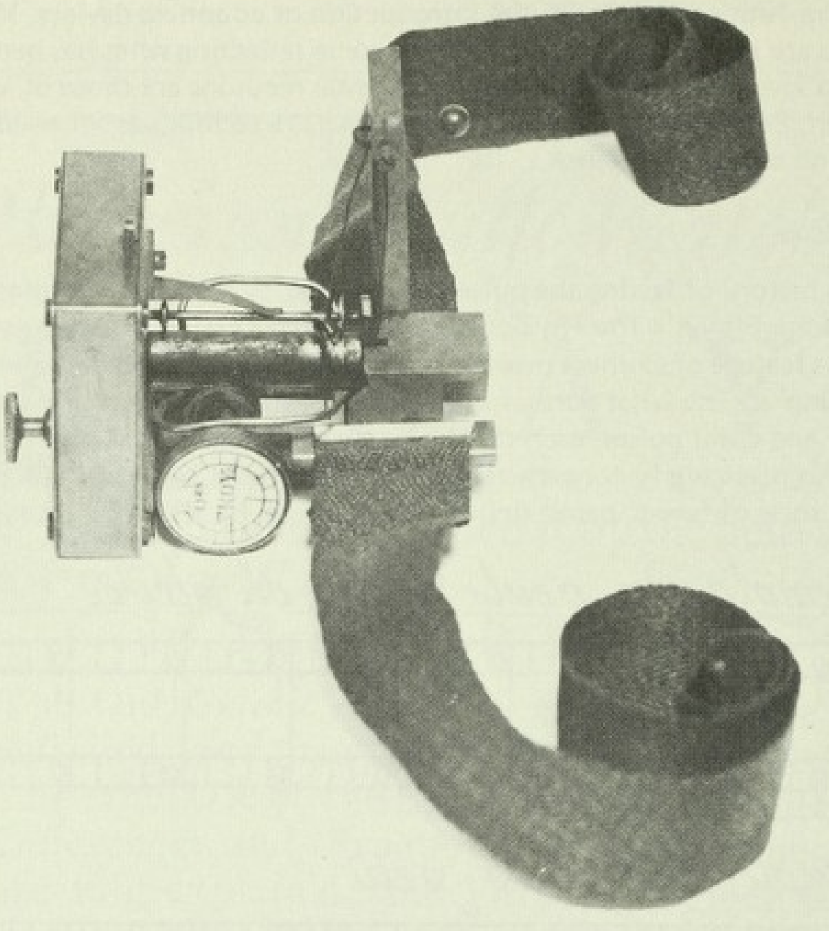
The long history of feeling the pulse is illustrated by the very informative title page of John Floyer's *The Physician's Pulse-Watch* (1707). The pulse was a dominant feature of Chinese medicine, and complicated procedures were evolved for 'reading' it. The wrist pulse, for instance, was divided into three parts, the inch, bar and cubit pulses, each of which represented different internal organs. Floyer was particularly concerned with the pulse rate ('by the number 100 I know all sorts of fevers, pains, defluxions'), though he also took into account



Illust. 17. Example of Marquet's musical notation; from *Nouvelle méthode facile et curieuse pour connoitre le pouls par les notes de la musique.* Amsterdam, Paris: Didot, 1769.

other characteristics, such as the 'smallness of the pulse'. To help his work Floyer introduced a 'pulse watch' having a second hand. At present it is not certain how popular this became in general practice, though there were many publications suggesting an interest in the pulse. F. N. Marquet's method (published in 1747) is specially noteworthy because it registered the pulse in musical format.

There is no doubt that taking the pulse became very prominent in the second half of the 19th century, especially in the form of a pulse trace. Numerous types of sphygmograph were produced following the first one by Vierordt in 1855 (based on ideas stemming from Ludwig's kymograph). None of the instruments produced was particularly easy to operate (as can be attested by many now in the Wellcome collections) and even the most popular British model, a small portable one introduced by Dudgeon in 1880, needed smoked paper for recording the trace. 'Take a piece of camphor about the size of a bean, put it on the bottom of an inverted teacup, or other convenient place and ignite it'



Illust. 18. Dudgeon's sphygmograph. Originally belonging to Dudgeon, this was probably the first one commercially produced.

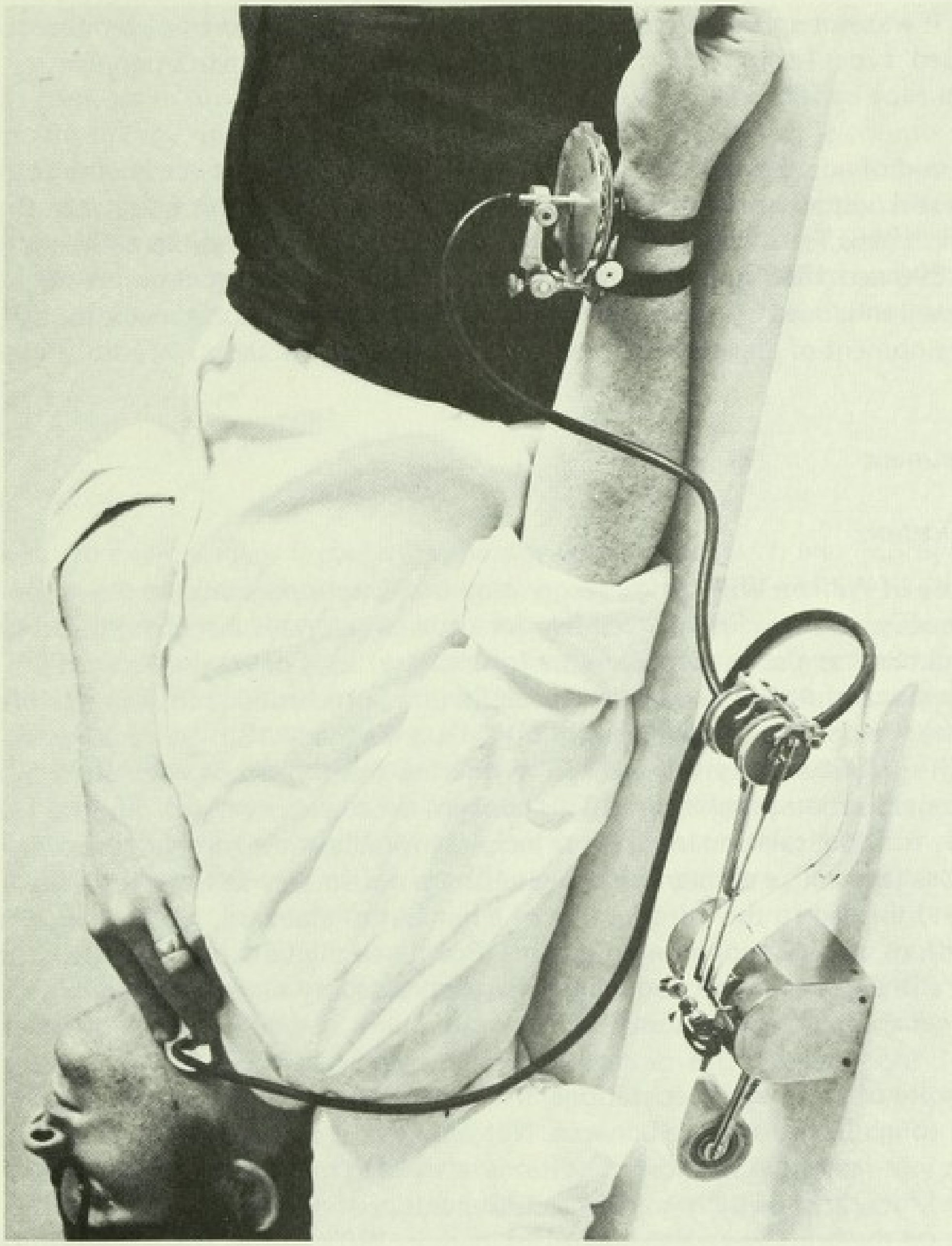
were Dudgeon's directions for producing smoke through which a strip of paper was passed.

Much discussion and debate went into interpreting abnormal traces, and great advances were made by Sir James Mackenzie around the turn of the century, largely by correlating radial pulse, venous pulse, and cardiac pulsation. This opened the way to improved interpretation of cardiac arrhythmias and the separation of auricular fibrillation from extra systoles. Mackenzie's data came initially from using Dudgeon's sphygmograph (with a tambour attached for the venous pulse, etc.), but after various modifications he produced an ink-polygraph (for registering two traces and a time scale) reflecting atrial and ventricular rhythms simultaneously.

d. Percussion and auscultation

The last sections have reflected advances in physiology in the second half of the 19th century, whereas percussion and auscultation stem from the great era of clinical teaching at Paris in the early decades of the century. Large numbers of students were attracted there from all over the world, and in 1812 the educational facilities were being used to highlight the inferior situation in London, though in truth, London facilities were certainly meeting the demands.

Percussion had, in fact, been introduced by the Viennese physician Leopold



Illust. 19. Mackenzie ink polygraph (c. 1910) recording radial pulse and carotid venous pulse.

Auenbrugger in 1761, but it was at Paris that it was popularised, notably by Napoleon's physician Corvisart, who published his small book on it in 1808. This use of the ear was extended further by the introduction of auscultation by René Laënnec. In 1819 he published his *De l'Auscultation Médiate, ou Traité du Diagnostic des Maladies, des Poumons et du Coeur.* This included an illustration of his wooden stethoscope, an elaboration of a rolled up sheath of paper he had first applied to a patient's chest. Laënnec's work was convincingly proved by autopsy and his method taken up quickly by many younger physicians, even though it was not an easy technique. Difficulties in hearing led to a plethora of 'improved' types (e.g. Potain's) and the introduction of Camman's popular binaural type in 1855.

Stokes said of auscultation in 1828, that it was substituting the ear for the eye, but the real 'visualisation' of the heart did not come until the introduction of X-rays in 1896. The story of this is well known, but the illustrations of X-rays dated 1896 and 1898 indicate its rapid use in cardiology. The great value of X-rays was enhanced by the administration of radio-opaque substances, though the development of angiography had to await until the 1930s.

6. Treatment

a. Medication

The story of William Withering's recognition of *Digitalis purpurea* as the active ingredient in a Shropshire folk remedy for oedema is always intriguing (especially as digitalis was also used at the time for insanity). But of greater interest is Withering's careful clinical work with standardised preparations to ascertain precisely the therapeutic effectiveness of digitalis. Like many 18th-century investigators (he published his work in 1785) Withering was concerned with the quality and standardisation of medicines. This concern became more marked in the 19th century with the isolation of active principles, notably the alkaloids. However, glycosides (the active substances in digitalis) are not so easy to isolate in pure form, and this led to the introduction of a number of standard, mixed glycoside preparations, such as Homolle's digitaline. Powdered digitalis, compounded into tablets, still survives today, though largely superseded by digoxin (a glycoside from *Digitalis lanata* isolated in 1930).

Yet in spite of improved preparations, the 19th-century use of digitalis was confused through its becoming a panacea. Not only was it employed as a general diuretic, not restricted to those conditions advocated by Withering, but it was also used for a host of other ailments. 19th-century studies of the action of digitalis on the heart were also unfruitful, and, in 1905, James Mackenzie wrote: 'no clear conception of the manner in which the drug acts can be obtained'. It was Mackenzie, however, who did so much to initiate the modern appreciation of its value by establishing its effectiveness in controlling auricular fibrillation.

The study of materia medica in the 19th century gathered momentum from investigations on large numbers of foreign drugs obtained through exploration, colonization and commerce. A notable success was the recognition of the strophanthus glycosides for heart disease. These became popular at the turn of the century and, like many other glycoside cardiac medicines, such as digitalis and squill, were found to be steroidal in structure. Other naturally occurring compounds, used for cardiac ailments and introduced during this century, are quinidine, antibiotics, and anticoagulants such as heparin and dicoumarol.

Concurrent with studies on natural products were investigations on pure chemical substances, for the 19th century rise of organic chemistry added another dimension to materia medica. Amyl nitrite was introduced for angina in the 1860s, the forerunner of innumerable synthetic products which have been introduced in this century, such as beta-adrenergic receptor antagonists.

In contrast to drugs are forms of treatment which have developed from electrophysiology, such as the use of pacemakers and direct electric counter shocks to break arrhythmias. It is also appropriate to mention here methods of resuscitation embracing cardiac massage and artificial respiration. As is shown, the growing need for this treatment has produced a better understanding of the various measures. Likewise intensive care units, which are as much a triumph for electronics as for medicine, have developed for the simultaneous monitoring of pulse, blood pressure, and electrocardiogram.

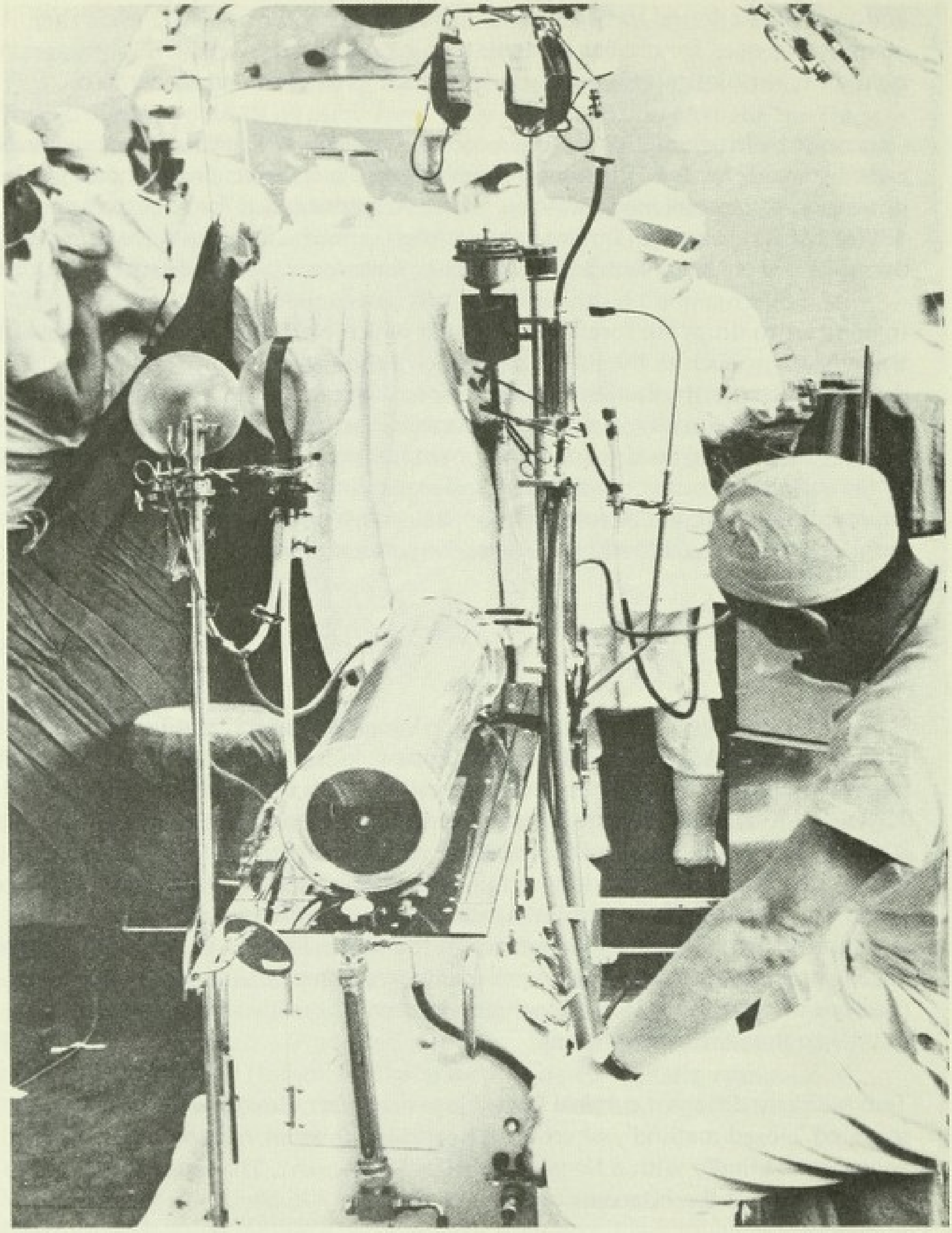
b. Surgery

Modern heart surgery is rooted in the physiological research and improved recognition and diagnosis that has developed since the late 19th century. Before then, especially without anaesthetics and antiseptics which became established in the 1840s and '60s respectively, successful surgery could not be contemplated. Thus it was in 1896 that the Frankfort surgeon, Ludwig Rehn, first succeeded in suturing a heart stab wound, and two years later Kienboeck removed a bullet from a heart. There then followed isolated reports of successful operations, but only since the 1940s have the risks inherent in the surgical treatment of heart disease been appreciably reduced. One particular factor contributing to this is refined methods of anaesthesia, which include a system of positive pressure ventilation so vital to thoracic interventions.

Two basically different surgical techniques have been developed. One is the so-called 'closed method', where such heart lesions as mitral stenosis are approached blindly with a finger or with an instrument. The heart continues to beat throughout the intervention.

The other is the 'open method' where operations are performed on the stopped heart. In such cases the circulation is either temporarily interrupted (hypothermia) or is maintained by means of extracorporeal circulation. Hypothermia was developed in the 1950s, and owed much to the work of Bigelow in Toronto. In 1952, Lewis conducted the first successful hypothermia operation.

The origins of the heart lung machine as a physiological tool have already been noted, and it was in the early 1950s that the extracorporeal circulation was first used in human surgery. On display is a Melrose heart lung machine, in which the blood flows over rotating discs while a current of oxygen is blown over the blood. Other exhibits include illustrations of other types of machines, a selection of instruments for closed heart surgery, and also artificial heart valves.



Illust. 20. A Melrose-NEP machine in operation; from Mcleave, H., *The Risk Takers.* London: Muller, 1962. Photograph by courtesy of Firth-Vickers Stainless Steels Ltd.

c. Rehabilitation

For so much of the period covered by the exhibition, recognition of cardiac complaints was not of great benefit to the patient in terms of effective treatment, though a physician might improve his reputation through an accurate prognosis. Nevertheless, there was often a recognition of the importance of such factors as sober living and an attention to diet, now important factors in long-term treatment and rehabilitation. By illustration and quotation this section indicates interest in these factors over many centuries. The last quotation is from the first edition of Lewis's well known *Diseases of the Heart* (1933), on the topical subject of smoking:

> It were best that the cardiac patient did not smoke at all, but if they will, it must be done in very strict moderation.

SELECT BIBLIOGRAPHY OF THE HISTORY OF CARDIOLOGY

The secondary sources for the study of the history of cardiology and related disciplines are immense. Though the guide is in no sense a review of the literature, the following works are a useful introduction.

HERRICK, J. B. A short history of cardiology. Springfield: C. Thomas, [1942].

WILLIUS, F. A. *and* KEYS, T. E. Classics of cardiology. 2 vols. New York: H. Schuman, [1961].

WILLIUS, F. A. *and* DRY, T. J. A history of the heart and circulation. Philadelphia: Saunders, [1948].

FISHMAN, A. P. *and* RICHARDS, D. W. Circulation of the blood: men and ideas. New York: O.U.P., 1964.

ESCHMANN, E. W. *and others.* Das Herz. 2 vols. Biberach and Riss: K. Thomae, 1965-66.

EAST, C. F. T. The story of heart disease (Fitzpatrick Lectures 1956-7). London: Dawson, [1957].

LEIBOWITZ, J. O. The history of coronary heart disease. London: Wellcome Institute of the History of Medicine, 1970.

SIEGEL, R. E. Galen's system of physiology and medicine. Basle: S. Karger, 1968.

KEELE, K. D. Leonardo da Vinci on movement of the heart and blood. London: Harvey & Blythe, 1952.

PAGEL, W. William Harvey's biological ideas: selected aspects and historical background. Basle: S. Karger, 1967. (An important source of references to the vast literature on the subject).

DOBY, T. Discoverers of blood circulation. From Aristotle to the times of da Vinci and Harvey. New York: Abelard-Schuman, 1963.

WIGGERS, C. J. Some significant advances in cardiac physiology during the nineteenth century. *Bull. Hist. Med.,* 1960, **34**, 1-15.

McKUSICK, V. A. The history of methods for the diagnosis of heart disease. *Bull. Hist. Med.,* 1960, **34**, 16-18.

FEIL, H. History of the treatment of heart disease in the nineteenth century. *Bull. Hist. Med.,* 1960, **34**, 19-28.

CLOWES, G. H. A., jnr. The historical development of the surgical treatment of heart disease. *Bull. Hist. Med.,* 1960, **34**, 29-51 (Includes an extensive bibliography).

STARLING, E. H. Starling on the heart. Facsimile reprints, including the Linacre lecture on the law of the heart. Analysis and critical comment by C. B. Chapman and J. H. Mitchell. London: Dawson, 1965.

ROTHSCHUH, K. E. Geschichte der Physiologie. Berlin: Springer, 1953.

GRIFFENHAGEN, G. B. *and* HUGHES, C. H. The history of the mechanical heart. [In *Smithsonian Report,* 1955, pp. 339-356].

GIBBON, J. H., jnr. Development of the artifical heart and lung extracorporeal blood circuit. *J. Amer. med. Ass.,* 1968, **206**, 1983-6.

RICHARDSON, R. G. The surgeon's heart: a history of cardiac surgery. London: Heinemann, 1969. (The most recent of a series of popular histories on heart surgery).