Contents

Preface To The Second Edition

THIS BOOK is the outgrowth of a course in auscultation of the heart given for the past 10 years at the New York University Post-Graduate Medical School. The purpose of both the course and the book has been to teach clinical auscultation; over this period of time audio-visual technics have been developed to improve this teaching process. Although these audio-visual methods lend themselves better to the classroom than to the pages of a book, every effort has been made to explain and illustrate these principles.

The first edition contained only stethograms (the photographic reproduction of the vibrations produced by the heart) as illustrations. Since, however, some individuals have difficulty in interpreting stethograms when not recorded with some other timing mechanism, we have attempted where possible to use new illustrations incorporating timing by the electrocardiogram or carotid pulse curve. Admittedly, stethograms are a poor substitute for actual auscultation, and further we feel strongly that one should see and hear the heart sounds simultaneously. This is not possible without special equipment, but we have found that the added information gained through the use of audio-visual methods can then be translated to the stethoscope alone.

We should like to emphasize that we have attempted to deal with clinical auscultation as far as possible, and this text is not intended as a comprehensive work of cardiology. Therefore, many controversial points and references to the literature have been omitted with the intention of keeping the book practical and short.

It is a pleasure to thank the Cambridge Instrument Company, Dr. Charles A. Poindexter and members of the Division of Cardiology of the New York University Post-Graduate Medical School for their help and co-operation. We are also most grateful to Olive Emslie for her drawings and charts.

Finally, we are deeply indebted to the William Haebler Fund and the New York Heart Association whose support has enabled us to carry out this work.

1960

The Authors

THIS BOOK is affectionately dedicated to the memory of

DR. ROBERT HURTIN HALSEY,

eminent cardiologist, founder in 1908 of the cardiac clinic of the New York Post-Graduate Medical School and Hospital, and one of the leaders in the organization of the New York Heart Association in 1914 and the American Heart Association in 1922.

CHAPTER I

Historical Aspects of Auscultation of the Heart

WILLIAM HARVEY is generally regarded as the discoverer of the circulation of the blood. His book, "An Anatomical Dissertation Upon the Movement of the Heart and Blood in Animals,"[1] was published in Frankfurt in 1628. It is often said of Harvey that he failed to give due credit to Servetus, Columbo and Cesalpino, who held certain basic ideas regarding the circulation, but in his own words he began his studies to learn "from actual inspection, and not from the writings of others."[2] Perhaps it should be said of Harvey that he demonstrated the circulation rather than that he discovered it, and about this there can be no disagreement.

In his book Harvey mentions the heart sounds, saying that "with each movement of the heart, when there is the delivery of a quantity of blood from the veins to the arteries, a pulse takes place, and can be heard within the chest."[3] Inasmuch as immediate or direct auscultation, in which the ear is placed directly against the chest, has been known since the time of Hippocrates, it seems certain that heart sounds had been heard previous to Harvey's observation but the interpretation placed on these sounds is unknown.

It appears, however, that the knowledge of the existence of heart sounds and the use of immediate auscultation had added nothing of material value regarding the heart and its diseases. This came with publication of the book by René Théophile Hyacinthe Laënnec, appearing in France in 1819 under the title of "A Treatise on Mediate Auscultation,"[4] which introduced mediate or indirect auscultation by means of the stethoscope (Gr. *stethos,* breast + *skopos,* watcher).

It was Laënnec's opinion that the heart sounds were unrelated to the impulse of the heart against the chest wall. He stated that the first heart sound resulted from ventricular contraction, and the second sound from atrial contraction. This explanation proved to be incorrect, as did certain of his ideas regarding heart murmurs. However, Laënnec gave the first careful descriptions of the auscultatory findings of the normal heart and of many varieties of heart disease, and he is regarded as the founder of the art of auscultation of both the heart and the lungs.

At the time Laënnec discovered the principle of mediate auscultation he was physician to the Necker Hospital in Paris. His own words best describe the discovery: "In 1816 I was consulted by a young woman labouring under the general symptoms of diseased heart, and in whose case percussion and the application of the hand were of little avail on account of the great degree of fatness. The other method just mentioned* being rendered inadmissible by the age and sex of the patient, I happened to recollect a simple and well-known fact in acoustics, and fancied at the same time, that it might be turned to some use on the present occasion. The fact I allude to is the augmented impression of sound when conveyed through certain solid bodies as when we hear the scratch of a pin at one end of a piece of wood on applying our ear to the other. Immediately on this suggestion, I rolled a quire of paper into a sort of cylinder and applied one end of it to the region of the heart and the other to my ear, and was not a little surprised and pleased that I could thereby perceive the action of the heart in a manner much more clear and distinct than I had ever been able to do by the immediate application of the ear. From this moment I imagined that the circumstance might furnish means for enabling us to ascertain the character, not only of the action of the heart, but of every species of sound produced by the motion of all the thoracic viscera."[5]

The type of stethoscope Laënnec developed from his discovery was the wood monaural, which is carefully sketched in his book. The following information regarding binaural stethoscopes was obtained from a handbook entitled "Diagnostic Instruments and Techniques in Medicine."[6] The advantage of a flexible stethoscope which would lead the sound to both ears had been recognized for some time in the United States, but it was not until 1843 that the first binaural stethoscope was placed on the market. No specimen of this instrument is known and its description is very vague. In 1855 a stethoscope was introduced by Doctor George P. Cammann (1804–1863), of New York City, which had a chest piece of ebony, flexible tubing made of spirals of wire covered with layers of silk dipped in gum elastic and ear tips made of ivory. The curved metal ear tubes were fastened to a hinged cross piece, and approximation was provided by a strip of elastic web sewn between the tubes. Although other types were subsequently developed, a modification of the original Cammann stethoscope, placed on the market about 1890, having a steel spring between the metal ear tubes, has remained the standard American stethoscope since that time.

* Immediate auscultation.

Attempts to time the occurrence of the heart sounds in the cardiac cycle by means of the apex beat or arterial pulsations were first made in 1856. The observer marked the tracing by hand as he heard the heart sounds. This early interest in timing the sounds has led to present day phonocardiography in which the heart sounds are recorded simultaneously with the electrocardiogram. The greatest advances in phonocardiography have been made since about 1940 and resulted from the development of modern methods of electronic recording.

CHAPTER II

Importance of Cardiac Auscultation Audio-Visual Equipment

NEWER DIAGNOSTIC MODALITIES in cardiology have tended to relegate cardiac auscultation to a position of secondary importance which is unwarranted. It is our firm belief that the accuracy of diagnosis in most types of heart disease can be greatly increased by auscultation.

Cardiac auscultation has become more important as a precise diagnostic tool as the result of recent studies correlating the auscultatory findings with cardiac hemodynamics. For example, the diagnosis of pulmonic stenosis can be suspected from the duration and form of the systolic murmur, but more important is the ability to estimate the severity of the stenosis by the timing of the maximal intensity of the murmur and by noting the degree of delay of the pulmonic component of the second sound.[7]

Many other examples could be cited of the value of auscultation, but its importance can best be appreciated if one remembers that heart sounds and murmurs are the result of hemodynamic phenomena. Thus, by proper interpretation of the timing and intensity of the heart sounds and murmurs, one can indirectly interpret hemodynamic changes.

Method and Equipment

Since 1946 we have been interested in the problem of teaching auscultation of the heart by the use of audio-visual equipment.[8] Our primary concern has been to faithfully reproduce what the physician is accustomed to hearing with his stethoscope. This is possible by the use of a carefully designed apparatus consisting of a microphone which is applied to the chest of a patient, a special amplifier incorporating filters in the low frequency range of heart sounds and murmurs and an electronic stethoscope for each observer. The number of individuals listening simultaneously is limited only by the number of available stethoscopes. In this way, many physicians may listen to a patient at the same time. This is acceptable to the patient, since the period of examination is materially reduced and repeated examination by one individual after another becomes unnecessary. One instructor is thereby enabled to conduct a large group with a great saving in time and with a minimum of room noise and other distractions.

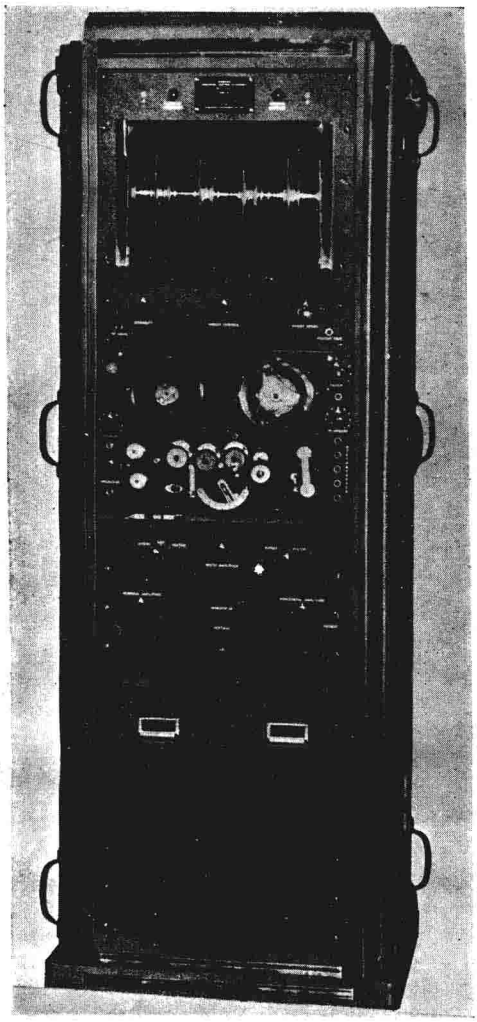

FIGURE 1. Educational Cardioscope. This instrument, designed primarily for teaching, utilizes a 17 inch oscilloscope. It is used to demonstrate the instantaneous stethogram, electrocardiogram or combinations of the two while a large group listens to the heart sounds through individual electronic stethoscopes. A tape recorder makes permanent recordings of heart sounds. Vectorcardiograms may also be demonstrated easily on this instrument. In our group, this instrument is affectionately called "Cyclops" (Cambridge Instrument Company).

While reproduction of the heart sounds through a loudspeaker instead of stethophones is also used, in our experience individual stethophones have been decidedly more satisfactory.

In addition to the accurate reproduction of the sounds we have found their *simultaneous visualization to be of the greatest importance.* This is accomplished by feeding the output of the sound amplifier to an oscilloscope with a screen which retains the image of the electron beam for a few seconds producing a persistent pattern of the

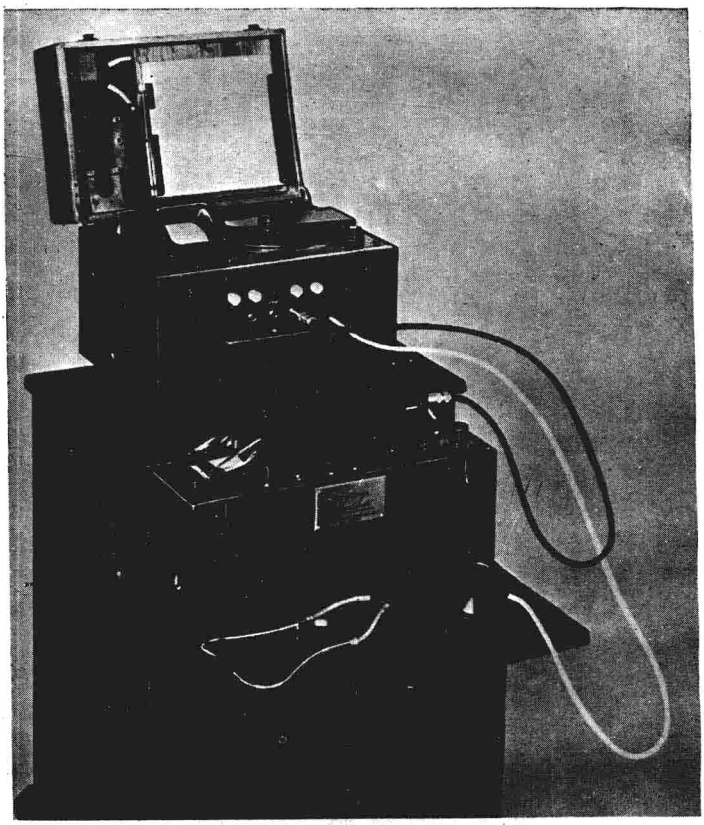

FIGURE 2. Audio-Visual Heart Sound Recorder (above) with Direct Writing Electrocardiograph (below). These two instruments may be used singly or together. The audio-visual heart sound recorder was developed for use by individuals and small groups and is portable. It enables the physician to study the auscultatory findings in patients by the combined audio-visual method. Amplification and selective filtration make the perception of difficult sounds and murmurs easy. In addition, permanent sound recordings on discs of magnetic tape can be made and filed with a patient's chart for future reference. A direct-writing electrocardiograph can be used with this recorder for timing purposes and an immediate record of the sound and electrocardiogram may be made (Fig. 3). The electrocardiogram may also be visualized, if desired, on the oscilloscope (Cambridge Instrument Company).

stethogram (FIG. 1).* Other phenomena such as the electrocardiogram, may also be visualized simultaneously with the sounds for accurate timing.

It has been our experience that the *simultaneous reception of sound by the ear and the visual pattern by the eye has great advantage over either alone.* The ear is much better than the eye in discriminating

* The terms phonocardiogram and stethogram are often used interchangeably. It is our opinion that the word phonocardiogram implies the simultaneous recording of the stethogram (cardiac sound) and the electrocardiogram or other timing event.