CARDIAC FAILURE

MORISON.

ON CARDIAC FAILURE AND ITS TREATMENT

WITH ESPECIAL REFERENCE TO THE USE OF BATHS AND EXERCISES.

BY

ALEXANDER MORISON, M.D.EDIN., F.R.C.P.ED.

PHYSICIAN TO OUT-PATIENTS TO THE GREAT NORTHERN CENTRAL HOSPITAL AND THE PADDINGTON GREEN CHILDREN'S HOSPITAL; PHYSICIAN TO THE SAINT MARYLEBONE GENERAL DISPENSARY.

Felix, qui potuit rerum cognoscere causas,
Atque metus omnes et inexorabile fatum
Subjecit pedibus strepitumque Acherontis avari!
. . . .
Quos rami fructus, quos ipsa volentia rura
Sponte tulere sua, carpsit;
P. VIRG. Maron. Georgic. Lib. II.

". . . in disease, many paths conduct to the same end; and the duty of the physician is, first, to learn the mode of recognising the affection, no matter how produced, and next to ascertain its various causes."—WILLIAM STOKES, "Diseases of the Heart and Aorta," p. 320, line 10.

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1897

DEDICATED BY PERMISSION
TO
SIR RICHARD QUAIN, Bart, M.D., F.R.S., LL.D., etc.
PRESIDENT OF THE GENERAL MEDICAL COUNCIL,
IN RECOGNITION OF
THE SERVICES HE HAS RENDERED
TO THE SCIENCE, PRACTICE, AND
PROFESSION OF MEDICINE,
AND
AS A TOKEN OF PERSONAL ESTEEM.

PREFACE.

It is the peculiar merit of those who are responsible for the attention now given to the balneological and gymnastic treatment of chronic heart disease, that they have extended into the domain of active therapeutics, and during the progress of cardiac failure, the roborant influences of that exercise which, formerly and in greatest measure, found its place in the period of convalescence.

"The fatigue of which after prolonged or novel exertion," says Dr. M. Foster (*Textbook of Physiology*, p. 88, 3rd Edit., 1879), "we are conscious in our own bodies, arises partly from an exhaustion of muscles, partly from an exhaustion of motor nerves, but chiefly from an exhaustion of the central nervous system concerned in the production of voluntary impulses. A man who says he is absolutely exhausted may under excitement perform a very large amount of work with his already wearied muscles. The will rarely if ever calls forth the greatest contractions of which the muscles are capable."

No more than the will, does the ordinary wear and tear of life call forth all the reserve force at the disposal of the organs beyond the control of will. To utilise without exhausting this reserve of force, is the object of the treatment of the enfeebled heart by baths and exercises. In this respect, however, these measures enjoy no monopoly. It is true that absolute rest of the structures subject to the will may be necessary to the recuperation of an exhausted involuntary organ, but, when we use the well-known cardiac tonics, without the aid of which rest alone would in many cases be insufficient to save life, we also draw upon what remains of unused energy. Into this subject I have, therefore, considered it permissible to enter with greater detail in one part of this book.

It is manifest, when from the presence in the blood of any cause of active constitutional disturbance—a condition frequently associated with fever—there is a progressive drain upon accumulated energy, that still further incentives to the output of force would be irrational unless accompanied by means calculated to promote its storage. Thus, the use of digitalis in a febrile state associated with cardiac failure, without the employment simultaneously of measures for the reduction of fever, if it did no harm would certainly do little good; while the treatment of such a case by active exercise would not only be irrational in theory, but from the increased discharge of spontaneous energy and its indirect consequences upon the circulation, would in all probability be disastrous in practice.

It is, therefore, only in chronic diseases of the heart, or in cardiac failure in patients free from other sources of continued drain upon strength, that the active treatment of the organic condition referred to is likely to prove useful, and has indeed, in the opinion of those who have had experience of it, done so. The natural and wholesome scepticism with which disappointed expectations in the past have imbued the profession, has caused it in the first instance to look askance at new methods of treatment. From this no remedy which has stood the test of time has been, so far as I know, exempt. Even the modern system of antiseptic surgery, now so firmly established as an article of faith in prophylactics, was originally subjected to adverse criticism, but, based as it was upon accurate observation and well-weighed experiment, time has but afforded it the opportunity of triumphant progress and universal recognition. And so must it also be with any other scientific method. If it be founded upon the rock of correct observation, the adverse winds of criticism will do little to injure it, and time will supply scientific explanation of the causes of its security. The one circumstance to be regarded as treason by seekers after truth, is the retardant influence of prejudice, envy and malevolence, and the unworthy personalities which have from time to time impeded scientific progress.

In the argument and observations contained in this book I have endeavoured to see facts as they are, and not as a partisan might wish to regard them, and, while trying to do what I conceive to be justice to the claims of those who have been instrumental in promoting the employment of baths and exercises in the treatment of cardiac failure, have not forgotten that the "strong" have also lived in past generations and contributed materially to our present knowledge of the treatment of these disorders by other means.

When I was asked to write a book upon the balneological and gymnastic treatment of heart disease I suggested to the publishers that a wider scope should be given to the work, in order that the place and influence of those measures might be determined by some consideration of the character and general treatment of the conditions they were designed to rectify. To this they readily assented, with the result that I have written the sections which precede an account of the measures in question. In doing so, I have endeavoured to acknowledge my indebtedness to sources mentioned in the text, but have drawn largely upon my own experience. For, what we see with our own eyes and handle with our own hands has a reality for us which the most courteous attention to the observations of others fails to convey.

> Erquickung hast Du nicht Gewonnen,
> Wenn sie Dir nicht aus eigner Seele quillt.

If, therefore, in the following pages, the first personal pronoun should seem to any to appear with greater frequency than the canons of good taste in literature permit, I can only plead that it is a difficult matter for the writer of a practical essay to avoid casting his own shadow, in some measure, across his own work. In the section dealing with treatment I have, however, endeavoured to correct this tendency by submitting the portions dealing with the use of baths and exercises to Medicinalrat Dr. Gröedel of Bad-Nauheim, before publication, and I have had much pleasure in translating and publishing as an Appendix, the remarks which Dr. Gröedel has been good enough to favour me with. Sir Richard Quain's views on the cause of the first sound of the heart to which I have referred, have been communicated to the Royal Society (June, 1897) since these pages were printed.

For the photographic illustrations I have to thank my friend Mr. Frank Crosbie, whose reputation as an amateur photographer is not confined to the circle of his immediate acquaintance. For his kindness in assisting me to revise the proof sheets, and especially for having in the most self-sacrificing manner undergone the ordeal of compiling the index, I have to express my indebtedness to my friend Dr. Forbes Ross of London.

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AN ARTICLE BY MEDECINALRAT DR. GROEDEL IN BAD NAUHEIM, ON BATHS AND EXERCISES.

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To Proper Names, Bibliographical References, and Annotations from this Text.

ERRATA.

Fig. 5 p. 9, is upside down.

For Russel read Russell, p. 4.

For cohesion read adhesion, p. 88.

For cordes read corda, p. 87.

PART I.

THE DIAGNOSIS AND SYMPTOMATOLOGY OF CARDIAC FAILURE.

SECTION I.

ANATOMICAL LANDMARKS, INSPECTION AND PALPATION.

It would be inappropriate on the present occasion, and it is not my intention, to touch with any fulness upon the diagnosis of diseases of the heart; but I desire to consider the evidences of failure in that organ, whatever the character of the grosser mechanical conditions which contribute to its overthrow. In doing so, however, I shall refer to certain anatomical and physiological facts which it might not be necessary under other circumstances to emphasise, but which require to be mentioned in this place, on account of the remarkable physical alterations which occur, and are said to occur, in the position and action of the heart after the use of baths and exercises in the treatment of chronic diseases affecting it.

The normal heart may be roughly stated to lie between the second and fifth intercostal spaces and almost equally to the right and to the left of the *left* edge of the sternum. It is, naturally, from its function and the actions devolving upon it, an organ of considerable mobility and variability of outline. Comparatively moored at its base by the more or less elastic structures entering and leaving it, namely, the arteries and veins, its apex has a wide range of possible movement, especially towards the left, in which direction increase in the weight of the organ due to hypertrophy of its substance, or engorgement of its chambers and structures by blood, or both these factors combined, tend to displace it. This displacement of the heart to the left is favoured by the bulk of the organ lying to the left of the *midsternal* line, which marks tolerably accurately its central line of suspension, and from the absence of hepatic resistance in the left half of the thorax.

While the boundaries of the costal pleura may be said to extend from the supraclavicular regions to the eighth rib

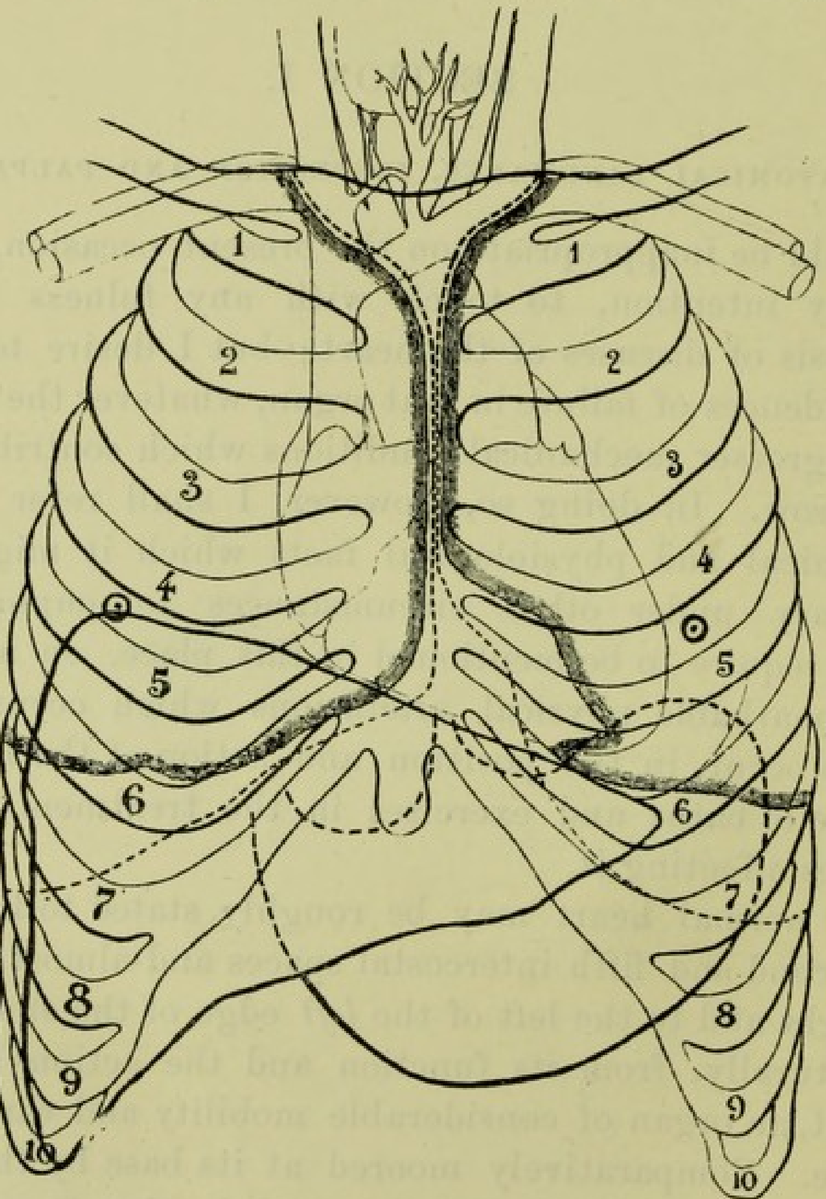


FIG. 1.—The relations of the heart to the lungs, liver, stomach, and thoracic walls. The shaded outline represents the lungs moderately inflated. The dotted pulmonary outline represents forced respiration.

on each side, the actual anatomical outlines of the moderately inflated lungs, that is to say, of the lungs in a condition of ordinary respiration, do not extend so far. Approximating in the middle line anteriorly about the level of the second costal cartilages, they run together as far as the cartilages of the fourth ribs, at which point the left lung makes a sinuous and oblique excursion outwards to the left as far as the lower border of the fifth rib, again takes a sharp curve inwards in the fifth interspace and as sharp a turn outwards again, cutting in its final course the fifth interspace, the sixth rib, the sixth interspace and the seventh rib. The inferior boundary of the right lung anteriorly is practically the same, but the anterior central margin of this organ drops straight down as far as the cartilage of the sixth rib and is free from the bay-like excursion of the left lung already mentioned. The result of this anatomical difference is the comparative exposure of an irregularly triangular portion of the anterior surface of the heart consisting of portions of the right and left ventricle. On deeper respiration, especially during its inspiratory phase, the boundaries of both lungs are extended and this area of cardiac exposure commensurately diminished.

It is necessary in this connection to refer briefly to the relation of the liver and stomach to the thoracic viscera.

The liver reaches the level of the fourth interspace on the right side in the mammary line; the nipple in the majority of males being in the fourth interspace about three quarters of an inch (2 centimetres) beyond the rib cartilages (Luther Holden, *Landmarks*, p. 19). Its superior anatomical outline passes from this point obliquely downwards and to the left until it reaches a point under the sixth left rib about the situation of the normal apex beat. A considerable portion of the inferior boundary of the heart thus practically coincides with this aspect of the liver. Its inferior, or more accurately left lateral border passes from this point across the stomach, until it reaches the ninth rib cartilage and ultimately the lowest point of the right thorax. Its right lateral border sweeps up from thence to the fourth interspace again. It is covered by lung from the fourth to the sixth right interspace, and I shall show presently that in some cases the evidence of this is clinically much more striking in the erect than in the recumbent position. The pyloric end of the stomach is on a level with the sixth right intercostal space, the inferior point of its lower curve in a line with the umbilicus at about the level of the eighth intercostal space, and the highest point of its superior curve touches the fifth left rib, that is, a point somewhat higher than the normal position of the apex beat. It is not necessary for our present purpose to indicate the clinical landmarks on other aspects of the chest. Those given may be gleaned from any text-book of anatomy, but the sources from which I have verified my own experience are von Dusch's *Lehrbuch der Herzkrankheiten*, Luther Holden's *Landmarks, Medical and Surgical*; and Gibson and Russel's *Physical Diagnosis*. The illustration is from von Dusch's book, modified by reference to the other two. A knowledge of these anatomical facts is essential to a reliable and methodical physical examination of the heart, and has acquired, if possible, additional clinical importance since the increased attention which has been given to the determination of the size of the heart by percussion before, during, and after the treatment of cardiac failure by baths and exercises.

Whatever method of determining the size and force of the heart be pursued at the moment, whether inspection, palpation, percussion or auscultation, it is of paramount importance for correct comparison that the examination should be made on successive occasions, so far as possible, in the same position, and under similar circumstances as to time, the taking of nourishment, and the state of the patient as regards emotion and previous exertion. Dealing as we are with *cardiac failure*, not with *cardiac disease*, it is also necessary that we should have a correct knowledge of the normal average condition of the individual patient. It follows from this that, while there can be no difficulty in diagnosing cardiac failure in an evidently distressed patient, the actual value of physical objective signs can only be arrived at after careful examination on more than one occasion.

By INSPECTION of the cardiac area and its surroundings we determine in cases of cardiac failure: (1) The position of the visible "apex beat" of the heart, that is that point at which a part of the heart, more or less near the apex, comes into closest relation with the thoracic wall. This may be a difficult matter, as the situation of this pulsation may be very obscurely or not at all marked, and in the discovery of the so-called apex beat we may have to seek the further aid of palpation, percussion, and auscultation. (2) The situation of motion communicated to the chest wall by the underlying pulsating heart at some point or points in the cardiac area other than at the apex. This may be in a measure diagnostic of a disease of the heart, not of failure in that organ, in which case *variations* in such a phenomenon are more important for the diagnosis of failure than the mere observation of the phenomenon itself. (3) The situation and condition of visible motion imparted to organs or areas in the immediate vicinity of the heart, or related to it by close anatomical connection. Thus pulsation in the epigastrium may be of diagnostic importance, as also pulsation to a certain degree in the large vessels leaving and entering the heart. With the possible exception, however, of communicated venous pulsations, here also the first necessity for the diagnostic estimation of these signs is a knowledge of the normal average state in these respects in a given case.

These remarks will show the importance of a close scrutiny of such points on the part of the usual medical attendant of a patient, whether in hospital or private practice. The most important ocular evidence in the heart itself of failure, is the tendency for the apex beat, carefully observed in a given position, to travel away from the middle line.

What has been said of inspection applies with equal force to the evidence supplied by PALPATION. It is easy to determine by the applied hand the presence or absence of a greater or less degree than the normal average of impulse communicated to the hand thus used, but the bearing of such evidence upon the diagnosis of cardiac failure in a given case is directly related to the knowledge which the physician has of the normal average force of the heart perceptible by the hand in that case. Without a correct standard for comparison, deduction can only be approximately if at all correct in regard to the failure of a given heart, unless the signs be so evident as to render diagnosis very easy.

The situation of palpable pulsation is, however, in cardiac failure, even more important than its degree. Moreover, the actual force of pulsation may, in some situations, be greatest when cardiac failure is most pronounced. The palpable phenomena most significant of cardiac failure are those which occur within the area of the right ventricle. None who have seen and felt the pulsating intercostal spaces along the left edge of the sternum, the powerfully heaving precordium, and the well-marked pulsation of the inferior border of the heart in the epigastrium; or who have noted the subsidence of all these phenomena on the removal of dextro-cardial distension, will feel inclined to underestimate the pathognomonic value of these palpable signs of cardiac failure. No more striking clinical picture can be presented to the observation of the physician than the undulatory right-ventricular storm manifested by some such cases and the great calm that pervades the precordial region when the tumultuous heaving of disordered action has given place to the steady pulse of a recuperated heart. But, farther, the superficial position of the pulmonary artery near the sternal end of the third left intercostal space renders abnormal tension of this vessel comparatively easily observable by the experienced hand in this situation, especially if the patient be of a somewhat spare habit. A *fremissement* or thrill in connection with valvular disease in an otherwise normal pulmonary artery feels so superficial, is so immediately under the examining hand as to impress one with the accessibility of this artery to clinical investigation (*Trans. Path. Soc. of London*, Vol. xxvii., p. 83, 1876), and Friederich used the palpable evidence of accentuated closure of the pulmonary sigmoid valves as means for determining the position of the base of the heart (L. Bard, *Lyon Medicale*, 1896). Palpation is probably the oldest means of examining the heart's action, and had it not been that the data yielded by auscultation and percussion have been so striking, it is probable that a greater cultivation of it as a clinical method would have afforded still more valuable signs than it has already done.

The Radial Pulse.

In conditions of health the pulse varies in rate, regularity, and tension; but these changes usually bear some relation to changes in attitude, occupation at the moment, or nutrition of the subject, that is, to influences other than the mere carrying on of the circulation. In conditions of cardiac failure these normal changes are frequently emphasised and are mainly attributable to the difficulty of maintaining the circulation without reference to extraneous influences brought to bear upon it. Early and slight degrees of cardiac failure may require such additional factors to induce these changes in the pulse, and the question the physician has to determine when such a case comes before him is, whether they are diagnostic of failure of the cardiac muscle or are a neurotic peculiarity of the patient. The latter is a conclusion which can only be arrived at with some hesitation and after sufficient observation. The average pulse rate of an individual may, however, be habitually slower, quicker, more irregular, or tenser than in the majority of cases, and a personal peculiarity compatible with healthy cardiac action must not be overlooked as a clinical possibility, but should not be hastily assumed as a fact in any given case.

In cardiac failure the pulse rate may be greatly retarded, and this bradycardia may either be persistent or transient, variable or invariable. It is usually persistent when it is associated with evidence of old myo- or endo-carditis, and it is then also usually invariable and incapable of being influenced by exercise or other cardiac accelerants. It may, however, have these characters and be unassociated with gross change in the heart. The assumption which has been made, however, in some cases of a healthy condition of the organ in some fatal cases of bradycardia, does not rest upon satisfactory pathological evidence. The pulse in such cases is slow, and frequently easily compressible, unless considerable atheromatous changes have taken place in the radial artery. The sphygmogram reveals an increased length of ventricular upstroke with or without exaggerated predicrotism and dicrotism and a prolonged diastolic interval, as shown by the descending limb of the tracing.

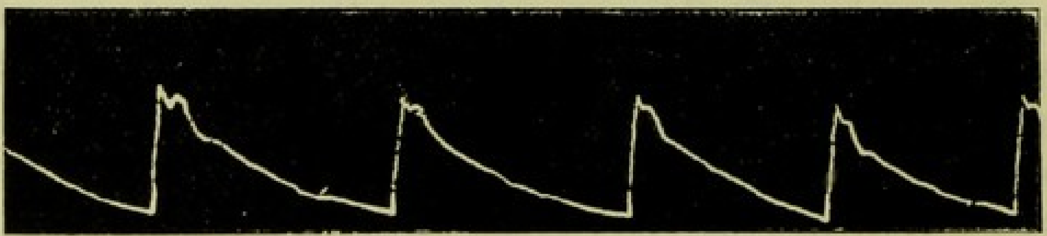


FIG. 2.

Fig. 2 is the tracing from the pulse of a gentleman 64 years of age. His pulse rate was 38 to 40 in the minute. He died of syncope two months later.

The pulse rate in cardiac failure may be much quickened. The quickening may be paroxysmal or persistent, and when persistent defies in many cases retardent agents, just as persistent bradycardia refuses to be accelerated. Paroxysmal tachycardia, on the other hand, associated with extreme rapidity of action, and it may be with signs of cardiac dilatation, may suddenly subside into a normal pulse rate. In tachycardia, from the hurry with which the cardiac movements are made, the duration and amount of every incident in the sphygmogram is necessarily curtailed, and the general pressure, when the tachycardia is significant of cardiac failure, is low.

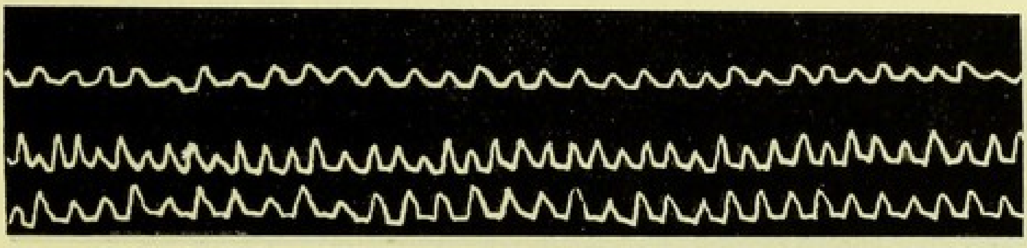


FIG. 3.

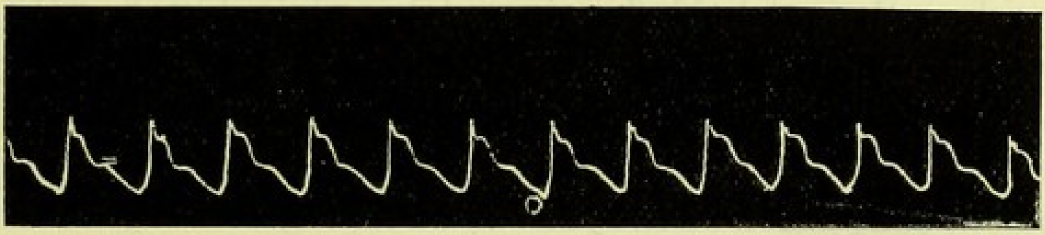


FIG. 4.

Figs. 3 and 4 are from a case of paroxysmal tachycardia under my care at the Great Northern Central Hospital, and exhibit an extreme degree of the condition which rapidly resumed a normal state. Persistent tachycardia with serious and prolonged evidence of cardiac failure may be associated with much irregularity, as well as rapidity, of heart's action. In all tachycardial, as well as in bradycardial cases, it is well to note both the heart rate by the stethoscope and the pulse rate at the wrist, for these fre-

FIG. 5.

quently do not correspond. Thus Fig. 5 is from the radial artery of a lady 73 years of age, who died shortly afterwards in a syncopal condition, and shows a well-marked "dropped beat," which gave the palpatory evidence of pulsus bigeminus, or a long beat and short beat, like the systole and diastole of the heart, but dependent upon a systole and a half, or

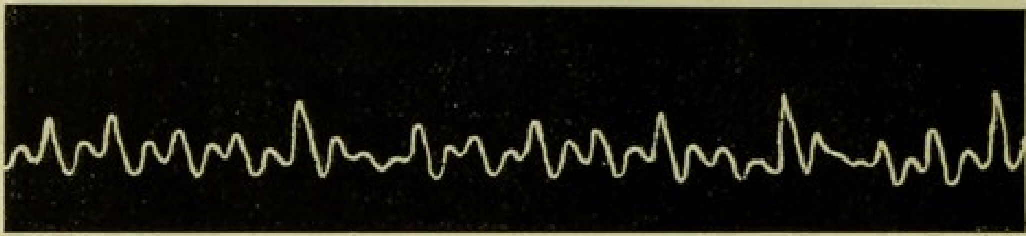


FIG. 6.

even less than a half (hemisystole); while Fig. 6, with a cardiac rate of 150 and a radial pulse rate of 102, is from a man 29 years of age, who, in addition to persistent tachycardia, has mitral valvular regurgitation and at the moment congestion of the base of both lungs, chiefly the left, copious prune juice expectoration, and diminished urinary secretion.

Irregularity of pulse may, however, be the only or chief evidence thus obtainable of cardiac failure, and this abnormality of rhythm may be of regular or "rhythmical" recurrence or an irregular and "arhythmical" event. The pulsus bigeminus associated with bradycardia, which I have already mentioned, is an example of the former, as also is the well-marked triple pulse of Fig. 7, from a

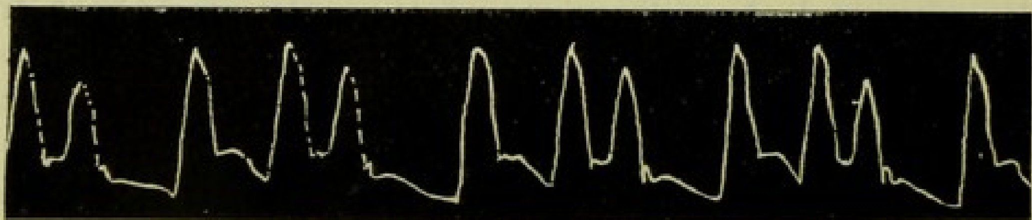


FIG. 7.

case of double aortic disease under the care of my colleague, Dr. Burnet, at the Great Northern Central Hospital. The latter will be seen to consist of two cycles and a half—lup-dup-lup-lup-dup. The second diastole is here the missed phase, and the last of these contractions of the ventricle is rather less powerful than the two which preceded it. When at regular or irregular intervals there is a clearly perceptible pause in cardiac action, the action of the organ is said to be intermittent.

This "intermittent action" of the heart in cardiac failure may be of a mixed character. A pause may take place, during which a whole cardiac cycle might have occurred, but does not. This pause, apparently complete to the finger at the wrist, may or may not have been quite so, as shown by sphygmography. Thus Fig. 8 is from the

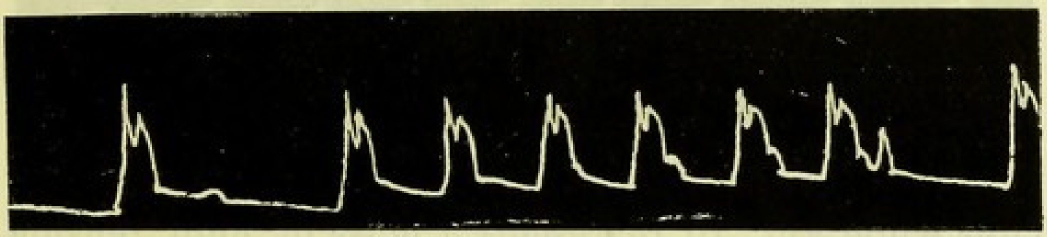


FIG. 8.

radial artery of a gentleman 81 years of age, and without valvular disease. It will be observed that in the first of the two well-marked intermittent pauses there was the faintest attempt possible at ventricular contraction, revealing the point at which the event should have occurred. Cases of cardiac failure may, however, be met with in which well-marked evidences of heart strain may be present, even associated with considerable cardiac dyspnœa, but in which there may be little abnormal in the rate or character of the pulse. This was so in the case from which Fig. 9 was

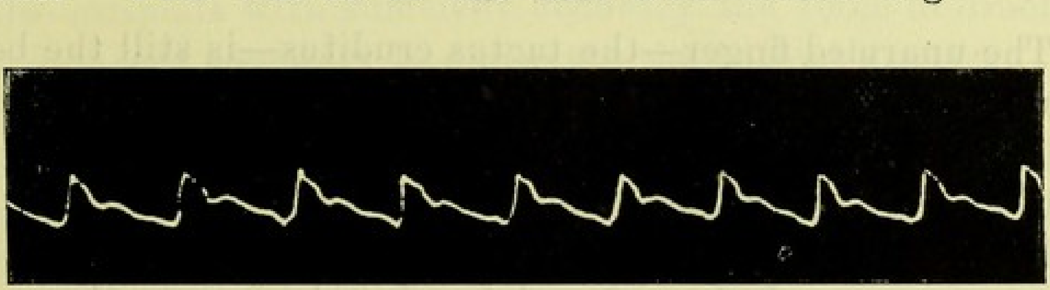


FIG. 9.

taken, in which only an occasional intermission was to be detected.

It is of importance in cases of cardiac failure to note the tension of the radial pulse. Instrumental estimations of pulse pressure have hitherto been unsatisfactory. A clinical instrument to be of real utility should cultivate, not supplant, our perceptions. Carefully used, the sphygmograph affords valuable information as to the *character* of vascular pulsation, but gives a very rough estimate of its amount or force.

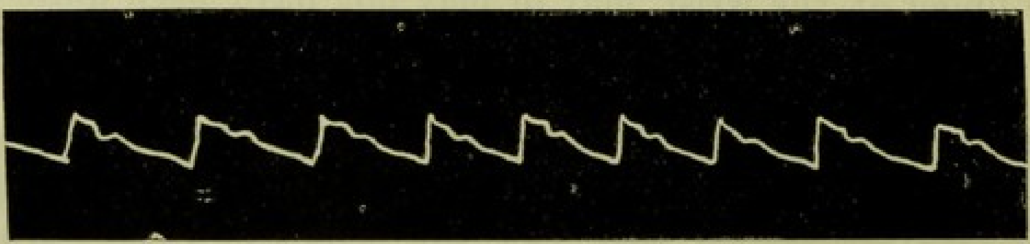


Fig. 10.

Thus while Fig. 10 represents a pulse of high tension in a dyspeptic man 27 years of age without organic disease, and Fig. 11 a pulse of low tension in a youth of 18 years, convalescent from pneumonia, neither tell the degree of tension, although to the finger both the "high" and "low" tension were very distinct clinical conditions.

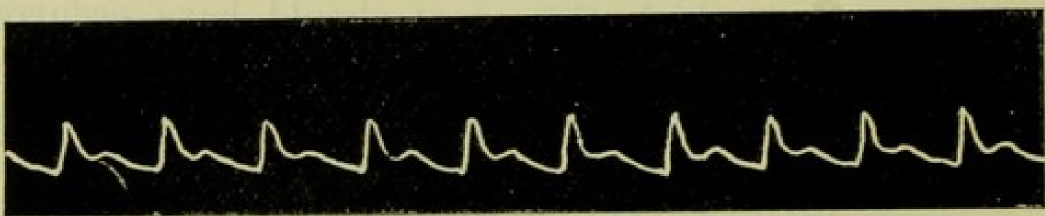


Fig. 11.

The unarmed finger—the tactus eruditus—is still the best gauge of pulse tension, and the cultivation of tactile sensibility and the muscular sense is the object of education in sphygmology. An instrument which will further this is calculated to be of real use. Our increased knowledge of the important relation of peripheral resistance to the work thrown upon the heart renders greater perceptive accuracy in the examination of the pulse desirable.

Various methods have been suggested for gauging by palpation the tension and force of the pulse. That which I have personally found most satisfactory is as follows:— The patient's hand, in a position of easy supination, lies in

FIG. 12.—Digital method of estimating pulse tension.

one hand of the physician, who, with the thumb of that hand, feels the pulsation of the patient's radial artery. With one finger, usually the index of his other hand, he exercises gradual pressure on the vessel until pulsation just ceases to be felt by the palpating thumb. By gently easing the pressure exercised by the index finger on the radial artery and again increasing pressure upon it so as to obliterate the lumen of the vessel, a very fair idea of the pulse tension in a given case may be acquired. The finger, educated by such an instrument as I shall now describe, may also estimate with sufficient accuracy the force in drachms and ounces necessary to obliterate the patient's artery.

The late Dr. Handfield Jones devised an instrument for estimating pulse pressure and educating the sense of touch, well calculated to fulfil its object but for certain defects in its construction. The spring measure employed was a collapsing, not extension spring, and to keep it tolerably straight a rod passed through it, and thence through the top of the instrument, which interfered with the application of the tip of the physician's finger to the upper end of it. It was also somewhat heavy.* To obviate these objections I have had constructed for me the instrument of which I give an illustration.

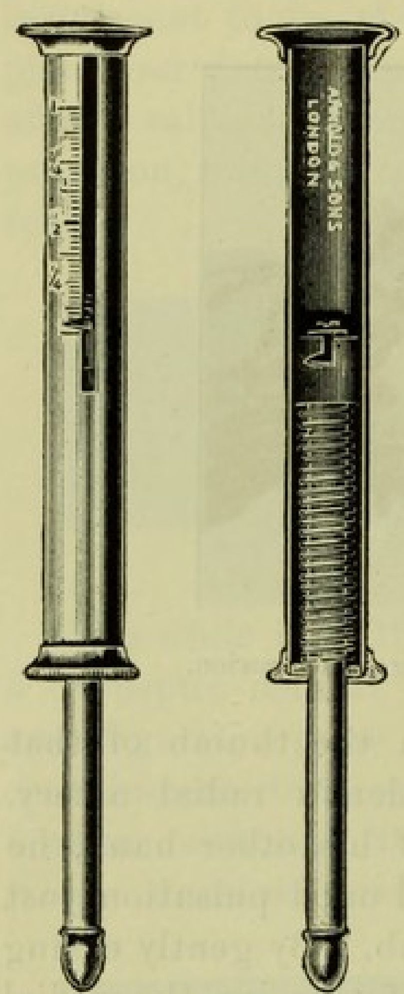


FIG. 13.

Having an extension screw, and being made chiefly of aluminium, it is comparatively accurate, very light, and of a known weight which is indicated. The finger can also conveniently be applied to its proximal end, and thus educated in the estimation of obliterative pressure. The simple principle adopted is that used in the sensory dynamometer to be described later.†

Arterial tension as shown by increased resistance to the examining finger may be increased in cases of cardiac failure, and fluctuations in it are a valuable indication of the power exerted by the heart to deal with peripheral resistance, once the physician has gauged the normal average of pulse tension in a given case. With progressive loss of power in the central organ peripheral pulse tension falls, and such a fall must be regarded as a degree of syncope which may at any time become complete.

* It was made by Messrs. Hawkesley, of Oxford Street, W.
† It is sold by Messrs. Arnold and Sons, of Smithfield, E.C.

SECTION II.

PERCUSSION OF THE HEART.

Since the subject of the treatment of heart disease by baths and exercises has been more prominently before the profession, some discussion has taken place upon the comparative value of different methods of percussion. For practical utility it is necessary that any method pursued should be convenient, efficient, and likely to come into general use. Regarding Auenbrugger's discovery as a development of palpation, it is, I think, by the education of touch that we are most likely to develop and generalise the art of percussion, and on this account the manual method as ordinarily employed, or assisted by a suitable pleximeter and plessor, is to be preferred to any other. The plan I have for some time pursued has been well described by Professor Potain (*Clinique Medicale de la Charite*, 1894, p. 366), and differs little from that in general use, which speaks well alike for its convenience, utility, and prospects of future employment. Potain has likewise described a convenient means of roughly estimating the superficial area of the organ, to which I shall presently refer. It would enhance the practical utility of percussion as a clinical method were writers always quite clear as to the significance of the terms employed. The terms "superficial" and "deep," or "absolute" and "relative" dulness have no doubt a distinct meaning to many, but confusion is apt to arise from their being qualifying adjectives of a common substantive. This would be avoided were we to limit the term "cardiac dulness" to the "deep" or "relative" dulness, the Herzdämpfung of the Germans, and used instead of "absolute" and "superficial" dulness, the term "cardiac leerness," the equivalent of the Herzleerheit of the Germans. In advocating the employment of the latter somewhat uncouth but very expressive Saxon word, I but echo a preference of Dr. Gee, of London (*Percussion and Auscultation*).

To return to Potain's procedure. He determines first the line corresponding to the base of the heart represented by the right auricle, which in the normal state is almost parallel with the right edge of the sternum, then that corresponding to the border of the left ventricle; next the curve uniting the lines which mark the arch of the aorta, and finally the site of the apex.

The resonant qualities of the sternum and the anatomical disposition of the lung to the right of that bone render this part of the procedure a delicate operation, and in many cases in which the dilatation of the right auricle does not extend very considerably beyond the right edge, the precise outline of the organ is difficult to determine.

Potain commences with percussion, using the fingers only, about four centimetres to the right of the sternum, and on detecting the change of note at once marks the chest or super-imposed linen on the outer aspect of the applied finger. He deprecates prolonged percussion as misleading to the physician and fatiguing to the patient. Similarly some points are marked along the border of the left ventricle, and one or two indicating the arch of the aorta. The confines of the right ventricle are then made out; and this he does indirectly. By palpation and percussion, and I may add that auscultation may also be necessary, he determines the external and inferior limits of the cardiac "apex," the most difficult in many cases, and the most important part of the process in all. This done, the upper border of the liver is determined, and the tangent to its highest point noted. From the angle formed by the curve of the liver and its tangent a line is drawn to the inferior limit of the site of the apex. Potain is frank enough to state, and most clinicians will agree with him, that although the inferior cardiac and the liver percussion note may not be identical, he himself is incapable of recognising the difference. The determination of the cardiac leerness is an easy matter, and is effected in the usual way by gentler percussion than that necessary for more covered portions of the organ. The organ having thus been mapped out, the points determined, as also leading anatomical "landmarks," such as the episternal notch, the xyphoid cartilage, the nipple, and the junction of the manubrium with the gladiolus of the sternum, may be transferred to tracing paper and retained as a record. For convenience of transference to an ordinary note book, I have found a cardiac cyrtometer made for me by Messrs. Arnold and Sons, of Smithfield, London, of service. This is constructed of flexible metal with registering strands of silk (Fig. 14). As this cyrtometer adapts itself to the curve of the thorax a

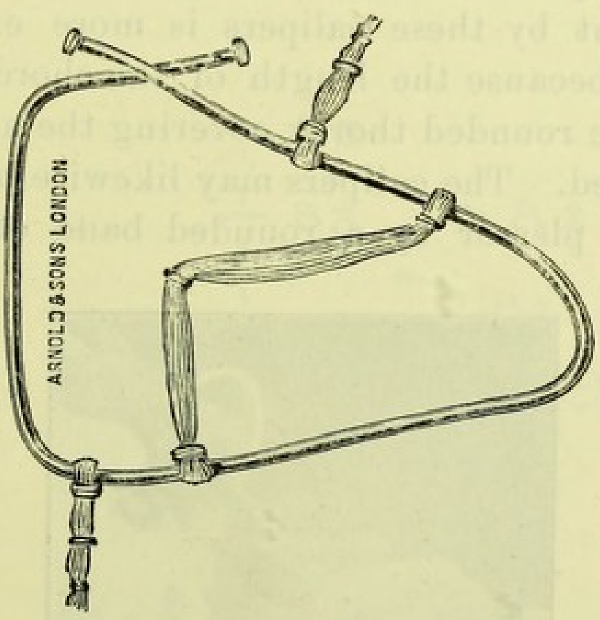


FIG. 14.

pencil should be drawn round its outer border without flattening it over the paper of the note book. To flatten it is to expand it, and thus to increase considerably the area of cardiac dulness beyond its actual boundaries.

Professor Potain has devised a useful means of gaining a rough estimate of the size of the superficies of the heart from measurement of the cardiac area. He multiplies the height of the figure of the cardiac dulness obtained by percussion by its length, and the product by an empirically found co-efficient, which he found to be about 0·83. The result in square centimetres is not far from the truth, provided the figure mapped out does not depart much from the normal blunt triangular shape. For the purpose of such

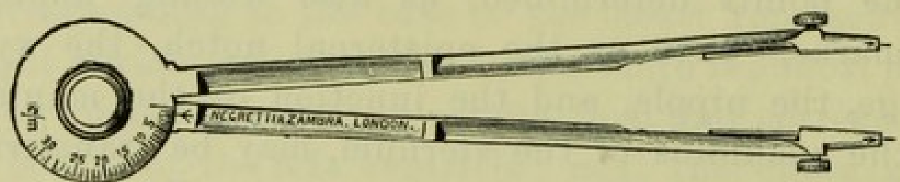


FIG. 15.

measurement, as also to note angles of the figure, I have for some years used a cardiac calipers made for me by Messrs. Negretti and Zambra, of London, which is marked on one side of the hinge disc in centimetres and on the other in degrees. It may also be used as an æsthesiometer (Fig. 15).

Measurement by these calipers is more exact than by other means, because the length of the chord only of that segment of the rounded thorax covering the area of cardiac dulness is noted. The calipers may likewise be transformed into a perfect plessor by a rounded band of india-rubber

FIG. 16.—Plessor and ring pleximeter in use.

placed transversely round the disc and used with a ring pleximeter, constructed for me several years ago by Messrs. Arnold and Sons, of Smithfield, which has a plate of rubber on the surface to be struck. With the ring pleximeter the palpating finger does not altogether cease to feel the resistance of organs percussed. After use calipers, pleximeter, and rubber ring may be conveniently arranged together so as to be carried easily in a watch pocket.

Whatever method be pursued in determining the dimensions of the heart by percussion, it is of the first importance that the posture of the patient should, so far as possible, be exactly the same on successive occasions when this point is under examination. For, the influence of gravitation is exaggerated by increase of weight in the textures or contents of the heart, and displacement of the organ from these causes shows notable difference on percussion, which, it is conceivable, might lead to erroneous conclusions as to its actual size. These differences, although discernible in kind, are evident in a less degree in normal hearts acting vigor-

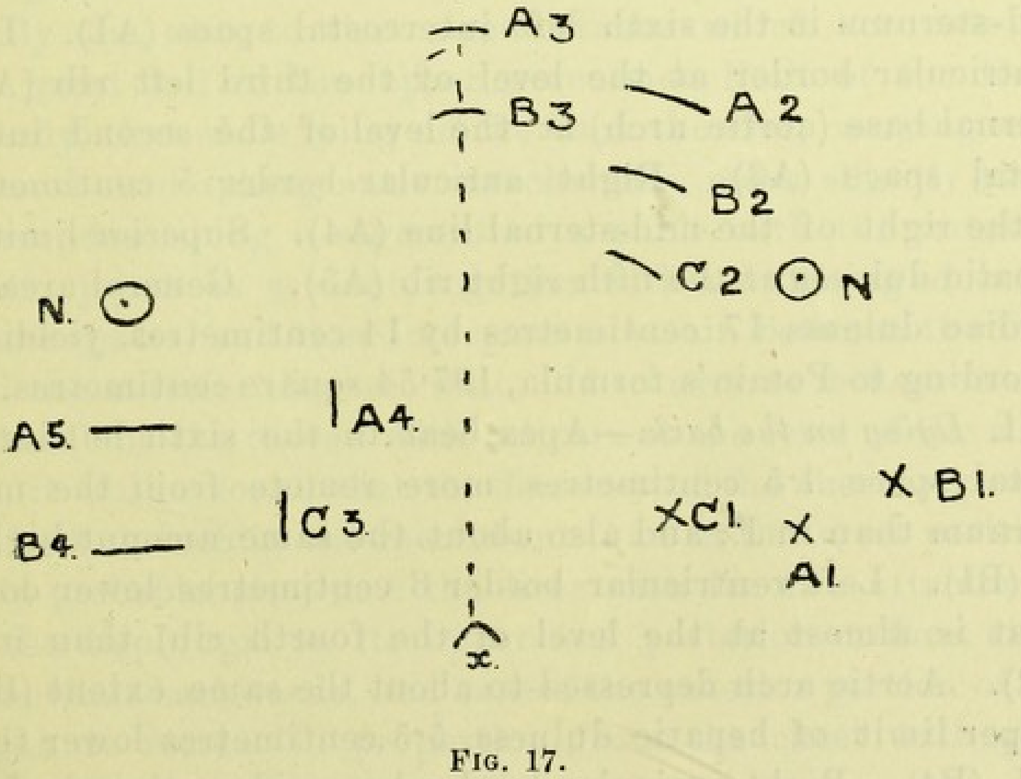


FIG. 17.

ously than in those enlarged by hypertrophy or dilatation or enfeebled in action, and some of them, as I shall again mention, are superficial and fallacious, and due to skin, not heart, movement.

To illustrate this important point I shall mention some particulars of a case which came under my care at the St. Marylebone General Dispensary, not because it was in any way singular, but because it was peculiarly well adapted for demonstration. Dr. Forbes Ross, of London, was present, and made the diagram (Fig. 17) from my percussion, satisfying himself at the same time of the correctness of the points noted.

J. B., a tall, spare bricklayer, 62 years of age, who, without previous history of important disease, had been ill for four months, consulted me on August 22nd, 1896. He had not abandoned work, but complained of great breathlessness on exertion. His respiratory rate was 36 in the minute after slight exertion, but his lungs were not otherwise diseased. The physical examination of his heart by percussion gave the following results :—

I. *Standing up.*—Apex beat 11·5 centimetres from the mid-sternum in the sixth left intercostal space (A1). Left ventricular border at the level of the third left rib (A2). Sternal base (aortic arch) at the level of the second intercostal space (A3). Right auricular border 5 centimetres to the right of the mid-sternal line (A4). Superior limit of hepatic dulness at the fifth right rib (A5). General area of cardiac dulness 17 centimetres by 14 centimetres, yielding, according to Potain's formula, 197·54 square centimetres.

II. *Lying on the back.*—Apex beat in the sixth left intercostal space 1·5 centimetres more remote from the mid-sternum than in I., and also about the same amount higher up (B1). Left ventricular border 3 centimetres lower down (that is, almost at the level of the fourth rib) than in I. (B2). Aortic arch depressed to about the same extent (B3). Upper limit of hepatic dulness, 5·5 centimetres lower than in I. (B4). Right auricular border less evident than in I.

III. *Lying on the right side.*—Apex beat under the sixth left rib cartilage 7·75 centimetres from the midsternal line, that is, 3·75 centimetres nearer the middle line than in I., and 1 centimetre higher (C1). Left ventricular border 3 centimetres lower down than in II., and 6 centimetres than in I. (C2). In III., the auricular dulness to the right of the sternum was more evident than in I., and much more than in II. (C3).

It will be observed that the heart swinging round its basal attachment as a centre, describes the arc of a circle with its apex, a movement of this mobile point associated with a notable change of shape of the figure of the area of cardiac dulness obtained by percussion, but quite unassociated with change in the volume of the heart. The patient was submitted to no exercises before examination.

To this subject I shall have occasion to refer in discussing the question of cardiac shrinkage after baths and gymnastic exercises.

The mobility of the heart and its retreat in the recumbent position from the chest wall, no doubt in part account for the percussion differences in that position, but these are partly due, also, to that circumstance which accounts for the great fall of the upper percussion limit of the liver, namely, that while lying on the back the ribs, carrying with them their diaphragmatic attachments, move slightly headwards, describing a segment of a circle with the vertebro-costal joints as a pivot, together with a widening of intercostal spaces, and thus interpose more air between the liver and the anterior thoracic wall. If transverse measurements be made of the thorax with calipers at the level of the sixth rib, it will be found that the diameter of the chest is greater by half an inch in the recumbent than in the erect position. It is probable, also, that the liver with its firm attachment to the diaphragm on its upper and posterior surface, sinks somewhat backwards, and causes the anterior portion of the organ to retreat in proportion from the chest wall when a man lies upon his back.

Inspection, palpation, cardiac and arterial, and percussion, therefore, afford information in cases of cardiac failure as regards the size and situation of the heart, the equability or otherwise of its action, the competency of the guards at the great vascular orifices, and, in some measure, of the working force of the organ. But there is yet another means of estimating the force of the heart in a given case, namely, the sounds generated by the organ during its action, and audible on auscultation.

SECTION III.

AUSCULTATION.

To appreciate the value of cardiac auscultatory sounds in the diagnosis of cardiac failure as apart from heart disease, it is necessary to have a clear perception of their causation, even more than in the determination of gross lesions. It is generally agreed that the second or diastolic sound of the heart is due to tension of the closed semilunar valves and to vibrations in the aortic and pulmonary arterial blood-columns so engendered. As, however, the diastolic pause is largely a passive interval, it is chiefly by indirect inference that we can come to a conclusion as to the significance of changes in that period of the cardiac cycle for failing action of the heart.

The event itself is second in time, and changes in it, important chiefly in so far as they reveal the condition of those circumstances which produce the first sound.

The great driving force of the heart is systolic, and therefore related to the first sound of the heart. With regard to the generation of this phenomenon no such accord prevails as in the case of the second sound, and some discussion of the point is desirable.

The chief theories which have been advanced to account for the production of the first sound of the heart are :—

1. That it is due to impact of the organ against the thoracic wall.

2. That it arises from vibrations caused by tension of the

valvular apparatus of the heart or of these and vibrations in the fibres of the heart muscle rendered tense by action.

3. That it is caused by the contraction of the muscular fibres of the ventricles.

4. That it is due to impact and vibration in the blood itself.

5. That more than one of these factors are concerned in its production.

That it is not due to the first cause suggested is shown by the presence of the first sound when the chest has been opened during life, and in those rare cases of ectopia cordis in which the organ is uncovered from deficiency in the thoracic wall.

As to the second theory, Brakyn's experiments with the apparatus, described in the *Lancet* for November, 1849, in which air was made to circulate through the heart instead of water or blood, proved that tension of the auriculo-ventricular and aortic semilunar valves produced sounds like those of the normal heart. But in concluding that the first sound was caused by tension of the auriculo-ventricular valves, because no first sound resulted when the apparatus was so modified that these valves could be seen through the top of the auricle, which communicated with the open air (a wire cage being placed in the atrio-ventricular orifice to prevent tension of the mitral cusps), he erred, as, under these circumstances, the *vis a tergo* necessary for the required tension of the medium (air) circulating through the heart, was absent.

That the *bruit musculaire* or muscle sound could not be regarded as producing the first sound was conclusively proved by Dr. George Britton Halford (*The Action and Sounds of the Heart*, p. 25, 1860), who showed that in the case of large dogs, when blood was prevented from entering the right heart by closing the venæ cavæ with bull-dog forceps, and the pulmonary veins by compression with the fingers, the heart sounds could be extinguished or produced at will, according as blood was prevented from entering or allowed to enter the heart. I have myself moreover ascertained that the eviscerated turtle's heart yields no sound on contracting when empty of blood or other fluid. Dr. Halford's view, however, that the first sound of the heart is due to tension of the auriculo-ventricular valves, is not proved by him in his essay, because he did not destroy the aortic and pulmonary sigmoid valves. Had he done so, and still found the first sound present, he would have proved his point, but this he did not.

Halford's experiments were frequently performed before responsible and well-known members of the profession, whose names are mentioned by him, including that of Dr. Marshall Hall (*op. cit.*, p. 25), and there seems little reason to doubt the essential truth of the important conclusion that, in the absence of fluid in the chambers of the heart, there can be no sound. Halford's conclusion upon this point has been disputed by some continental physiologists, including the late Carl Ludwig, the revered Master of the Leipzig School, but an examination of their experiments and reported results has failed to convince me that the countryman of Harvey was wrong and the Germans right.

More recently Drs. Yeo and Barret (*Journal of Physiology*, Vol. vi., p. 145) satisfied themselves that Halford's experiments did not bear the interpretation he gave them, and concluded that muscular contraction was the essential cause of the first sound of the heart. As, however, they did not carry out Halford's method in its entirety, not having occluded the pulmonary veins at the same time as the venæ cavæ and azygos major, their experiments and results cannot be accepted in refutation of his views. They did succeed in greatly diminishing the audibility of the first sound even in their procedure.

Finally, that more than one factor may play a part in the production of the first sound may be admitted, without diminishing the importance for clinical purposes of the cause assigned for this phenomenon by Sir Richard Quain, to which I shall refer presently.

Dr. Arthur Leared, formerly Physician to the Great Northern Hospital, in his *Essay on the Sounds Caused by the Circulation of the Blood* (London, 1861), contends that "All sounds formed in connection with the circulation are produced by and in the blood itself and their mechanism is virtually the same" (p. 1). He sets himself to prove (p. 2) that rapid movements of a fluid produce sounds independently of any action such as friction or vibration upon the vessels in which the fluid is contained. His explanation of the first sound is that:—

"Blood having been forcibly driven from the ventricles into the aorta and pulmonary artery, comes into forcible contact with blood in these vessels, which, supported by the semilunar valves, had attained a state of momentary repose. The impact between fluid in motion and that in a state of rest gives rise to the sound" (p. 9).

His general conclusion is that "vibration of valves or of other structures when in contact with blood has no more to do with the sounds of the heart than the vibration of a door with the sound produced by air through its key-hole. The sounds are due in the one case to rapid motions in the air itself, and in the other, to rapid motions in the blood itself" (p. 22).

Sir Richard Quain's view is that the first sound of the heart is caused by the powerful impact of the blood, projected with a spiral or rifle-like movement against the semilunar valves of the aortic orifice bearing the weight of the aortic column of blood, the sound being the result of this forward movement being resisted by the closed valve and the said aortic column.

So long ago as 1852 he expressed this view in a paper read before the Harveian Society of London, and I have reason to believe that continued reflection for more than forty years has not caused him to change his opinion. In repeating some experiments to prove this point recently undertaken, he did me the honour to ask me to assist him, and we found that if the mitral valve were destroyed the coronary arteries ligatured, a tube inserted into the aorta and the heart filled with water by way of the pulmonary veins, both sounds of the heart could be produced on alternately compressing and relaxing the left ventricle as in systole and diastole. We found also that if the aortic valve were destroyed, these sounds could not be elicited, and were replaced by a regurgitant bruit. What applies to the left applies also to the right ventricle. I have known the heart sounds to be clear and normal in a case of malignant endocarditis under my care at the Great Northern Central Hospital in which both mitral and aortic valves were much diseased, and the heart feeble and beating at the rate of 150 a minute. After death the right heart was found to be healthy and had evidently produced both sounds, their clearness being probably due to increased tension in the pulmonary circuit from the pronounced failure of the left ventricle (Figs. 18 and 19). Adopting, therefore, Sir Richard Quain's view of the causation of the first sound of the heart, it is manifest that, excluding such a source of fallacy as existed in the case I have just mentioned, or an excessive thickness of thoracic wall, there must be a certain diagnostic value for cardiac failure in the audibility of the first sound taken in connection with the general state of the arterial circulation. What I have said with regard to the diagnosis of cardiac failure by the other clinical methods, applies with equal force to auscultation, namely, that a correct estimation for particular cases depends upon the knowledge of an average pitch of sound in these cases. This is an especially interesting point in connection with morbid sounds originated at the cardiac orifices. These, although by no means diagnostic of the amount of lesion, and with such we are not at present concerned, certainly have a relation to the degree of force with which blood is projected through the cardiac orifices, and are of diagnostic value in this connection for the force of the ventricle, provided care be taken, while the patient is under examination, to place him on successive occasions in the same position. It may be stated generally that in

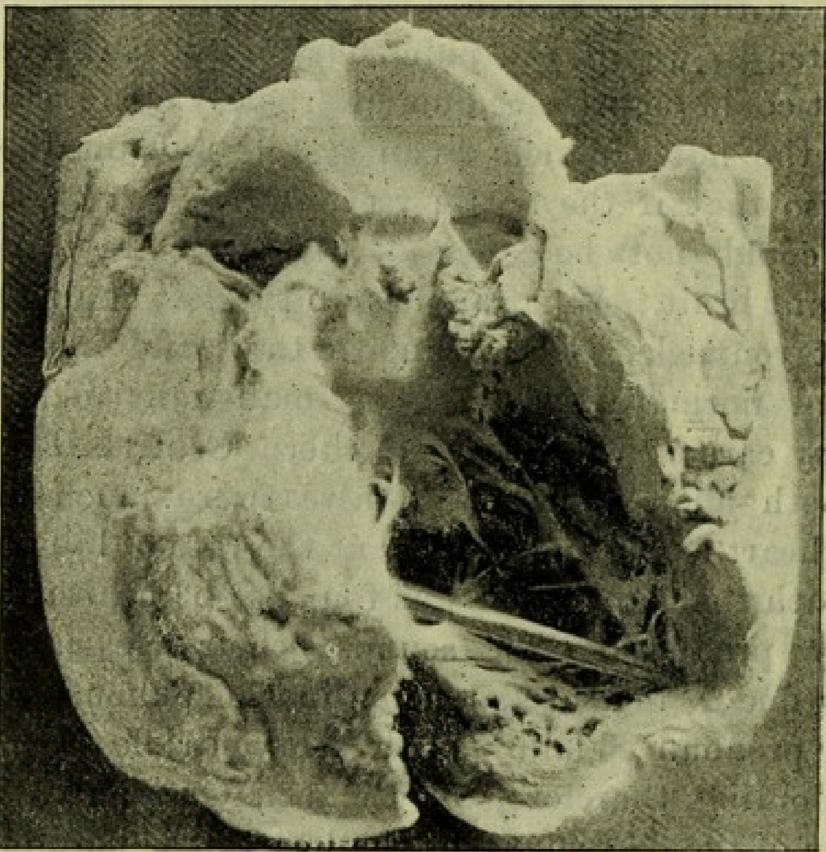


FIG. 18.—Left ventricle and diseased aortic cusps.

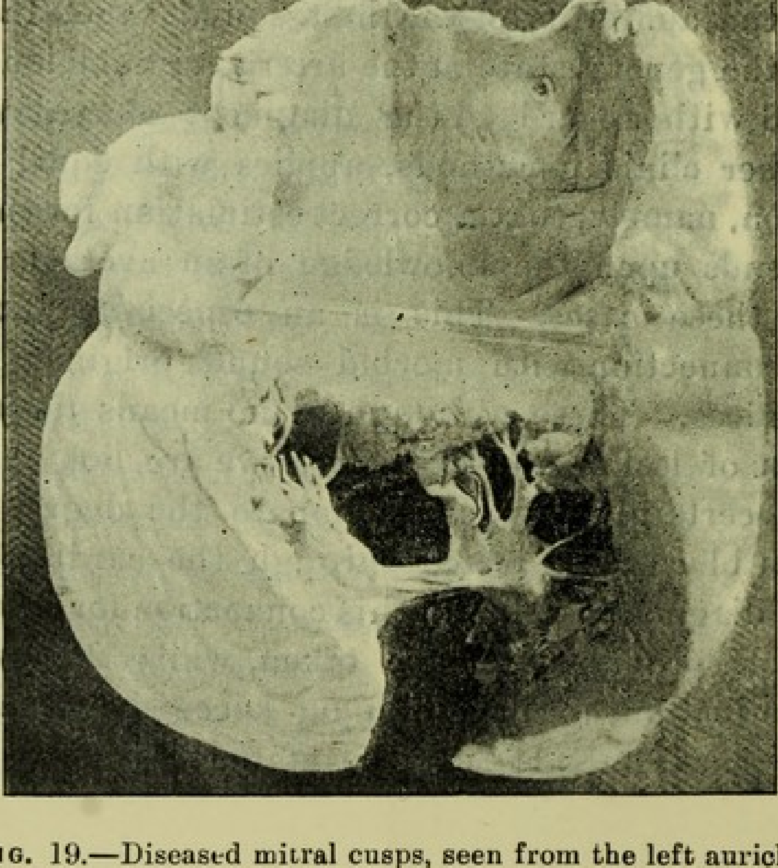


FIG. 19.—Diseased mitral cusps, seen from the left auricle.

pronounced organic lesions which have reached their ultimate development, the louder the bruit, the greater the force of the ventricle and *vice versa*. In the case of incompetent bruits due to dilatation, and which vary with the capacity of the ventricle, there is greater variability of tone and more difficulty in fixing the average note. When the bruit of cardiac disease reaches a distinctly musical pitch, however, its average may be recorded by comparison with a musical instrument, and variations in its tone are then easily remarked. Thus a case of aortic obstruction in an elderly lady was associated with a musical systolic bruit closely resembling B flat in the treble on the piano, and diminution in the distinctness with which this note was heard was always associated with other signs indicative of failure in ventricular force. In a case of aortic regurgitation with musical bruit, which I mentioned in my paper on "The Blood Pressure in Angina Pectoris" (*Edinburgh Hospital Reports*, 1895), the bruit was always nearly obliterated during a paroxysm of angina and was associated with accentuation of the pulmonary second sound. As the syncopal state passed off, the bruit gradually reached its habitual pitch and the pulmonary arterial accentuation subsided. A tuning fork, or as in the case I have mentioned a piano, suffices for registering the habitual note in such cases, but, so far, the ear and memory of the physician alone can register the average note and average force of most hearts, accompanied or not, as the case may be, by bruit. The stethoscope in cultivating his perception and judgment of sounds, and in enabling him to estimate the cardiac force, is a true type of a clinical instrument of the first rank.

I have laid particular emphasis upon this point, as my own experience has convinced me of its value, and I have occasionally observed its importance to be underrated. It is of especial importance in connection with the treatment of heart disease by baths and exercises, the action of which has been compared by those who have had much experience of these methods with that of digitalis.

We are not here concerned with the diagnostic value of certain heart sounds for particular lesions, but with those indicative of cardiac failure, and a practical essay like the present upon that subject demands some consideration of true and false multiplication of the heart sounds, although the subject is still enveloped in considerable obscurity. Those who have written upon the subject have in many cases prudently avoided entering upon the disputable normal and pathological physiology which underlies these signs, but some consideration of this is necessary to an intelligent definition of the terms themselves. Dr. Gee (*Auscultation and Percussion*, 1893, p. 152) quotes Schafer as having been the first to note precisely the relation in time of physiological reduplications of the heart sounds to the movements of respiration, and an examination of this question without reference to the latter would resemble *Hamlet* played, if not without the Prince of Denmark, certainly without the ghost. Schafer determined that reduplication of the first sound occurred at the point at which expiration passed into inspiration, and reduplication of the second sound when inspiration passed into expiration. The following sphygmogram taken during forced respiration will bring out these points more clearly and also show the effect of respiration upon the systemic arterial blood pressure, a subject to which we must recur when considering the respiratory evidences of cardiac failure.

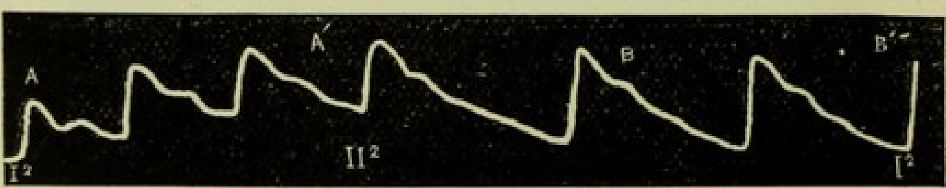


FIG. 20.

In Fig. 20 a to a^1 is the ascending inspiratory series of reduced arterial waves and b to b^1 the descending series of larger pulsation which are associated with expiration. a and b^1 mark the situation of reduplication of the *first* sound of the heart and a^1 b that of the second sound. In other words, when the pent-up repletion of the pulmonary circuit is about to relieve itself into the systemic arteries the pulmonary and aortic cusps ring a consecutive note on *closure*; and when expiration, which favours systemic propulsion, ceases and is about to pass into inspiration, which tends to retard it, the propulsive act of the ventricles meets with more difficulty. It may be objected to this argument that the whole of it is vitiated by an unproved theory of the causation of the sounds of the heart, but this evidently depends upon a consent between writer and critic as to the fact. Being convinced myself of the essential correctness of the theory propounded by Sir Richard Quain, I may be permitted to regard these statements as to the cause of reduplication as resting upon evidence fortifying the conclusions arrived at.

The occasional reduplication of the heart sounds is, of course, of little clinical importance, and, especially in children, may be perfectly physiological, but a protracted or permanent presence of such reduplication is significant of a temporary or permanent abnormality in the condition of the circulation. The clinical significance of protracted reduplication of the first sound has in my experience appeared to be that there is a prolongation of the state of systemic arterial repletion, virtual or actual, coupled with a spurious form of high tension. The ventricles do not act energetically enough to propel the blood in the arteries with normal force. This need not necessarily be associated with actual retardation of pulse, but with an insufficient effect of each ventricular systole. Thus a severe case of typhoid fever, barely convalescent, which was under the care of my colleague Dr. Beevor at the Great Northern Central Hospital,

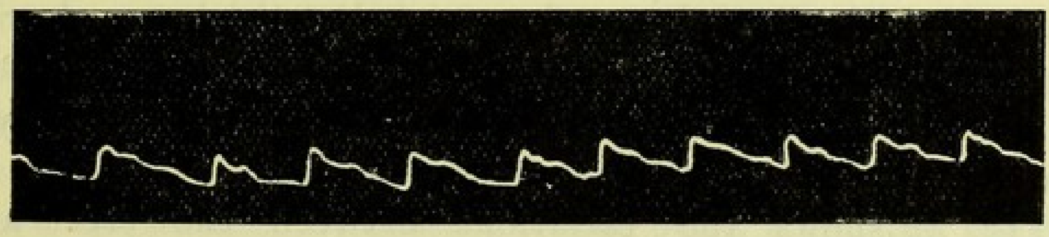


FIG. 21.

and which I saw in his absence, manifested this sign for a considerable period. The foregoing sphygmogram of his radial pulse shows the spurious high tension to which I have referred (Fig. 21).

Protracted reduplication of the first sound of the heart may be regarded in cases of cardiac failure, therefore, as an indication of a propulsive rather than obstructive difficulty in the circulation. It is maintained, as will be explained presently, that the condition is one of hyposystole or hemisystole.

Reduplicated sounds heard chiefly at the apex and associated with recognised bruit, open up the contentious field of false reduplications or split murmurs. That they are influenced by position, that is gravitation, is, I think, certain, and in the description of the "cantering" bruit, *bruit de galop* or triple rhythm, it would be well if the physical signs in the erect and recumbent positions were always recorded. Indeed, attention to this point in all investigations of the hydraulics of the circulation and sounds emitted by the circulatory blood, would, I believe, tend to elucidate many controversial points in the physical examination of the heart. For example, a girl, 11 years of age, under my care at the Children's Hospital, Paddington Green, the subject of right hemichorea and of rheumatic parentage, had a soft systolic apex bruit of limited range. Whilst erect, there was a closely approximated reduplication of the second sound at the base, the tone of which indicated its origin at the arterial orifices, while at the apex there was no such reduplication and the systolic bruit occurred alone. On lying down, the apex beat moved slightly inwards, the general area of cardiac dulness was somewhat contracted, the same reduplicated sound persisted at the base, physiological in character but for its regularity and persistency, and the first sound, with its systolic bruit, was followed by a cantering reduplication. There was no thrill.

Fig. 22 shows the variations between the erect and recumbent positions—*a* and its numerals indicating the position and percussion outlines of the heart in the erect position, and *b* and its numerals the same on lying down.

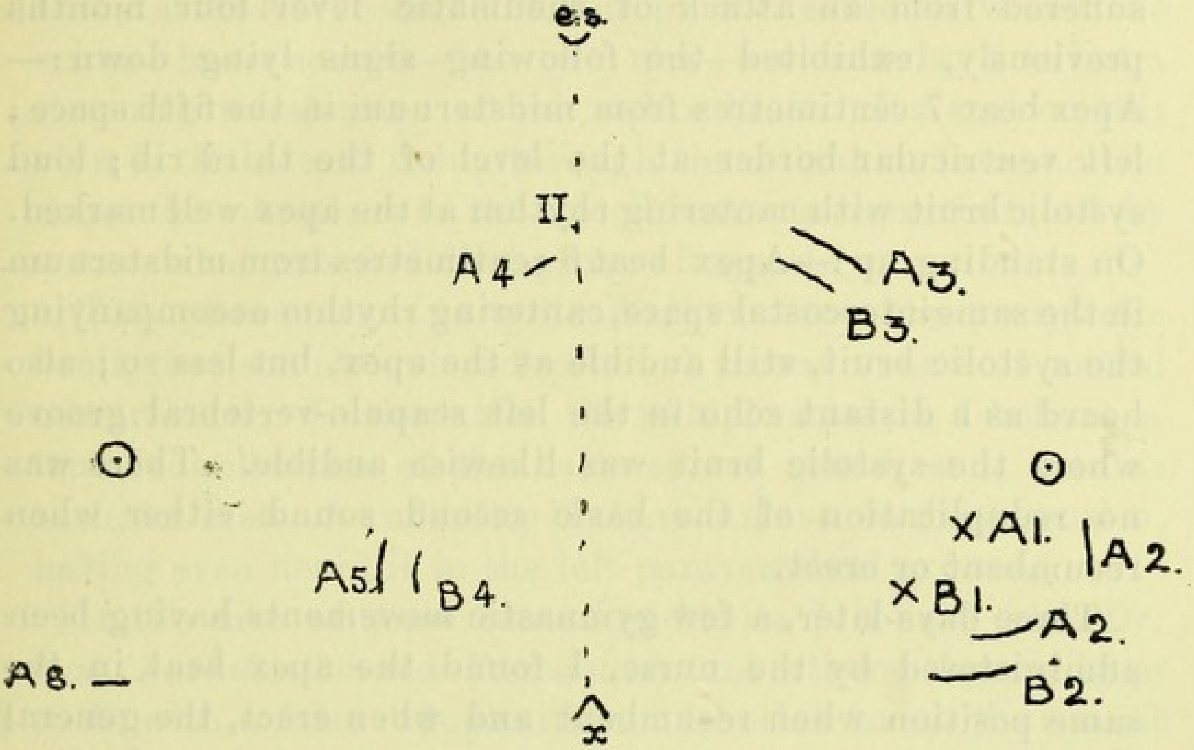


FIG. 22.

The transverse or centrifugal movement of physical points observed in examining the heart has not the same significance as longitudinal movements marked upon the skin of the chest. When the latter alter their position within certain limits—half an inch or so, the apparent displacement may only be due to the different position of the skin in the erect and horizontal position. The heavy skin supported on the loose subcutaneous textures slides downwards, carrying with it the markings upon it.

The tone of the apex reduplication was not the same as that of the basic reduplication, which was not in any case audible enough to be heard so far away; it resembled ub-durrub, not the *oob-trip* heard at the base. On resuming the erect position, the cantering sound at the apex at once disappears, the basic reduplication being the same in character and degree in both postures.

While modified by posture on the other hand, the cantering rhythm may not quite disappear on standing up, as the following case shows :—Emily M., nine years of age, under my care at the Great Northern Central Hospital, who had suffered from an attack of rheumatic fever four months previously, exhibited the following signs lying down:—Apex beat 7 centimetres from midsternum in the fifth space; left ventricular border at the level of the third rib; loud systolic bruit with cantering rhythm at the apex well marked. On standing up :—Apex beat 6 centimetres from midsternum in the same intercostal space, cantering rhythm accompanying the systolic bruit, still audible at the apex, but less so; also heard as a distant echo in the left scapulo-vertebral groove where the systolic bruit was likewise audible. There was no reduplication of the basic second sound either when recumbent or erect.

Three days later, a few gymnastic movements having been administered by the nurse, I found the apex beat in the same position when recumbent and when erect, the general dimensions of the heart about the same, and no reduplication of the sounds in any position. A week later still, the apex again differed lying and standing, being nearer the midsternal line lower down in the same (5th) interspace. With this variation, the cantering bruit on recumbency reappeared, but less distinctly than at first, and disappeared on standing up. The left ventricular outline also was in the 2nd space when standing and under the 3rd rib when lying.

Now, the tone of the heart sounds is somewhat different under all circumstances when observed at the apex as compared with their note at the base, and in the triple rhythm ub-durr-ub, which resembles the cantering rhythm in some cases, the first ub, on the view of the causation of the heart sounds adopted in this essay, must be attributed to the impact of blood opening the aortic and pulmonary arterial cusps with their superincumbent columns of blood, the last ub to the closure of the same on the cessation of systole, and the phenomenon to be accounted for is the intervening "durr." Preceded as this is, in all cases which I have observed, by a systolic apex bruit, I am inclined to place it at that point in time at which the force of systolic regurgitation is subsiding and the auricular inflow increasing, and that, instead of being a sound in the sense in which the normal heart sounds—the two ubs—are sounds, it is but a churning termination of the reflux bruit. Its seat on this view is the site of reflux through the mitral curtains and its cause the vibrations in the blood currents there induced by a somewhat retarded final phase of systole.

This phenomenon is quite distinct from the presystolic bruit, first sound, and reduplicated second sound of mitral constriction. In the latter, the reduplication is, I believe, a true reduplication of the basic second sound, and, even as such, its area of audibility I have known to be extensive, having even heard it in the left paravertebral groove.

In the case of some cantering bruits I believe with Dr. Gee (*Auscultation and Percussion*) and others that we have to do with a false reduplication. In other cases, the second sound of the triple rhythm has not the character of a bruit as distinct from a cardiac sound, but of a shorter tone sound—a tone reduplication, and explicable on the same hypothesis as the unquestioned first sound which is repeated in a minor degree by a hemisystole or imperfect systole of the heart. Its association in these cases moreover with what has been described as a diastolic shock perceptible by the hand placed over the precordium, points to its ventricular origin. This double shock requires some practice for its perception in some cases, and as Dr. Graham Steel states in a recent paper on the subject (*Practitioner*, Sept., 1896) the tactile sensation may be absent while the auditive is present. It is well in looking for the tactile to forget the auditive sensation, as, with an irregular heart and the heaving impulse of hypertrophy, we may imagine a detection of the late-systolic double shock from a recollection of the triple rhythm of the heart, perceptible to the ear. It may, however, and frequently is present so markedly that there is no room for the play of the imagination. The finger feels the diastolic blow as distinctly though less forcibly than it does the ordinary systole. This tactile sensation which accompanies the triple rhythm audible at the apex in some cases and at some phases of cardiac failure, is an interesting phenomenon to which Potain has given considerable attention (*Clinique Medicale de la Charite*). But it appears to me that the " double jog " perceptible to the hand and described by Hope (*On the Diseases of the Heart,* 1839, p. 198) as a sign frequently met with in cases of adherent pericardium is not unlike the sign later described as associated with the bruit de galop. " It is more distinct," he writes, " when the heart is hypertrophous and dilated; and under these circumstances I have found the jogs correspond with the ventricular systole and diastole respectively, that of the diastole being sometimes nearly as strong as the other and having the character of a receding motion suddenly arrested." In writing thus he was probably influenced by his preconceived notion of the action of adhesions. This jogging motion, he further remarks, " is distinguished from the undulatory movement of fluid in the pericardium, both by its nature, by the exact synchronism of the jogs with the sounds, and by the feeling that the heart, at each systole, *comes in immediate contact with the thoracic walls.*" The italics are mine. It has appeared to me, in examining well-marked cases of triple rhythm associated with diastolic impulse at the apex, that the latter has at times been double, one of the two diastolic impulses being less perceptible than the other. There may thus be the tactile perception of (1) a large systolic impulse; (2) of a much smaller diastolic impulse, and (3) of a still smaller and not so constant second diastolic impulse: Thus, A is the palpating finger shown as raised by the large systolic impulse S, and B the finger having sunk on diastole or towards the end of systole perceiving one (D^1) and sometimes two (D^2) subsidiary late-systolic rather than diastolic impulses. Of the probable cause of the reduplicated apex bruit in these cases I have already written, and, rash as an indication of the tactile mechanism may appear to be, I believe the diastolic impulse or impulses, as the case may be, are due to one or more so called "hemisystolic" or even "hyposystolic" contractions. In one of the cases on which this conclusion is based, there was a short reduplication of the cardiac second sound at the base imperceptible except on careful auscultation, and the apex reduplication not only exhibited a much longer interval, but the late-systolic or diastolic impulses were quite unlike the shock of closure of the sigmoid segments so frequently observed by palpation when the second sound is reduplicated and accentuated.

It is a small diastolic muscular blow which reaches the chest wall and is felt by the finger. It is a "hemisystole" or "hyposystole." A rhythmical hemisystole causing a

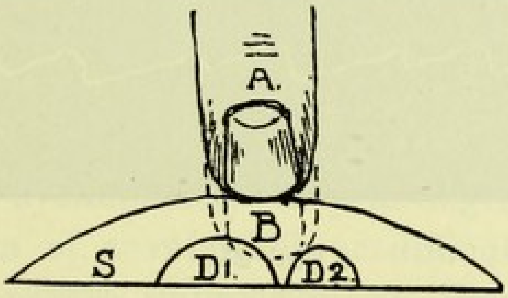


FIG. 23.

quadruple sound may, indeed, under altered conditions of gravitation and pulse rate, break into a canter or become a triple bruit, and a diastolic impulse very easily felt by the hand during the quadruple phase of cardiac action may be still perceptible, but less so, when the triple sound takes its place. I have known the quadruple sound, while sitting or recumbent, become triple on standing up, and the triple sound, while lying, disappear on assuming the erect position. The following sphygmograms (Figs. 24, 25, 26) illustrate these facts.

These tracings are from a long-standing case of mitral reflux and contraction in a woman, 49 years of age (Mrs. B.), under my care at the Great Northern Central Hospital. The quadruple rhythm, lup-a-dup-a, was associated with Fig. 24; with Fig. 25 the rhythm was mixed, but chiefly quadruple, while with Fig. 26 the rhythm was triple, lup-a-dup. On first assuming the erect position after sitting with the quadruple sound in force, the cardiac action was slightly irregular (and such a hemisystolic intermission is seen in Fig. 26), until it settled into a steady triple canter. Similarly, on first

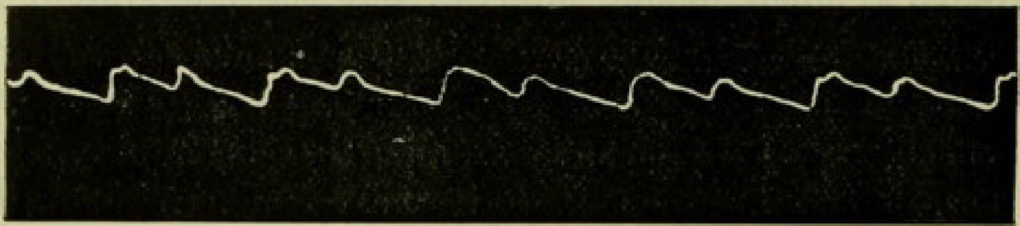


Fig. 24.

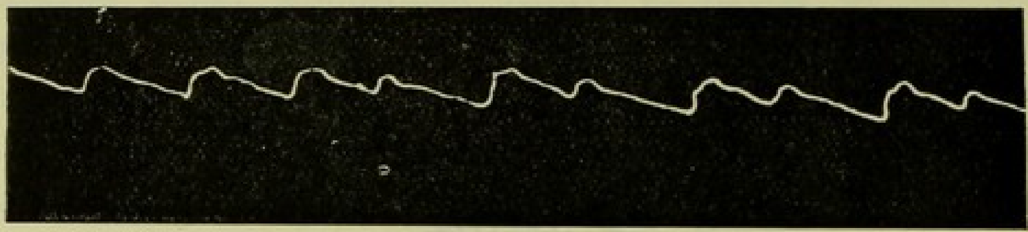


Fig. 25.

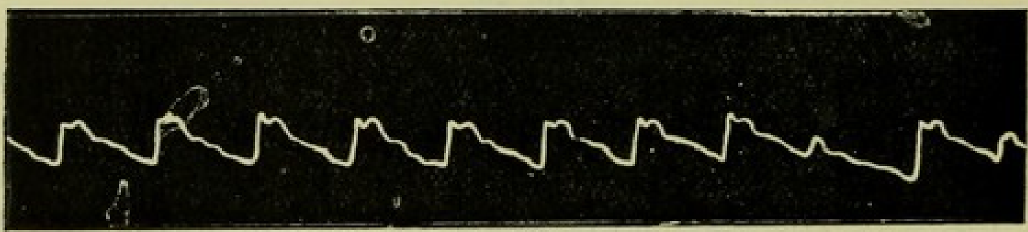


Fig. 26.

sitting down after standing with the triple rhythm proceeding, irregularity marked the transition to the quadruple rhythm. In this case the quadruple rhythm was emphasised by the use of digitalis and modified while taking belladonna.

The following sphygmogram (Fig. 27) is from the case of E. F. S., related elsewhere, in which the triple rhythm was most pronounced while recumbent and usually abolished on standing up.

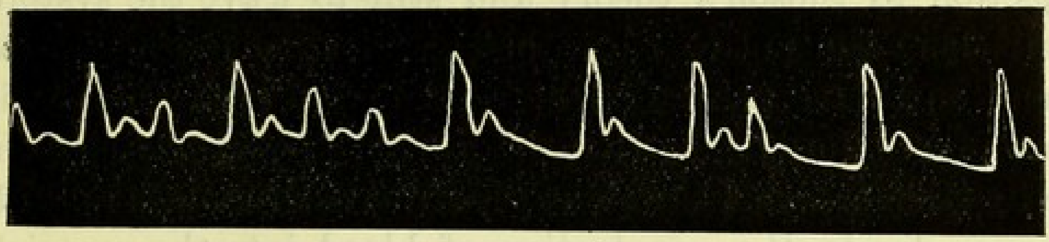


Fig. 27.

The sphygmograms illustrating the case of Dr. W., as well as those illustrating that of E. J. C., were associated with a triple rhythm which was audible but not palpable. Assuming the post systolic or diastolic impulse perceptible in some cases to be a hemisystole sufficiently powerful to reach the thoracic wall, it is not remarkable that in the above cases it should not have been perceived, as the power of hemisystole is usually related to the force of systole, and the latter having been difficult to perceive by touch, the former could scarcely be expected to be felt. Hemisystole, like systole, may vary in degree, and I believe may take the form of a retarded or difficult systole, which need make no separate impression on the sphygmograph. In the case of Mrs. B. both triple and quadruple rhythms were associated with diastolic impulse, but the secondary ventricular blow was most perceptible when the cardiac action was quadruple. The theory of audible and palpable hemisystole on this showing takes the place of Sibson's asynchronous action of the ventricles (*Lancet*, 1874). Potain (*loc. cit.*, p. 45) in the light of later research properly takes exception to Sibson's theory because it postulates a dissociation in the contraction of the two ventricles. He also maintains that the *timbre* of the added *bruit* does not resemble a *claquement* or valvular sound. That the added bruit has a modified note may be admitted, but that its timbre has in some cases a distinct resemblance to a cardiac sound rather than a murmur has been already maintained above. The theory of retarded systole, hemisystole and hyposystole, appears to me to obviate Potain's objection to Sibson's theory and still to leave the systolic ventricle as the active cause of the phenomenon. The explanation I have suggested appears to me also to explain more satisfactorily than that put forward by M. Potain, the tactile signs which I have already discussed. Potain regards these as due to the penetration of blood into the ventricle during the diastolic period, and draws a distinction between the gradual recession of the tonic muscular action of a normal heart in diastole and that of the disabled heart, in which, he maintains, the interstitial fibrous structures of the heart, without the moderating influence of the muscular fibres, are suddenly submitted to the inrush of auricular blood. Hence the diastolic shock (*loc. cit.*, p. 49). This theory resembles that put forward by Dr. Ernest Sansom in his work on *The Diagnosis of Heart Disease* to explain apical reduplication of the first sound (p. 209 *et seq.*). Whether, however, we adopt Sir Richard Quain's theory of the production of the first sound, or prefer to regard it as generated by contracting cardiac muscle (which I believe to be untenable), it appears to me more feasible that the post-systolic shock should be regarded as due to a subsidiary systole than that the walls of the heart should be supposed to flap out against the thoracic wall like a flaccid sail suddenly catching the wind.

I have entered with some detail into this point because it is interesting in itself, and because it has had considerable importance attributed to it as a sign of cardiac failure.

While the cantering rhythm may undoubtedly be met with when compensation is being lost in a disabled heart, it may also, as I have indicated, be produced under other circumstances which merely indicate a transient alteration in the conditions of gravitation affecting the circulation. It cannot therefore be regarded as pathognomonic of cardiac failure unless associated with other phenomena which render this state probable or certain.

The physical signs discussed in the preceding remarks may for convenience be summarised in the following manner:—

Term.	Time.	Cause.
Reduplication.	Second sound.	Asynchronism of sound, from inequality of pressure in the aorta and pulmonary artery.
Triplication.	First and second sounds.	1. Hypo-hemisystole, that is retarded ventricular action accompanied by double sound audible at the heart, but not perceptible by the hand, either at heart or wrist, and not notified on the sphygmogram except by elevation of the dicrotic notch. 2. Incomplete rhythmical hemisystole, that is, shortening of the second diastolic interval in a coupled beat, which is inaudible at the heart. The tactile phenomena are weak diastolic impulse at the apex, absence of bigeminal pulse at wrist, and sphygmographic anacrotism. (Fig. 26.) Phonetically it may be rendered as lup-a-dup.
Quaduplication.	First and second sounds.	Complete rhythmical hemisystole, that is, a perfect coupled beat audible at the heart as a shortened first diastolic pause and second systole (hemisystole) and prolonged first systole and second diastole. This may be phonetically rendered as lup-a-dup-a. The tactile phenomena are more or less forcible apparently diastolic impulse at the heart, and at the pulse the dropped beat may be felt in a lesser degree or not felt, but the sphygmogram reveals the rhythmical hemisystole (Fig. 24). It should be borne in mind that this sign may be induced by the use of digitalis. As Sir William Broadbent states (*The Pulse*) there are cases in which digitalis seems always to induce it.
Arhythmia.	First and second sounds.	Irregularly occurring hemisystole or *hyposystole*, and by the latter I mean a stunted or small, not an abortive systole (Fig. 27) which may be either a hemisystole or a hypo-hemisystole.
Acyclia.	Neither during first nor second sounds.	An intermission in the cardiac cycle, neither systole nor diastole occurring.
Anisochronia.	First and second sounds.	Systole and diastole are both complete, but occur with greater frequency at some periods than at others. It is an irregular occurrence of isochronia or the normal pulse rate, and is usually termed irregular action of the heart. It may be physiological when occurring under the influence of exertion, emotion, or other known stimulation, but when present in the absence of these, is an evidence of nervous instability or loss of muscular power.

The utility of these definitions and terms may not appear to all as subserving a useful purpose. To my own experience they seem rational from the standpoint of our present knowledge, and have proved of service to me in practice. I trust they may do so to others. I have no desire to dogmatise or to regard them as final, but fanciful descriptions such as *bruit de rappel* and *bruit de galop* are only less objectionable than a patronymic nomenclature. We can honour the pathfinders of the past without constituting them a source of confusion to posterity, in an age in which men run to and fro and knowledge is increased at an inconvenient pace; while all must agree with Potain (*loc. cit.*) that approximately correct physiological terms are to be preferred to phonetic descriptions.

SECTION IV.

EXTRA CARDIAC SIGNS OF FAILURE OF THE HEART.

THE evidences of cardiac failure outside the circulatory system proper are not less important than those within it, and the earliest of them in time as well as in importance are manifested in the *respiratory* system. This is so, because the lungs are only second to the heart as organs of circulation. This is not the place to enter into detailed discussion of somewhat obscure problems in the fœtal circulation; but, notwithstanding the anatomical independence of the circulatory apparatus of the mother and child, there is evidence that pressure in the former is not unfelt in the latter. In the fœtus the chief source of blood supply to the heart is from the higher level of the umbilical vein on hydraulic principles, for even in placenta prævia the maternal source is always higher than the circulatory apparatus of the secondary organism, and it cannot be maintained that the fœtal heart is capable without assistance of driving blood along the frequently very long umbilical arteries and frequently very large cake of the placenta on to the right heart without the co-operation of favouring circumstances. The chief propelling force is at this time the right ventricle, which lies in the course of the principal blood stream, although both ventricles are necessary to propel the blood through the difficult vascular system of the fœtus. The blood supply from the umbilical vein being constant and sufficient, little pressure is felt in that mere diverticulum of the circulatory apparatus under the circumstances—the pulmonary circuit. Hence the comparative quiescence of the latter in utero. When respiration is established, and the circulation through the cord arrested, a powerful and rhythmical aspirative force begins to exert itself upon a limited quantity of blood in a perfectly closed circuit. While therefore there is, as some have said, neither air nor a vacuum in the circulation, there is both air and a vacuum around the circulatory apparatus capable of very materially modifying conditions of pressure within it.

Germe (*Recherches sur les Lois de la Circ. Pulmonaire*, 1895) has shown that the lung removed from the body and placed in vacuo with adjustments to its vascular inlets and outlets, and also when directly inflated per tracheam, attracts fluids by way of the pulmonary arteries and allows them to escape by way of the pulmonary veins. A sphygmographic study of the question teaches the same lesson. Towards the end of inspiration the systemic arterial pulse-wave is diminished in size, and the predicrotic evidence of increased arterial resistance is clearly shown by a diminution in the waves and a blunting of their apices. At the commencement of expiration, on the other hand, the size of the *systemic* arterial pulse-waves is increased and predicrotism falls, leaving a sharpened wave summit due to lessened arterial resistance and a greater ease of propulsion in the systemic vessels. It is of course impossible clinically to manipulate the *pulmonary* arterial system, but the collapse of venous channels near the thorax during inspiration shows that the converse is probably true as regards it. The following sphygmograms illustrate this point:—

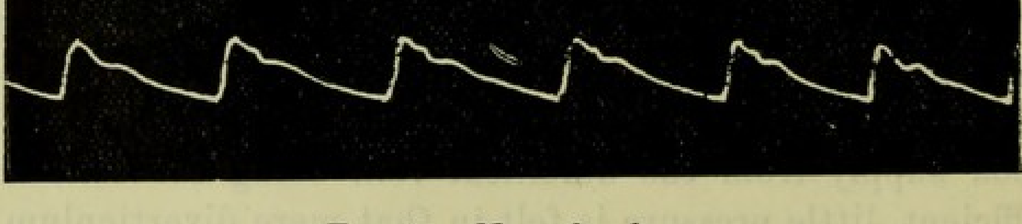


FIG. 28.—Normal pulse.

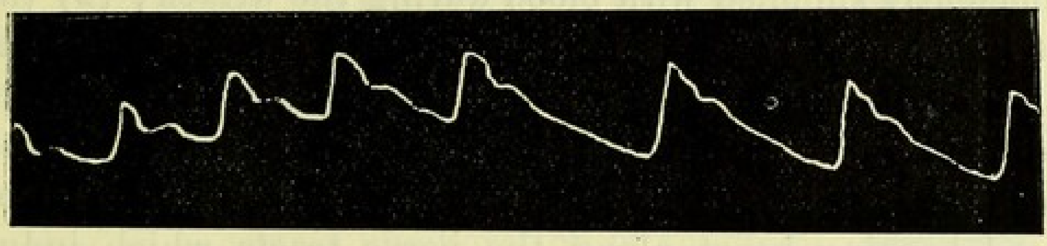


FIG. 29.—Pulse during forced inspiration and expiration.

It is not, therefore, a matter of surprise that a degree of dyspnœa, especially on slight exertion, should be one of the earliest evidences of cardiac failure, and that a very pronounced degree of this should manifest itself under circumstances of more sustained effort in these cases; and that, moreover, in more pronounced conditions of cardiac failure, the respiratory efforts of the patient, even without active exertion, should frequently amount to orthopnœa. Cardiac dyspnœa is but a pathological exaggeration of physiological sighing. What is its mechanism? The answer to this question has an important bearing upon treatment, and especially upon treatment by baths and exercises, and deserves careful consideration.

The hydraulic conditions of the fœtus having been transformed into those of the aërial being, in whom pulmonary action has taken the place of the steady inflow from the maternal source, it is reasonable to believe that stimuli originating in the heart should be transmitted along the accelerant fibres of the pneumogastric nerve so as to provoke that acceleration and exaggeration of breathing which physiologists have experimentally shown to result from stimulation of that nerve. (Foster, *Physiology*, p. 336.) Inasmuch, therefore, as the sufferer from cardiac dyspnœa may stand upright, walk about, and be perfectly conscious; and inasmuch, also, as careful examination of his chest may reveal no signs of pulmonary œdema, or of congestion other than a transient rise of tension in the pulmonary circuit, chiefly marked by an accentuation of the second sound of the heart in the area of the pulmonary arterial orifice, we are forced to conclude (1) that his respiratory centre may be sufficiently supplied with blood during the attack; (2) that his lungs may not be so involved as in themselves to be a cause of dyspnœa ; and (3) that the essential cause of his "difficulty of breathing" is the provocation of the adjuvant mechanism of respiration, by impressions transmitted from the labouring heart along the nerve tracts which induce exaggerated respiration. After having come to this conclusion, in a paper which I read before the North London Medico-Chirurgical Society in 1896, I found a reference to some observations of Dr. D. B. Lees in the *Lancet* for October, 1893, in which he propounded a somewhat similar theory, limiting his remarks to a consideration of the dextro-cardial section of the circulation; but there seems no reason why, in the case of an initial stimulation of the left heart from abnormality in the conditions of blood-pressure within it, there should not, also, be a reflex provocation of respiration. While the essential mechanism of cardiac dyspnœa may thus be regarded as a cardio-respiratory reflex, this in no way minimises the importance of the hæmic factor—that excessive accumulation of blood in the chambers of the heart, which is excitant of the nervous mechanism referred to. To this I shall refer again when discussing the treatment of the condition. In connection with cardiac failure, no phenomenon is of greater interest and sometimes of graver import than the rhythmical variation in breathing known as Cheyne-Stokes respiration, but which might better be termed tachy-bradypnœa to avoid the objections to a patronymic nomenclature. Few clinical signs are more striking than it, and few have elicited so much ingenuity in attempts to explain it. Those desiring an exhaustive historical review of the subject cannot do better than consult the excellent monograph on the subject by Dr. G. A. Gibson, of Edinburgh. No theory advanced in explanation of it has found general acceptance. The factor common to cases observed by myself has been exhaustion, and some consideration given to the subject inclines me to believe, that the excitant to the intermittent pulmonary effort to aid the circulation is called forth, on a certain stage or acme of cardiac discomfort being reached; and that the long pause which follows this intermittent effort is due to a certain amelioration of thoracic discomfort thus attained, the exhausted sufferer requiring a rise in the urgency of his distress to recur before he can be roused by reflex action, or by this combined with voluntary effort, to make a fresh attempt to re-establish the balance between the pulmonary and cardiac factors in the circulation. Sleep with its blunted sensibilities may be observed to exaggerate this phenomenon, or to induce it when absent while awake. The accompanying pneumogram from a paper by Drs. Hutchison and Elder in the *Edinburgh Hospital Reports* for 1895 is a good graphic representation of this sign. The small undulations in the bradypnœic intervals are due to cardiac pulsations transmitted to the epigastrium on which the receiving tambour of the apparatus was placed.

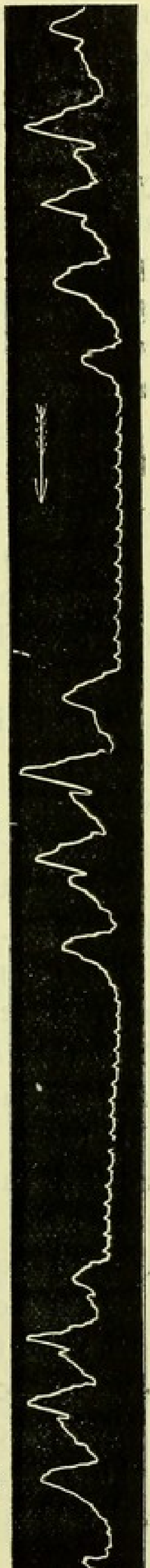


Fig. 30.—Tachy-bradypnœa.

It is only necessary to refer in passing to such grosser phenomena in the pulmonary system as the copious prune-juice expectoration of œdema of the lungs associated with cardiac failure, and the more sanguineous hematemesis due to the same cause, as also to the chronic basic consolidation and moderate emphysema of what has been well termed the "cardiac lung." But there is a point upon which I wish to dwell rather more fully, as it is one which is not yet quite appreciated by clinical writers. It is one which I dealt with in a paper on "Passive

"Congestion of the Lungs from Heart Failure," in the *Practitioner*. The clinical detection of minor degrees of percussion-dulness at the lung bases is sometimes difficult, and the finer crepitation of alveolar exudation may escape notice. The coarser crepitation of unmistakable bronchial exudation is easily discovered, and is practically the earliest auscultatory evidence in the lungs of the abnormal retardation in the pulmonary circuit. This sign, in my experience, in the majority of cases of cardiac failure first manifests itself at the base of the left lung posteriorly, and is, I believe, to be accounted for on anatomical and physiological grounds. The left bronchial veins are more dependent than their fellows on the right, and enter the larger trunks at a point more distant from the right ventricle. Moreover I have found no record of a rhythmical contraction in the innominate vein, such as that which occurs in the superior vena cava; while the valve which guards the orifice of the thoracic duct where it enters the venous system at the junction of the left subclavian with the internal jugular vein, argues the presence of a possibly injurious intravenous pressure in these vessels, uncompensated by any rhythmical propulsive power inherent in the latter. Farther, one of the causes of emaciation in cardiac failure is, unquestionably, impediment to the easy escape from the thoracic duct into the venous system. (*Cf. Twentieth Century Practice*, Vol. iv., p. 661.) Notwithstanding, therefore, the greater size and vascularity of the right lung, we have, I would submit, in the conditions affecting the left bronchial veins, circumstances which account for their earlier manifesting the signs of retrograde pulmonic pressure. Such a conclusion, however, in no way traverses the experience of those pathologists who assert that it is the base of the right lung which exhibits the condition in greatest degree after death (*Wilks' Fagge's Medicine*, Vol. ii., p. 64); nor does it oppose the opinion of those clinicians who aver that it is the same part which usually at last becomes most congested during life. Under normal circumstances the longer course of the right pulmonary veins, and the larger quantity of blood they convey, have the hydraulic advantage of a greater fall than the vessels on the left. But when the patient has been recumbent for a time, and cardiac force has become impaired by general exhaustion, this hydraulic advantage is nullified in great measure by that posture. It is therefore easy to understand how, ultimately, the greater distance of the larger organ from the enfeebled left ventricle (the right continuing to pump the larger quantity of blood into it) renders it more prone to congestion than the left lung. It ought to be remembered, however, that, as Dr. Wilkinson King pointed out (*Guy's Hospital Reports,* Series I., Vol. iii., pp. 175-178), the left lung may permanently take the lead in engorgement on account of pressure exerted by a dilated left auricle in cardiac failure on the blood supply at its root.

Signs in the extra-thoracic venous system.—With failure of cardio-vascular force and tonicity, the inertia of the blood stream tends to assert itself in the venous system, systemic and portal. Upon these well-known effects of cardiac failure it is only necessary to touch cursorily. The liver may in such cases be increased in size in varying measure. Its upper limit may reach above the nipple line (4th space) and its lower edge be felt as low as the umbilicus. In stating the limits obtained by percussion it is well, as has already been stated, to mention the position assumed by the patient during examination, as recumbency may appreciably lower the upper percussion boundary.

Liver pulsation.—The dilated right ventricle may, by pulsating in juxtaposition to the liver, impart a systolic movement to it, but this, as Dr. Sansom points out in his excellent work on *The Diagnosis of Diseases of the Heart and Thoracic Aorta* (p. 122), is limited in great measure to the left lobe. Systolic pulsation may, however, be manifested by the whole organ, and be perceptible to the palpating hand, if the organ be grasped with sufficient firmness.

Such uniform and general pulsation is due to systolic impulse imparted to the column of blood by regurgitation through the tricuspid valves. Of this condition there will usually under these circumstances be other clinical evidences. The pulsation of the liver may be so distinct as to allow of tracings of the movements being obtained. The following sphygmogram is from a case of uncompensated double mitral disease with expansile liver pulsation.

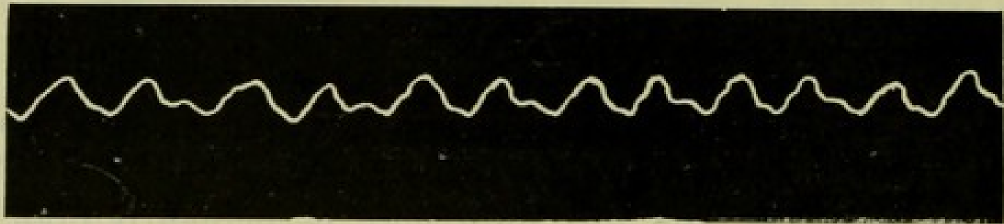


FIG. 31.—Tracing of liver-pulsation.

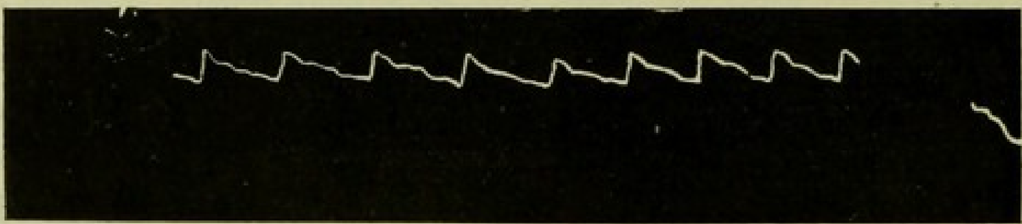


FIG. 32.—Tracing of radial pulse from the same patient.

Increase in the size of the spleen is not so noticeable in cardiac failure as a rule as it is in many cases of the severer strangulation of the portal system, due to cirrhotic changes in the liver, and when present is subsidiary to other retrograde phenomena.

It is remarkable for what a length of time organs with a firm fibrous investment will resist the distensive tendency of back pressure in the venous system. That is to say, distension beyond physiological limits and not transient. The clinical evidence of early passive congestion is most manifest in the case of the kidneys, and may attain all degrees of severity, from the presence of a trace of albumen fluctuating from day to day and between evening and morning, to the secretion of a smoky urine showing blood-casts under the microscope. Serum albumen may frequently be detected in the urine passed in the evening after the blood-pressure exerted by the day's work, and be found to be absent next morning after the night's rest. It is necessary, therefore, to obtain specimens for examination at both periods before coming to a conclusion on this important point. The urine may in cases of severe cardiac failure be much reduced in quantity, and have a high specific gravity, without any trace of albumen being present. While initial stasis in the renal circulation may be marked by an increased flow of urine, it is much more frequently observed that the relief of congestion is followed by more copious secretion. This renders the state of the urinary secretion as regards amount a very delicate index to the condition of the venous circulation, and to the benefit or injury accruing from the use of particular agents employed in cardiac failure. Persistent steady albuminuria is usually a late and grave sign in these cases, but may, and does, entirely disappear on convalescence.

Pressure in the systemic and portal venous system may be so great as to cause effusion of blood into the skin and subcutaneous cellular tissue, and into and from mucous surfaces. In the former situation petechiæ and ecchymoses may manifest themselves, and from the latter severe and uncontrollable hæmorrhage may occur. This is especially so when profuse *epistaxis* is observed in these cases, even when the general pressure in the venous system as a whole is not well-marked. This sign is one which should never be under-estimated when there is any evidence of cardiac failure, as it frequently resists treatment even by complete anterior and posterior nasal plugging, until the patient has lost much blood.

Serous effusion into the subcutaneous textures and into serous cavities is commonly associated with cardiac failure at various stages. It usually occurs earliest in the lower extremities and subcutaneous textures generally, next in the abdominal cavity, and last into the pleural sacs and pericardium. Circumstances which impair the muscular power of the abdominal walls favour peritoneal effusion. It is from this cause that multiparous women, and obese men, the subjects of cardiac failure, are especially prone to the supervention of ascites.

Retardation of the lymphatic circulation.—The emaciation so often observed in cases of cardiac failure coupled with increasing pallor and anæmia is due, in some measure, to the mental anxiety and frequently broken sleep of the patient, but that it is also in no small degree the result of impeded absorption of food and retarded chyle current cannot be doubted. Debouching as the thoracic duct does into the venous system at a point which is subject to very considerable retrograde blood pressure, when the efficiency of the valvular guards in heart and vessels against this state are impaired, it can easily be understood how progressive emaciation, without febrile or other constitutional causes to account for it, may be indicative of cardiac failure, and due to impediment to the flow of lymph into the veins. To this cause, which is not frequently mentioned in this connection, Dr. Dawson refers in his article on "Lymphatic Diseases" in *The Twentieth Century Practice of Medicine*, already mentioned.

SECTION V.

SIGNS IN THE NERVOUS SYSTEM.

Failure in cardio-vascular tone with defective propulsion through the central nervous system may be associated with a general depression of the functions of the body, but the evidence of this is of too general a character to require more detailed treatment. In all cases, naturally, an examination of a patient complaining of such symptoms would be incomplete without sufficient examination of the heart, and an estimation of its force. On the other hand grosser lesions of the central nervous system due to embolism or intracranial hæmorrhage from disease of the cardio-vascular system are not necessarily significant of cardiac *failure*, and therefore do not come within the scope of this book. The more notable signs in the nervous system of cardiac failure may be regarded as phases and consequences of complete or partial syncope with the alterations of blood-pressure due to this cause. *Sleeplessness*, frequently one of the most distressing and dangerous evidences of cardiac failure, is usually associated with other signs of the condition, but its importance should not on that account be overlooked, and we shall learn when we come to examine the general treatment of these cases, that means which affect the cerebrum and cerebellum directly may be the most effectual means also of relieving the conditions of which insomnia seems to be a consequence, not a cause.

Among the more striking nervous phenomena of cardiac failure, but also those requiring careful discrimination from local diseases causing somewhat similar symptoms, are the disturbances of the sense of equilibrium and of hearing at times associated with a failing heart. That the latter condition should cause such auditory phenomena is argued by the fact that these themselves, when of local origin, may give rise to evidences of cardiac failure. The enfeebled cardiac action and profuse perspiration characteristic of some cases of labyrinthine vertigo would lead one to expect that the initiative in the production of vertigo might be taken by the heart. And it is so. The question as to the predominance of the auditory or cardiac factor in these cases is to be decided mainly by three considerations, namely, the presence of other evidences of cardiac failure, the fact that cardiac vertigo is rarely so severe as well-marked cases of auditory vertigo, but may be more severe than many slighter forms of the latter, and finally by the presence or absence of local disease in some portion of the auditory apparatus. Cardiac and auditory conditions producing vertigo may of course be combined. Finally, vertigo due to non-cardiac and non-auditory peripheral causes will be distinguished by evidences of integrity in the heart and ear. What has been said of vertigo applies also to *tinnitus aurium*, which may in some cases of arterio-sclerosis with more or less cardiac failure be a very troublesome symptom. I have known it to be apparently influenced by posture. Encased as the internal ear is in a dense and "petrous" bone, it is admirably protected both from external sources of varying pressure and from pressure due to variations in intracranial blood pressure, but its very immunity from such sources of disturbances appears to enable slight degrees of the latter to produce phenomena out of proportion to their apparent cause.

The more serious manifestations of more or less sudden cardiac failure to which the term syncope is particularly applied, are among the gravest of physiological and pathological phenomena, and the application of the term is more general than may usually be gathered from writings on diseases of the heart. The empty and contracted heart which ceases to act in cases of hæmorrhage, and which may be seen in one of its most tragic forms *post partum*, scarcely comes under consideration at present. The syncopes with which we are at present concerned are the syncopes of inhibition and muscular failure rather than of depletion. I shall shortly refer to them in the following order:—

Complete syncope.
Incomplete and protracted syncope.
Syncopal bradycardia.
Epileptiform syncope.
Syncope anginosa or angina pectoris—
    Of valvular origin.
    ,, myocardial ,,
    ,, exocardial ,,
    ,, neurotic ,,

The suddenness with which *complete syncope* frequently supervenes and terminates in death, as frequently precludes the possibility of the physician observing or treating the condition. It is probable that many cases which have proved fatal might have had another issue had timely assistance been at hand. When the physician has been afforded an opportunity of seeing and treating such cases it has usually been when his presence has been demanded by some other cause, and the syncope has arisen as an unexpected incident. So occurring, when the patient is not under the influence of a narcotic such as chloroform, the patient is suddenly observed to fall down from the erect or semi-erect position and to lose consciousness. The entire muscular system becomes flaccid, and the limbs when raised fall limp to the ground like those of one recently dead. Pulse and respiration cease. No heart sounds can be detected, and the pupils suddenly become widely dilated. This condition prolonged beyond a certain point would pass into and exhibit all the phenomena of death. So grave a condition is easily distinguishable from the emotional syncope or loss of consciousness in which there is no such profound dissolution of the cardio-vascular and nervous systems. In the latter, the pulse, though retarded, has fair strength, and the pupils and muscular system do not absolutely fail to exhibit reflex action. When true syncope is not fatal, the first evidence of returning animation is an attempt at respiration, which becomes fuller with returning circulation, and points to the rational treatment of such an emergency by artificial respiration and the administration of a rapidly acting agent such as amyl nitrite.

But syncope may be *incomplete* and the syncopal state recurrent and protracted. The clinical picture of this condition is one not frequently observed, but is most striking when seen. At short intervals there is a sudden cessation of all pulsation—a complete and prolonged intermission in cardiac action—followed at first by slowly recurring pulsations, 18, 20, 30, 40 times in the minute, followed by another complete cessation of pulse. This syncopal bradycardia may be varied by short periods of more accelerated pulsation up to 60 or 70 in the minute followed again by a complete pause. The patient during these pauses may not lose consciousness and is quite aware of their advent, which he may signalise by an alarmed shouting and attempts at deep inspiration. Respiration generally is accelerated, the adjuvant mechanism of breathing coming to the assistance of the heart. If unconsciousness supervenes it may be associated with an *epileptiform* seizure. These grave symptoms may eventuate in recovery, but frequently the attack recurs and ultimately syncope becomes complete and prolonged, and death closes the scene.

Closely allied to this condition is the *persistent bradycardia* with syncopal attacks accompanied in many cases with epileptiform phenomena which was first described by Mr. William Adams and Dr. Stokes of Dublin, and which M. Huchard has proposed to name Stokes-Adams Disease

(*Maladies du Cœur*). These cases usually terminate fatally by complete syncope. The sphygmogram of such a case is given elsewhere.

The syncopal attacks described may be unaccompanied by pain, the absolute flaccidity of the cardiac muscle and depletion of the cerebral centres apparently allowing easy stretching of the chambers of the heart and blunting of the appreciation of pain. But cardiac failure may be associated with severe breast pang amounting to agony and be fitly described, as it was by Parry of Bath (*Inquiry into Syncope Anginosa, or Angina Pectoris*, 1799), as *Syncope Anginosa.*

It was his experience of the effect of nitrite of amyl in relieving the symptoms in a case of aortic valvular disease with severe heart pang which led Dr. Lauder Brunton to believe that spasm of the peripheral blood-vessels played a leading rôle in the production of such attacks (*Trans. of the Clinical Society of London*, Vol. iii., p. 191). It was my study of a case of aortic valvular inadequacy with severe angina which caused me to think that the essential cause of the attack under these circumstances was a syncope of the central organ rather than an active spasm of the periphery (*Edinburgh Hospital Reports*, Vol. iii., 1895). I found that on the advent of the attack a loud diastolic musical bruit which was present became almost inaudible, while the pulmonary arterial second sound became markedly accentuated. The action of the heart was quickened. As the attack passed off, the pulmonary arterial second sound became less audible, the heart's action slower and slightly irregular, and the musical diastolic bruit returned, being occasionally loud and prolonged, and again soft and short, and then pain passed off. The following sphygmograms show the state of the peripheral circulation under these circumstances.

Fig. 33 shows the attack at its height with a lowering of the predicrotic wave, and a flat drag in the diastolic interval showing that the collapsed and comparatively empty artery had failed to reach the lever of the instrument.

In Fig. 34 the cardiac force is increasing, its action becoming slower, and although blood still fails to reach the periphery in normal abundance, there is a rise in the position of the predicrotic wave and an indication of dicrotism. Pain is still present under these circumstances, but the patient is easier.

Fig. 35 represents the refilled and retarded pulse and the termination of the attack. The normal pulse tracing of this patient with temporarily re-established compensation is shown in Fig. 36.

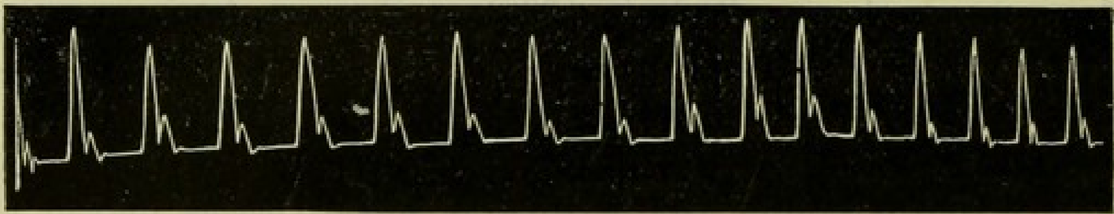


FIG. 33.

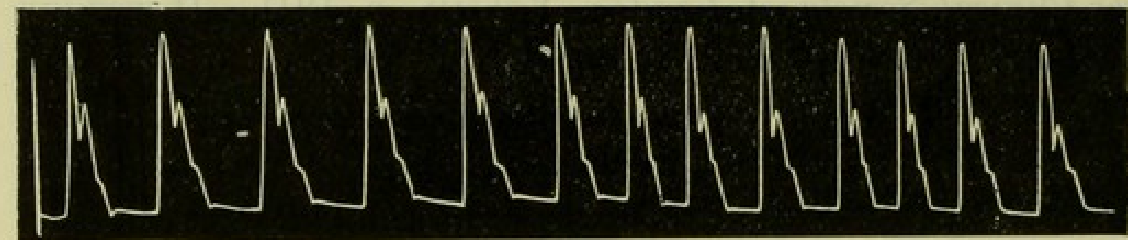


FIG. 34.

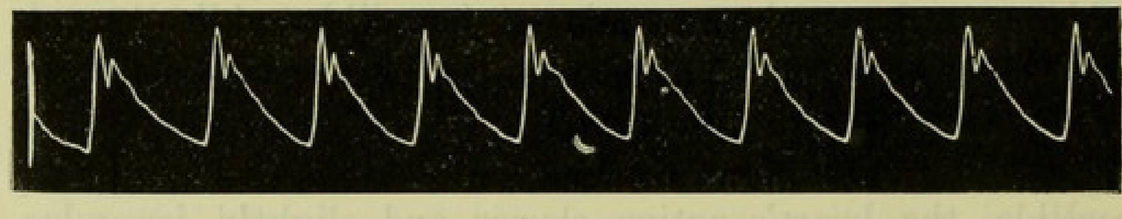


FIG. 35.

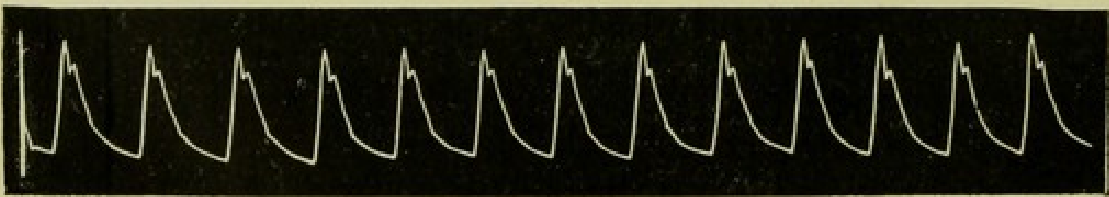


FIG. 36.

It may be argued that although the arteries indicated a fall of blood-pressure there may nevertheless have been an initial spasm of the arterioles. But what evidence is there of this? I know of none, except that a vaso-dilator relieves the heart pang and fills the peripheral circulation with blood. Are the arterioles then alone affected by this agent? The surface, it is true, is flushed. But is not the heart accelerated? Do not the larger arteries pulsate more rapidly and amply? Which then is the prior event? I believe they are almost contemporaneous and believe also that cardiac action is accelerated by direct stimulation and not merely in consequence of peripheral vaso-dilation. Finally, it is sound philosophy not to go in search of a remote cause when a nearer and sufficient one is at hand. What need for a heart labouring under the burden cast upon it by the overthrow of its main bulwark against reflux to require the importation of an assumed spasm in an invisible portion of the vascular system to account for its staggering under its load? May not the intrinsic mechanism of the heart fail suddenly without the aid of the peripheral factor? I believe that it may and that it does. The belief, however, which for a time was wide-spread, that there is peripheral spasm in these cases, is now less prevalent, and even writers who adhere to the peripheral theory in cases of arterio-sclerosis are fain to admit that in cardiac valvular anginas this cannot be always insisted upon (Sansom, *Twentieth Century Practice*, Vol. iv.), while a recent French author (Andre Petit, *Traite de Med.*, by Charcot, Bouchard, and Brissaud, Vol. v., p. 330, 1893) states that the heart is usually accelerated under these circumstances in association with diminished vascular tension.

In classical cases of angina pectoris—those, that is, associated with arterio-sclerosis, it may be with more or less occlusion of the coronary arteries, and usually without other signs of cardiac valvular disease than some atheromatous roughness at the aortic orifice, or some sign of mitral incompetency from ventricular dilatation—the question of an initial peripheral spasm is more difficult to decide. A sclerotic radial artery beating quickly and insufficiently replenished with blood may impart a sense of hardness to the finger which is not truly spastic. Comparative difficulty of compression must be associated with the sense of hardness under these circumstances to establish a spastic state, and in view of the diminished calibre of the vessel it is more easy to obliterate it than under circumstances of greater repletion. An accelerated pulse is of necessity a small pulse whether spasm be present or not. In non-valvular cases, however, especially in those with fatty degeneration of the myocardium, the pulse may be slow, full, and soft, and the obstacle to the blood-flow under these circumstances is not any increase in vascular impediment, but a syncopal failure of driving power. Heberden has asserted that the pulse during the attack may be unaltered, and I have on one occasion seen such a case which had experienced many attacks, taken frequent doses of nitrite, and only improved as regards the frequency and severity of the attacks after a series of baths and exercises at Nauheim. This case was under the care of Dr. Theodor Schott. The uninfluenced pulse is, however, a rare phenomenon, and the question of a possible pseudo-angina must under these circumstances be carefully considered. Whether, however, the periphery or the centre be primarily to blame in these cases, there can be no question that the symptoms are indicative of cardiac failure, that is of a degree of syncope. Professor Gairdner, of Glasgow, has pointed out that small aneurisms pressing upon and irritating the base of the heart are peculiarly prone to induce symptoms of angina pectoris (*Reynold's System of Medicine*, Vol. iv., pp. 544-545). This important clinical fact points to the large share taken by the central organ in the causation of these attacks, and to the condition being in such cases a painful cardiac inhibition or irritative syncope, which may be termed *exo-cardial* angina.

Finally, in the truly pseudo-anginous cases—those, namely, uninfluenced by age, occurring as frequently among women as among men (unlike true angina), and usually subsiding under treatment or with the lapse of time—I have noticed the occurrence of intermission in the heart's action simultaneously with the onset of heart pain. This is not necessarily the case, but when it is observed it must be regarded as an inhibition of the heart, that is as a syncope. Accelerated action, moreover, if at the same time weakened, although free from irregularity or intermission is likewise a temporary cardiac failure—a degree of syncope.

Clinical cardiac neurology is, however, still in its infancy, if indeed it can be stated to be even born, and we are compelled in the meantime to consider the possible significance of clinical phenomena unassisted by accurate pathological research. The physiologist, and more recently the anatomist, have done much to elucidate the relation of the nervous system to cardiac action, but the work of the pathologist in this department is still largely in the future. In the succeeding chapter I have endeavoured to arrive at a working hypothesis of some points in this sphere which have a bearing upon the prognosis and treatment of cardiac failure, and trust the day is not distant when the more systematic and routine examination of the nerves and centres which dominate cardiac and other visceral action will place clinical visceral neurology on a more scientific foundation.

PART II.

THE NEURO-MUSCULAR AND HÆMIC FACTORS IN DISEASE OF THE HEART, AND THEIR BEARING UPON PROGNOSIS AND TREATMENT.*

SECTION I.

THE NEURO-MUSCULAR FACTOR.

The discovery of percussion and auscultation, followed by greater precision in observation and experiment, succeeded in localising valvular insufficiency and obstruction, and fixed attention upon the state of the cardiac orifices. Physicians were thereupon ready to pronounce the doom of patients on the detection of a bruit. Riper experience and further observation brought to light the fact that, notwithstanding the presence of loud bruits, many patients were long able to follow more or less arduous occupations without notable discomfort; and that many active and happy men were quite unaware of the presence of well-marked cardiac disease until it was detected during a general examination such as that for life insurance. The condition of the cardiac muscle, apart from evidences of valvular lesion, then became the paramount consideration, and circumstances affecting the efficiency of this factor the chief concern of the physician. It is upon the neuro-muscular and hæmic elements in the problem that I now desire to offer some remarks as a preliminary to subsequent sections of this work.

* The chapter has been rewritten and altered from a paper published in the *Practitioner* for 1893-94.

The irritability of nervous structures may be normal or average, excessive or deficient. All excess tends in turn to produce a deficit, and any evidence of excessive expenditure of force, of excessive irritability of nervous structure, must arrest the attention of the physician whose duty it is to maintain the normal average in a given case. This is true in the case of every organ in the body. In the vast majority of cases—in all except those of poisoning of the nerve-centres by agents such as chloroform and opium, or except in traumatism and effusions of blood—the road to diminished irritability lies through exalted irritability; in other words the road to exhaustion lies through excessive action, and the result of exalted irritability implies the loss of muscular tone. With the loss of the latter, there is a relaxation of cardiac as of other muscular tissue, a loss which may ultimately be equal in degree, but which, from the peculiarity of the cardiac texture, innervation, and function, usually affects the heart, sometimes sooner, sometimes later than the locomotor system.

In order that we may appreciate aright the importance of the storage of energy, let us consider briefly the physiology of its liberation in living beings. A living organism is never absolutely at rest. It only rests when it dies. Rest, therefore, must be used as a comparative term, and is only a phase of work—of life. Active exertion conceals from most people the normal activity of respiration and circulation. These ever-constant conditions conceal from all the underlying vital processes which permit them to continue. Without entering more exhaustively into the subject, it will be enough for our present purpose that we direct our attention to the more manifest conditions of that system which may be said to originate and execute the functions of life, namely, the nervous system. Origination and execution, thought and action, may be said to correspond to the two fundamental properties of that system—sensibility and motor power.

The influence of experiments such as that of Sir Charles Bell, was to map out sensory and motor areas in the nervous system. *A priori* it might have been inferred that, as thought precedes action, and volition motion, the origination of energy (it matters not at present *how*) would take place preponderantly in the sensitive or feeling portion of the nervous system; and consequently that the more perfect sensibility or sensitiveness, the more energetic, for a time at least, would action be. As Mr. Victor Horsley has pointed out,* the sensory portion of the nervous system has not till recently been credited with this initiative, to which it appears to be entitled. He and Mr. Gotch determined by experiment that the nerve energy of a discharging nerve-centre overflowed down the posterior or afferent roots as well as the anterior, motor, or efferent roots; but that it could not be provoked by stimulating the latter. They concluded that "it is the afferent side of the nervous system which is the source of energy" (p. 172). This experiment is interesting, but the determination of the value of all experiment to the physician depends upon the consonance of its results with the teachings of clinical observation on man. Does the sequence of events in disorders of the central nervous system teach the same lesson? Although in many lesions of the nervous system producing paralysis or loss of motion, there is temporarily or permanently, partially or extensively, less or more anæsthesia, the question of the seat of executive energy is to be determined less convincingly by a consideration of those diseases in which there is a localised lesion, than by a study of those in which there has been a more general liberation of energy, a more general genesis of exhaustion, a more general derangement of precision of action, and a more general loss of motor power.

We see even in some diseases of more limited range in the central nervous system, for example in locomotor ataxy, in which the chief lesion is in the posterior columns of the cord, that is in a position bordering upon the sensory area, a remarkable loss of co-ordination, which has seemed attri-

* *The Brain and Spinal Cord*, p. 169.

butable in a measure and in some cases to diminished sensibility. In motor lesions, moreover, affecting one-half of the cord, anæsthesia in a corresponding area on the opposite side has been noted, and explained by the cross-action of that organ.* It is, however, in dementia, melancholia, hysteria, and general paralysis that the most extensive evidences of diminished sensibility have been noted, and it is just in these disorders, apart from the influence of local specific changes, that the moral and physical causes of exhaustion have been found to play the greatest part. There is some truth also in the popular belief that *work* kills few but *worry* many. That is, that the corporeal mechanism may be calculated to undergo a great strain with comparative impunity, so long as the great sensory organs are not subjected to circumstances that rob them of that periodic rest and habitual calm which are most favourable to their repair and promotive of their sensibility. These clinical facts, corroborating as they do the results of physiological experiment, warrant the conclusion that the centre of energy—the chief physical source of energy for the physician—lies, not simply in the nervous system as a whole, but more especially in the sensitive, perceptive, and cogitative portion of it. What is true of the whole active mechanism is true of every part of it. It is the exhaustion of the sensitive centres, whether of digestion, respiration, circulation, generation, or thought, that lies at the bottom of deranged function in each and all of them when gross organic lesion does not play the major rôle. It seems needless to labour this point farther, but the influence of sleep and nutrition and the phenomena of recuperated energy proclaim the same truth. It is, moreover, towards a sensitising and stimulation of blunted reflexes that we direct our treatment in all forms of atony and perverted action, by slow, rational, and enduring methods such as nourishment and rest when there is time for these, and by a retardation of the liberation of energy,

* *Prin. and Pract of Med.*, Fagge, Vol. i., p. 404.

or by the stimulation of a sluggish and intermittent liberation of it, when time is a consideration.

How does this argument affect the question of effective or defective cardiac action? How is it that a muscular organ, so perpetually active as the heart is, can avoid showing the evidences of wear and tear for so much longer a period than voluntary muscular structures?

Cardiac muscular fibre, although striped, is not quite the same as the fibre of voluntary muscle. Dr. Walshe, quoting E. Ormerod, remarks, "the transverse striæ are in the normal state less distinctly marked in the cardiac than in the voluntary fibre; this at least is true in the adult heart."* The editors of *Quain's Anatomy* (Vol. i., p. 317) also say that "the muscular fibres of the heart in their mode of action belong to the involuntary class, but are of a deep red colour, and possess the transversely striated structure. They are smaller than the ordinary muscular fibres; their striation is frequently as distinct in a longitudinal as in a transverse direction; and not only is there an exceedingly intricate interlacement of both fasciculi and fibres, but the latter appear to divide and unite frequently with each other, so as to produce a finely reticulated structure."

These conditions, constituting as they do a stage intermediate between voluntary and involuntary muscular fibre, have a natural corollary in corresponding transitional physiological conditions. A curious case is on record in which the will appears to have had some influence on the heart's action. In this case—that of the Hon. Colonel Townshend †—disease of the kidneys was discovered after death, and the apparent death which the patient was capable of inducing was possibly in a measure a voluntary yielding to the depressing influence of uræmic exhaustion. In any case, after being apparently dead for half an hour, he revived, but died outright the same day as that upon which three physicians satisfied themselves of the truth of

* *Diseases of Heart*, p. 333.

† Cheyne's *English Malady*, quoted by Guy and Ferrier in *Forensic Medicine*, p. 239.

the patient's statement, that "composing himself he could die or expire when he pleased, and yet by an effort or somehow he could come to life again." Without dwelling upon so exceptional a case we are all familiar with the influence of the emotions on cardiac action, now in retarding and again in accelerating it, an effect out of all proportion greater upon the vascular system than upon other structures possessing involuntary muscular fibre. While, therefore, one must regard the heart as an organ essentially beyond the control of will, its sensitiveness to mental conditions brings it functionally more into line with the voluntary muscular system than any other involuntary muscular organ. This fact renders it of the first importance that physicians, or others in contact with cardiac cases, should carefully avoid the intrusion of circumstances likely to depress or excite the patient. Moreover, the voluntary muscles themselves may pass into conditions of functional derangement such as tremor, when they may defy all the efforts of the will to steady them, and, as Dr. Walshe suggests,* "It may be that certain forms of irregular fluttering palpitation in part consist of genuine tremor." Nevertheless, while thus so closely allied in structure with, and presenting phenomena so much like those of voluntary muscle, the fundamental cause of the fact that a powerful muscular organ like the heart can for a lifetime sustain continuous contractile effort, broken only by a regular recurrence of short diastolic pauses, without undergoing exhaustion and deterioration, must be attributed to its semi-voluntary structure and its practically altogether involuntary function. For it is only secondarily that the will can influence cardiac action, as indeed it also can in a less evident manner, the rest of the body outside the sphere of voluntary motion.

What, then, is the essential character of the action of involuntary muscular fibre? It is not the occurrence of muscular movement without *volition*; for *in utero*, not only

* *Op. cit.*, p. 168.

does the fœtal heart beat, but the fœtal legs and arms move. This fœtal movement of voluntary muscles may be observed at a very early period of development. Again, as Spiegelberg notes,* one occasionally sees in a child which has been rapidly extruded in natural labour, that, while its heart beats, the infant remains for a short time quite apnœic and flaccid, until, as many must have observed, the respiratory and all the centres governing voluntary muscular action suddenly begin to act, and the limp body as suddenly curls itself up in tensile movement. In some cases of difficult labour also, after the child is born, a still further modification of movement may be observed. The heart may beat comparatively normally, the respiratory act may occur only occasionally and then imperfectly; and, by slow degrees, after the establishment of more vigorous circulation and more regular respiration, the voluntary skeletal muscles may be observed to move with increasing vigour. The movement of the ganglionic system here ultimately stimulates the cerebro-spinal, and indicates that we may in a converse manner stimulate the ganglionic through the cerebro-spinal system.

While such facts prove that the brain, *as a volitional organ*, may be excluded as an essential factor in the action of voluntary muscles, it does not follow that, even *in utero*, it is a negligible quantity as a reflex centre for such movements. Were it otherwise, the compression of the head by forceps (which *may* suffice, without a primarily notable retardation of the heart's action, or a cyanosis of the surface, to kill the fœtus) would not so frequently be observed to have so powerful an influence upon the abolition of movement in skeletal muscles. Finally, the occurrence of *post-partum* convulsions in the infant, from pressure upon the cerebral motor centres, points to the distinction between the action of voluntary and involuntary muscular fibre, and to the intervention in the case of the latter of some *buffer*, so to speak, between them and the cerebro-spinal centres. In this

* *Midwifery*, New Syd. Soc.

buffer lies the essential distinction between the action of voluntary and involuntary muscular fibre.

What is this buffer, and what does its presence imply? The buffer is the ganglionic nervous system, and *all* it implies is still unknown, or a matter of conjecture. It is interesting, however, in pursuing our present argument, to note that the ganglion, which appears to play so great a part in involuntary muscular movement, is met with in an obvious form on the *sensory* roots of the spinal nerves, at the point of approximation of the three branches of the great sensory nerve of the face, on the pneumogastric and glosso-pharyngeal nerves, and throughout the great gangliated chain of the sympathetic and its subsidiary portions.

In enquiring into the nature of involuntary muscular action as regards the heart, it must also be borne in mind, that the earliest rhythmical movements of the elementary organ are observed prior to the appearance of muscular fibres, and when it is formed of protoplasmic and undifferentiated cells (*Text-book of Embryology*, O. Hartwig, transl. by E. J. Marks). It is a rhythmical response of amæboid material to the vital impulse, but the very rhythm of its action reveals a complex condition as yet unravelled and perhaps beyond our powers ever to explain. It is of interest also to remember that at a still later period, when rhythmical action is fully developed, the fœtal heart does its work, according to His and Romberg, before the extra cardiac nerves which ultimately regulate it in so great a measure have grown into the organ from without (*Verhandl. d. Congres. f. innere Med.*, 1890, and *Fortschr. d. Med.*, 1890). But it must be conceded, that however independent of the nervous system, in its essence, cardiac involuntary action may be, the fully developed organ with which we have to deal as physicians, is sufficiently dependent for continued action upon that system, peripheral and central, to render a study of it in its relation to such action indispensable.

This "buffer" theory of the action of ganglia in relation to involuntary organs, if true, is, like many truths, not new. That it is not true to the extent which was at one time supposed, may be conceded. That modern physiological research has altogether set it aside may, however, be very reasonably disputed. Sir Charles Bell, in the preface to his classical work *On the Nerves*, remarks, "It has been asserted by our English physician, Johnstone, that ganglions were for the purpose of cutting off sensation." And, again, "Indeed, it appears to be one of the happiest provisions that these functions of vital importance, innervated by the sympathetic, are withdrawn from the governance of the mind. No part of the human body is altogether independent. When by circuitous influence the mind does operate on the vital functions, we know that disturbance is produced; which is enough to show with what beneficial effects the relations are remote."

In fact, regarding the cerebral hemispheres and cerebellar lobes as the dominant ganglia for perception and action, voluntary and reflex, we have a chain of intermediate ganglia, more or less directly connected with them, and intervening between them and the rest of the body in degrees of independency or potency proportionate to their proximity to the former. Between the cerebro-spinal and sympathetic ganglia there are, however, notable anatomical and physiological differences. Although the functions of the latter cannot be said to have been determined in all their details, two points, chiefly important to us at present, may be said to have been decided, namely, that impulses reach, and are transmitted from the sympathetic to the cerebro-spinal system with less rapidity and power than that which characterises the reactions which take place in the more closely related central nervous system itself. Dalton* points out various important consequences of this difference, amongst others, the fact that the consequences of a stimulus may be considerably delayed in their manifestation in the organs influenced by the sympathetic. Thus exposure to cold may have no less certain

* *Human Physiology*, p. 504.

because not an immediate effect. This delay in morbific influences reaching the vital organs is of importance to the physician because it affords him time for attempting to avert by therapeutic means possible consequences of a dangerous nature.

In the central nervous system, on the other hand, delay in response is in direct proportion to exhaustion,* and the buffer action of ganglia is here augmented by the anæsthesia of blunted sensibility. While, however, as Dr. Foster points out (*op. cit.*, p. 180), in the case of the heart "one great feature of the cardiac beat produced by artificial stimulation is the absence of that relationship between strength of stimulus employed and the amount of contraction evoked, which is so striking in a skeletal muscle," he also points out that there may be a *crescendo* in this respect, the force of resultant contraction being of an increasing character, the stimulus being apparently cumulative. Thus, he remarks, "Frequently by successive shocks of equal intensity a 'staircase' of beats of successively increasing amplitude may be produced."†

These general considerations are of great importance in relation to cardiac pathology; for, while the heart is thus guarded from sudden overthrow, its collapse under the influence of a cumulative exhaustion may be instantaneous or very rapid, and, as will be shown later, by continuous peripheral stimulation, we may save from collapse a progressively failing organ. Before, however, considering the practical bearings of this question as affecting disease of the heart, I shall refer in somewhat greater detail to the innervation of that organ, and enquire how the principles discussed specially apply to it.

The Innervation of the Heart.—Occupying, as the heart does, a position intermediate between voluntary and involuntary muscle, a consideration of its innervation shows a correspondingly transitional character. For, while, like the stomach, &c., the parent stems from which the heart draws its

* Foster's *Physiology*, pp. 593, 594. † *Op. cit.*, p. 168.

nerve supply are the pneumogastric and sympathetic nerves, the connections of the cervical ganglia of the sympathetic with the cerebro-spinal system regarded as supplying the heart, are more numerous and direct than those of the more distant ganglia in the cavity of the abdomen. Thus the upper cervical ganglion, which supplies the upper cardiac nerve, has connections with the first four spinal nerves; the middle cervical ganglion supplying the middle cardiac nerve is in touch with the fifth and sixth cervical spinal nerves; while the lower cervical ganglion from which the lower cardiac nerve issues is connected with the sixth and seventh cervical spinal nerves, and if, as frequently happens, it has coalesced with the first thoracic ganglion of the sympathetic, it may be said to be connected in addition with the first dorsal spinal nerve. To all the "cardiac nerves" issuing from the cervical sympathetic ganglia the pneumogastric sends branches, and itself contributes independently to the common bourne of those nerves—the superficial and deep cardiac plexuses. It is noteworthy also that the *par vagum* has near its origin two ganglia, and that both these are connected with the upper cervical ganglion of the sympathetic; while the spinal accesory nerve which loses itself in part in the trunk of the pneumogastric, avoids the ganglia on that nerve before doing so. These particulars may be gleaned from any modern text-book of anatomy.*

Among the most interesting anatomical discoveries in cardiac innervation of recent times, mention must be made of the "accelerator nerves," which pass from the spinal cord to the lower cervical ganglion, and issuing from it, continue their course to the heart with the lower cardiac nerve;† and also of the "depressor fibres" of the vagus, stimulation of which induces a marked fall of blood pressure.‡

The ganglionic character of the sources from which the heart draws its innervation has a remarkable development in

* Later research represents the spinal accessory nerve as avoiding the jugular ganglion, but passing through the ganglion of the vagal trunk.

† Foster, *op. cit.*, p. 175. ‡ Foster, *op. cit.*, p. 188.

the character the heart nerves reveal in their distribution. Besides the larger ganglia in the heart, Remak found that there were innumerable minute ganglia on different points along the course of even the small twigs on and in the heart; and Dr. Robert Lee, together with his classical demonstration of the nature of the uterine nerve supply, showed the occurrence of ganglia on the smallest nerves throughout every part of the heart.* Jacques has recently made a valuable contribution to the anatomical neurology of the heart by demonstrating the universal sensitisation of the organ, deep and superficial by nerves,† and Berkley (*Johns Hopkins Hospital Report*, 1894) and others have found the cardiac muscle to possess a wealth of nervous endowment.‡

There is thus, it will be seen, a general similarity between the nature of the cardiac nerve supply and that of other involuntary organs; but there is also a difference which has important practical bearings. Cases are no doubt met with, such as one referred to by Dr. Wilson Fox,§ in which mental emotion rapidly affected gastric digestion; but, speaking generally, the influence of emotions in affecting the movements of the heart is by common consent much more rapid than the effects from such a cause noticeable in other portions of the "involuntary" system of the body, less powerfully muscular.

Now, in the case of ganglia incorporated with the trunks of spinal nerves, it has been shown that, contrary to the conjectures of Dr. James Johnstone, there is no perceptible difference between the rate of transmission of stimuli to the cord through the ganglion and that from the cord through the ungangliated anterior roots. But, as has already been mentioned, it is not disputed that the behaviour to stimuli

* *Quain's Anat.*, p. 261.

† *Journal de l'Anat. et de la Physiologie*, No. 6, 1894.

‡ Although, as Jacques remarks (*loc. cit.*, p. 623), the nodular thickenings described by Lee as ganglia on the course of the cardiac nerves are regarded by some as mere accumulations of connective tissue, it is easily demonstrable that branching cell systems occur in the ultimate distribution of the cardiac nerves which may be regarded as representative of ganglia.

§ *Diseases of the Stomach*, p. 126.

of organs largely innervated by the ganglionic system is peculiar, and that this peculiarity consists in a disproportion between apparent cause and effect, between stimulus and reaction. The only positive information, so far, gained by experiment as regards the ganglion on the posterior spinal nerve roots, seems to be, as Waller* pointed out, that they exercise an influence on the nutrition of the nerve. This acknowledged fact is, however, in itself noteworthy, and might be regarded as supporting an opinion which seems to be warrantable, namely, that the sensory portion of the nervous system being in all probability the proximate "centre of energy,"† is likewise the portion subjected to most of the wear and tear of life, and requires for its own repair locally and to maintain its influence throughout the body a special provision for this purpose, that provision being the ganglion.

While, moreover, it has thus been shown that the intervention of a ganglion on the posterior roots of the spinal nerves does not delay the transmission of stimuli towards the centre, it has also been demonstrated that the transmission of stimuli through the *nervi accelerantes* towards the heart and through the inferior cervical ganglion has the same character, in delay and disproportion of apparent cause and effect, as that which the more distant involuntary organs evince on stimulation of their more detached sympathetic nerve supply.‡ This fact, likewise, is of practical importance. While, therefore, both anatomy and physiology have made great strides since Dr. James Johnstone lived, I do not think the advances in these sciences have altogether set aside that idea of which he had a considerable if incomplete perception when he came to the conclusion that "ganglia were checks to the powers of volition."§ Indeed there are portions of his essay which, read in the light of subsequent knowledge, leave little to be desired. Thus, after adverting to the activity of the involuntary organs as seen in sleep and after apoplexy, he writes: "I am not without hopes that the

* Foster, *op. cit.*, p. 450. † Horsley, *loc. cit.* ‡ Foster, *op. cit.*
§ *Essay on the Use of the Ganglions of Nerves*, p. 22.

doctrine we have advanced, concerning the nature and uses of ganglions of the great sympathetic nerves, will afford a natural solution of this difficult problem. The great sympathetic nerves being truly derived from the spinal marrow, have in the numerous ganglions proper to them so many receptacles of nervous energy, so many subordinate brains, which continue to dispense the nervous energy to the vital organs long after they cease to have communication with the brain, and support the irritability of the heart which makes it so long sensible to the stimulus of the blood flowing into its auricles and ventricles after the rest of the machine is in fact dead; but as the whole nervous system derives its energy from and ultimately depends upon the brain and cerebellum, these subordinate sources of nervous energy, being at length exhausted without possibility of a new afflux from the brain, the vital organs at length cease to move."* The ganglionic buffer-system is in short a chain of fortresses between the mother country of the brain and spinal cord and its dependencies, the viscera; and our present knowledge of physiology seems to indicate that, while the dependencies can signal rapidly to the central seat of government, there is an unavoidable delay in responding to the former on account of necessary communication with intervening and subsidiary seats of power; but that the aid ultimately reaching the dependencies, if somewhat delayed is all the more efficient on that account.

It has thus been abundantly shown that there is an intrinsic and extrinsic nervous mechanism influencing the action of the heart. These, while independent in a great measure of each other, as may be proved by the continued action of the eviscerated heart, and of different portions of a heart so removed, are neither of them independent of a central source of energy which is potent throughout the body, and as a condition of health regulates the whole mechanism of life. Circumstances may arise, however, which cause an excessive or deficient action of the extrinsic or intrinsic nervous mechanism of the heart. It can be readily shown

* *Op. cit.*, p. 71.

that the extrinsic mechanism, that in most direct relation to the cerebro-spinal system, is also that most easily influenced by the latter, whether by depression through the vagus or by accelerated or augmented action through the accelerator nerves. Towards such variations the intrinsic (ganglionic) cardiac centres and nerves seem to bear a regulative attitude. Depression within certain limits is followed by acceleration; acceleration, also within certain limits, by slowing. But, the one influence or the other acting beyond a certain point, a point which may be reached with a rapidity in inverse proportion to the general stability of the nervous system, overcomes the inertia of the intrinsic mechanism, and passes either into irregular quickening or slowing of the heart's action. A general exhaustion, in which the ejection as well as the reception of impressions is impaired, may, on slight provocation, call the intrinsic mechanism into predominant action. It is the latter *then* which appears to attempt the control of the extrinsic system, and may or may not succeed in the effort. Such final provocation may be emotional, or due to an amount of exertion quite tolerable under conditions of average strength.

The fulcrum or mid-factor, in cases of disturbed cardiac action, seems then to be the intrinsic nervous mechanism of the heart—that system which at a certain point causes the ventricles to take "on their own action," to use an expression employed by Roy and Adami.* In the interpretation of clinical phenomena, unless there be satisfactory experimental elucidation, a cautious use of hypothesis is permissible, and is certainly comforting to the physician who prefers to act rationally rather than empirically. It is allowed by physiologists that the results of reflex stimulation on special nerves is the same as that due to direct stimulation. The cardiac ganglia, being a midpoint receiving both depressant and accelerant fibres, as we have already seen, appears to be capable of directing a corrective stimulus, either towards the vagus or accelerant nerves, according as the needed correc-

* *Phil. Trans.*, Lond., clxxxiii., 1893, p. 284.

tion is provoked by undue depression or undue acceleration of the heart's action.*

Stimulation of the ganglionic system we have seen to be cumulative in its character. It may therefore overdo its corrective influence in a depressant or accelerant direction, and thus an irregularity or palpitation be produced or maintained, which may be regarded as a *ganglionic* irregularity to distinguish it from *vagus* and cerebro-spinal irregularity. The initial factor, whether acting through the depressant or the accelerant nerves, calls into play a system, which itself, after failing to correct, contributes to the disorder. Unfortunately the proof of original ganglionic stimulation is not so easy as that of other nerve trunks and centres; but the pricked eviscerated heart which contracts, and the experimental differences in the reaction of the ganglionic system to stimuli, reveal the rational possibility of an initial disorder in this system.

In those cases of irregular heart's action which originate in gastro-intestinal irritation, it is difficult to determine whether the vagus and spinal nerves or the ganglionic system is primarily involved; but the wide diffusion of the latter renders it probable in many cases that it plays the greater part, and by its sluggish reaction resists a disturbance of the nervous equilibrium, acts as a drag upon disorder once begun, and is apparently slow to reassert its influence when it is lost. But, by its peculiar property for the accumulation of stimuli, it appears suddenly in many cases to evince a power of control which is quite surprising. Thus, it is no uncommon experience to observe a totally subverted heart's action—a truly "runaway heart"—which our remedies seem to be impotent to "pull up," even when the patient seems on the brink of dissolution, suddenly right itself, and the storm of a few hours previously to be succeeded by a profound calm. This can, I think, only be explained by the cumulative influence of stimuli applied through the medium of the

* Since writing the above I find that a somewhat similar working hypothesis is adopted by Dr. Lauder Brunton (*Pharmacology, Therapeutics, and Materia Medica*), and appears to have been originated by Schmiedeberg.

blood to the sluggish ganglionic system, or by the peripheral stimulation due to drugs, or baths, or exercise, as will be explained later. The ganglionic system seems either to control the enfeebled vagus and incorporated accessory nerve by coming to their aid directly, or, by doing the work of these, to afford them a repose necessary to allow of their re-asserting their influence.

Provided, therefore, the more rapidly-acting cerebro-spinal depressant and accelerant nerves of the heart, do not succeed in overthrowing the resistance of the intrinsic ganglia by too sudden or powerful, or too prolonged an influence, no great harm results from the disturbed cardiac action. Depression passes into acceleration, acceleration into depression, with as great ease as the constant variations of vascular tone to which they correspond; but, if the ganglia at one end, and the reflex sensibility of central organs at the other, become exhausted, the situation becomes critical, and hope lies in the cumulative, if delayed, response of the ganglionic system; that is, in ganglionic stimulation of the heart, and in the powerful stimulation of the sensibility of the central nervous system, of which more later.

I have thus endeavoured to express a belief, founded on clinical experience and the teaching of experimental physiology, that the ganglionic system is at once a buffer between vital actions and extrinsic injurious influences, a store-house or accumulator of reserve force in situations protected from easy invasion, and a ground of hope in many desperate cases; and, moreover, that these conclusions apply with special emphasis to disorders of the heart.

I have not referred in this place to many recent anatomical and physiological researches on the sympathetic system, as it has been my desire to redirect attention from the clinical side, to the ancient buffer theory of the ganglionic system in its relation to visceral action.

SECTION II.

THE HÆMIC FACTOR.

Wonderful as are the powers of endurance of the heart, however, they have their limit. Its walls may undergo degenerative changes from interference with their due nutrition. "In the frog," Dr. Michael Foster remarks (*op. cit.*, p. 209), "the thin walls of the auricle and the spongy texture of the ventricle permit the nourishment of the cardiac substance to be carried on by direct contact of the blood in the cavities. In mammals," he adds, "this mode of nutrition must be insignificant." If the nutritive power of the blood passing through the chambers of the heart in man and other mammals be inconsiderable we cannot deny the stimulant or depressant effect upon the organ of blood and substances artificially introduced into it. It is probable, therefore, that the passage through the great driving chambers of the heart of the whole bulk of freshly oxygenated blood, has, if not by direct nutrition, most likely by direct stimulation of its nervous mechanism, which is, as we have seen, in a measure independent of the central nervous system, a powerful influence in sustaining its activity. Drs. Roy and Adami (*loc. cit.*, p. 289) point out that "the first effect of asphyxia upon the heart is to produce vagus action, due to excitation of the vagus centre in the medulla, as its appearance can be prevented by section of the vago-sympatheticus. There is also gradually-produced weakening of the auricular and ventricular contractions, due presumably to the imperfect supply of oxygenated blood to the heart-muscle." That, however, the chief support to the heart is given by its nutrient vessels proper cannot be disputed, although the presence of a highly-stimulating fluid in the left chambers of the heart, and of a more sedative fluid in the right chambers, would *a priori* seem a most appropriate arrangement in view of the lessened need for muscular exertion in the latter in the aerial animal. The problem is, however, more complicated than it appears. For, we may observe an enormous increase of muscular force in the heart under circumstances in which the whole volume of blood in the body is very insufficiently oxygenated, as in cases of cyanosis, in which not only the intracardiac, but also the coronary circulation, is highly charged with the products of metabolism. We may conclude from this fact that, while a wholesome quality of blood is powerfully promotive of sustained vigour, blood surcharged with effete products does not seem to have so great an influence in producing degeneration of muscular fibre as conditions in which there is defective elaboration of blood, a point to be considered presently. The growth of the heart-muscle in cyanosis also proves that there is an intrinsic neuro-muscular trophic capacity in the heart which can assert itself under the stimulus of obstructive resistance with a minimum of encouragement from the quality of the blood, so far as oxygenation is concerned. In such cases, however (and they usually occur when the forces of growth are in the ascendant, that is, in youth), great as may be the effort of nature to overcome the obstacle in some instances, the difficulty in propelling the circulation and the quality of the blood combined serve, in the majority of cases, to extinguish life at an early period. In a paper on the condition of the blood in the cyanosis of congenital heart disease (*Lancet,* Jan. 5th, 1895), Dr. G. A. Gibson, of Edinburgh, states in agreement with other observers that he found increase both of hæmoglobin and of hæmocytes in such cases, and suggests that the diminished activity of metabolism under the circumstances may permit of the survival of a larger number of blood cells, which may be regarded as a form of physiological compensation. It appears to me, however, that the high percentage both of hæmoglobin and of hæmocytes in conditions such as cyanosis is merely the excess of crowding, and not indicative of a life-giving fluid hyper-nutrient for the whole body. The subject, however, is a most interesting one, and indicative of the importance of a scientific examination of the blood in all cardiac cases. The blood, in short, should be as regularly examined in heart disease as the urine when the kidneys are affected. In gauging the value of healthy blood in sustaining the energy of cardiac action, we must be guided rather by a study of the normal nutritive circulation than by a consideration of the frequently heroic, but sooner or later futile efforts of that organ to overcome insuperable difficulties. Whatever view we adopt of the coronary circulation—whether that of a systolic or diastolic, or both systolic and diastolic, repletion of those vessels—one fact is patent and agrees with both views, namely, that the heart is the first powerful muscle to obtain the freshly-oxygenated vitalising fluid, and that its venous blood is not emptied by a circuitous route into the right side of the heart, but reaches it directly, and is sent thence to be oxygenated without the delay incidental to a longer journey.

It has been objected to Brucke's diastolic theory of the coronary circulation that a wounded coronary artery jets synchronously with the heart's systole (Foster, *op. cit.*, p. 150). The fact cannot be denied that the coronary arteries contain blood during systole ; but as little can the equally certain fact be denied that the completed aortic tension caused by the rebound of blood on to the semi-lunar segments relieves itself in a measure by imparting a greatly increased impulse to the coronary circulation. Hyrtl, in combating Brucke's views, convincingly demonstrated that the expansion of the sinuses of Valsalva on systolic repletion of the aorta stretched the semi-lunar valves, so that they constituted the chords of segments of circles formed by those sinuses, and thus in no way occluded the coronary orifices or obstructed the systolic flow of blood into the coronary arteries (Luschka, *Anat. d. Mensch.*, 1869, p. 402). Luschka also (*op. cit.*, p. 404) mentions a case in which the right coronary arose from the subclavian artery, and in which the blood flow must of necessity have been systolic. Dr. Sibson's interesting observation, however (*Med. Anat.*, p. 73), on the living animal, in which he observed that the arteries and veins on the surface of the heart became "prominent and tortuous" when the ventricles contracted, points to systolic impediment to the circulation in the substance of the heart; while their becoming straight and small during diastole is evidence of the comparatively free anastomosis and easy transit of blood through the uncontracted muscle which Dr. Samuel West has shown to exist (*Lancet*, June 2nd, 1883, p. 945), although all anatomists do not agree with him (Gray's *Anat.*, Ed. 1893, p. 523). Dr. J. Cockle (*Contributions to Cardiac Pathology*, p. 4, 1880) refers to the fact that in some animals the cardiac walls become almost transparent during systole. Some again who admit the fact of coronary anastomosis deny its great freedom (Osler, *Angina Pectoris and Allied States*, p. 13, 1897).

As in many contested questions, the last opinion is probably nearest the truth as regards anastomosis. Now, a fact is a thing which may or may not be explicable at the moment, but it can never be explained away. That the wounded coronary artery has a systolic jet is a fact. How is it to be explained compatibly with another fact, namely, that the diastolic rebound of the aortic blood relieves itself in a measure by expansion into the coronary vessels? For that it must do so can scarcely be denied, unless there is evidence to show that the aortic expansion and lengthening during systole (Britten) closes the coronary arterial orifices. I know of no such evidence. On the other hand, we do know that simple dilatation of the aorta tends rather to widen than narrow the coronary arterial entrances. The nearer a vascular circuit is to the seat of propulsion and aspiration, the greater must be the influence of these forces upon it in proportion to its calibre and the character of its channels. The coronary arterial channels, Dr. Norman Cheevers pointed out (*Guy's Hospital Rep.*, Vol. i.), resemble in some respects veins rather than arteries, and their comparatively small calibre, under the influence of the great intra-aortic pressure, is calculated to induce an extreme rapidity of blood transit. It appears to me, therefore, that the arterial pressure in the coronary system may be said to be continuous rather than either systolic or diastolic. The diastolic repletion of these vessels merely increases a systolic tension already present, which is further raised by compression short of obliteration of vessels in the substance of the heart while the ventricles are contracting, and contributes a force in aid of, but by no means the entire force-producing ventricular diastole. This force, moreover, in the presence of impaired muscular tonicity, gains importance as a diastolic factor, and contributes to the production of both sudden and gradual ventricular dilatation. This view of the coronary circulation appears to me to be supported by the preceding facts and observations, and by the following simple experiment :—

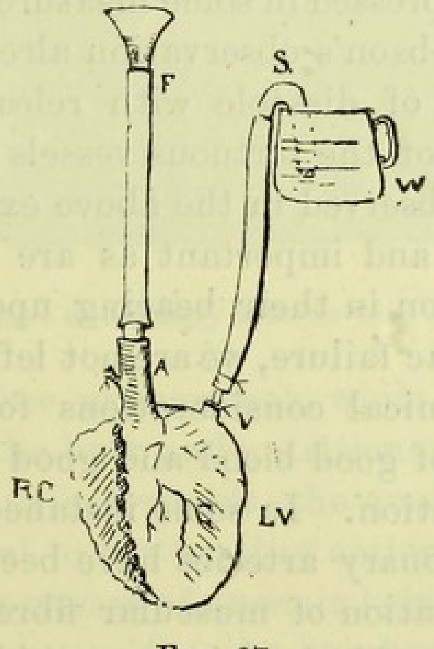


FIG. 37.

The syphon S was connected with the pulmonary vein V. The aorta A was adapted to the tubing and filler F. The right chambers of the heart (RC) were cut away. On the aorta being filled with water (W) either by syphonic inflow through S or by way of the aortic tubing from the filler F, a continuous jet sprang from the severed coronary arteries in the walls of the cut right chambers. The force of the current through these vessels was proportionate to the pressure of fluid in the aorta A. On systolic compression of the left ventricle (L V) fluid escaped *per saltum* (systolic jet) from those coronary vessels not compressed during systole, and the flow of fluid was arrested in those compressed. In the latter there was a diastolic jet.

This experiment, which appears to me in the main convincing as to the systolic impulse in the coronary circulation, enhanced by a post-systolic or diastolic impulse, requires partial modification from the fact that compression by the hand affects the coronary arterial current more than the natural systole of the heart, because of that natural provision against systolic compression of the chief branches of the coronary artery which has placed them in the sulci on the surface of the organ where the contracting muscular fibres cannot embrace them. That the deeper branches on the other hand *are* thus compressed in some measure, if not completely, is proved by Dr. Sibson's observation already referred to (p. 82). The advent of diastole with release of compression and straightening of the tortuous vessels corresponds to the diastolic impulse observed in the above experiment.

But, interesting and important as are these questions of coronary circulation in their bearing upon the nature and treatment of cardiac failure, we are not left merely to physiological and anatomical considerations for evidence of the great importance of good blood and good blood-vessels to a vigorous heart's action. In some instances obstructive conditions of the coronary arteries have been found associated with fatty degeneration of muscular fibres, presumably due to the organ being robbed of its proper blood supply. It is not unusual, however, to find great degeneration of muscular fibres without impediment to coronary circulation, and on the other hand great obstruction of the nutrient vessels of the heart may be observed without noteworthy degeneration of its muscular fibres. I have myself known almost complete obliteration of both coronary arteries in advanced arterio-sclerosis, associated with a long continued angina pectoris, which was ultimately suddenly fatal, and in which there was little change in the muscular structures of the heart. The case was under my care at the Great Northern Central Hospital.

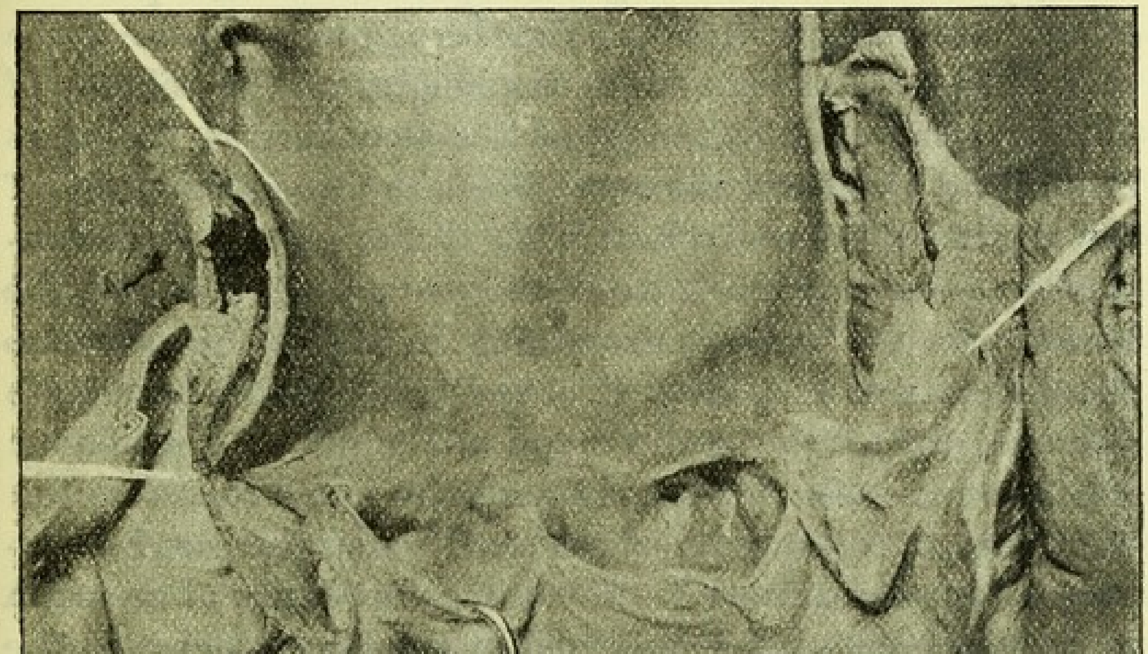


Fig. 38.—Stenosis of coronary arteries with angina pectoris.

It would, therefore, appear that, while there may be some relation between the bulk and nutrition of the organ and the condition of its nutrient vessels, the quality of the blood is even more essential to the healthy action of the organ than its quantity. The causes of anæmia being the causes of malnutrition generally, may thus be numbered among those of muscular degeneration general and cardiac, and, therefore, among those of cardiac failure. Such a conclusion renders a clinical examination of the blood in cardiac cases important both from a prognostic and therapeutic point of view.

The blood-weight and pressure.—The great importance of a nutritive quality of blood and of facilities for its permeating textures to be nourished does not, however, diminish that of another factor in the production of cardiac failure, namely, the influence of intra-cardiac and intra-arterial blood-weight and pressure. Its recognition may be said to be as old as bleeding and starvation. The pressure of fluid according to hydraulic law being proportionate to the surface exposed to it, and to the height of the column of fluid pressing upon it, the larger the chambers of the heart containing blood and the more direct the communication of the arterial column of blood with it, the greater the intra-cardiac pressure, the greater the distending effect of the blood upon the cavities containing it, and the greater also the difficulty of propelling it. As Drs. Roy and Adami state (*loc. cit.*, 213) "the strain upon the walls of a sphere or spheroid increases with its circumference, and therefore the resistance to contraction of the heart wall is increased whenever it becomes dilated." The clinical evidence of the truth of these principles is to be found in the hypertrophy of the muscular walls of the heart under the influence of increased intra-cardiac pressure and increased propulsive difficulty. It is for these reasons that, among valvular diseases of the heart, the hypertrophy attending regurgitation through the aortic valves is very noteworthy, and this notwithstanding the aid afforded the circulation by the respiratory movements and by gravitation in the descending portion of the arterial tract. When to the circulatory incentives to increased growth there is added the further impediment to effective ventricular contraction due to adhesion between the visceral and parietal pericardium, the highest degree of hypertrophy is reached in many cases, and the normal heart-weight of

9 to 11 ounces may reach such figures as 20, 30, 40, or even more ounces. In the production of these greatly enlarged hearts, not inappropriately termed cordes bovina, not only is there as a rule a free coronary circulation with gaping arterial orifices, but there appears also to be present an inherent capacity for great muscular development, such as is found to hold good for the muscular system as a whole—a capacity which appears to be in some measure an individual peculiarity. That is to say, the same lesion in persons of like general resemblance does not always induce an equal amount of cardiac hypertrophy, any more than gymnastic exercises in different people produce the same degree of general muscular development. This difference in muscular hypertrophic capacity has probably some influence upon the varying rapidity observed in the establishment of compensation in different persons, and in the permanency of improvement under treatment. It is, moreover, a point of practical importance in connection with the treatment of cardiac failure by the resisted movements to be described later, the object of which is in cases of organic disease to hasten the establishment and completeness of compensatory muscular growth. It is also the reason for which cardiac stimulation is maintained for a considerable length of time by the continuous administration of small doses of digitalis or strophanthus in appropriate cases, after the evidences of cardiac failure have subsided. Just as in the example already cited (p. 85), the coronary circulation may under difficult circumstances be sufficient to maintain the due nutrition of cardiac muscular fibres, so, in the following illustration (p. 88) the large ventricular cavity and wide coronary arteries, together with a firm but small pericardiac adhesion, account for the great muscular power attained by the walls of the heart. The case was under the care of my colleague, Dr. Burnett, at the Great Northern Central Hospital, who has kindly permitted me to copy the annexed description of the organ from the post-mortem record which was made by Dr. Freyberger, the pathologist to the hospital.

"The heart, of enormous size, weighs $2\frac{1}{2}$ lbs." (The normal weight of this man's heart was probably about 13 ounces.) "Apex in the seventh intercostal space in the anterior axillary line. Right ventricle begins at the right parasternal line. About four ounces of clear serum in the pericardial sac. A slight organised membrane stretching

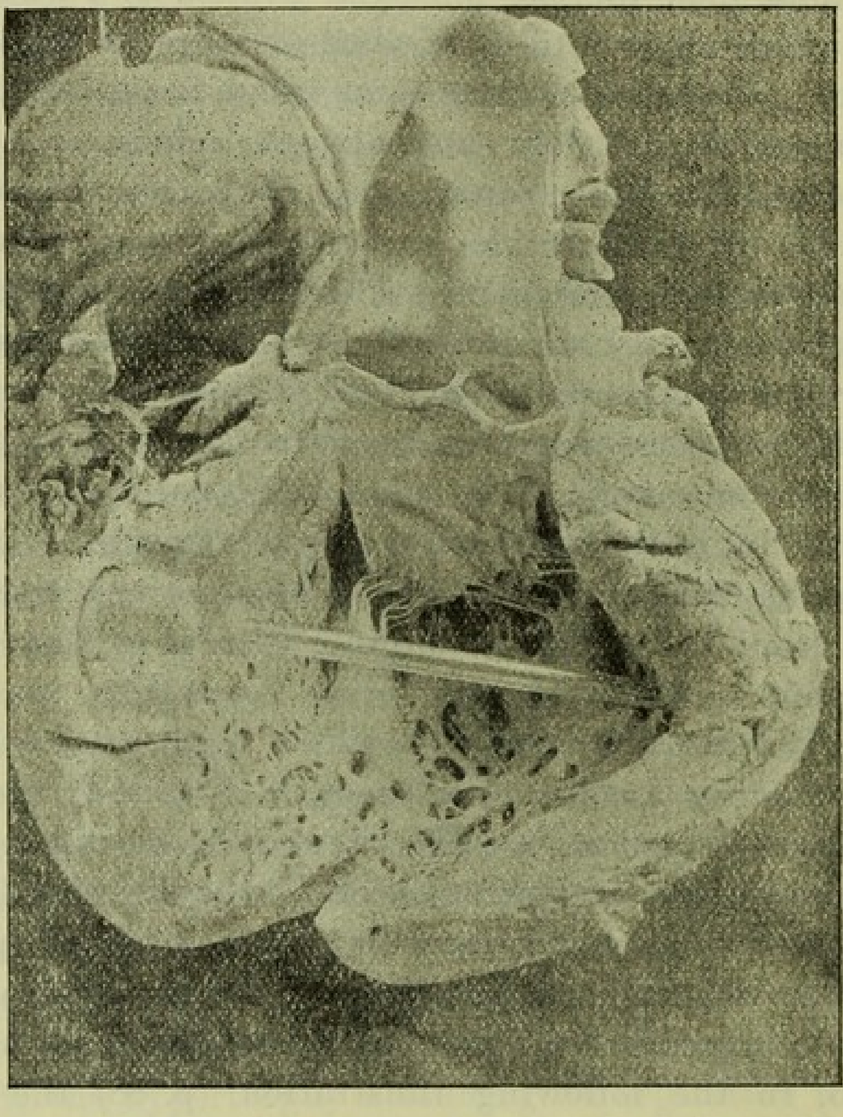


FIG. 39.—Cor bovinum with slight pericardial cohesion and little valvular disease.

from a point anteriorly near the apex to the opposite parietal pericardium. The left ventricle much dilated. Walls nearly an inch thick. The pyramidal muscles enormous. No tabby-cat striation. Consistency increased. Mitral valves admit three fingers easily. The free fringes of the valves are somewhat turned back. Valves not competent. All three aortic valves shortened. Their edges thickened and crumpled up, with patches of atheroma. Valves not competent, and leaving a cleft between them. Atheroma of coronary arteries, aorta and larger vessels, but not of an advanced character. Right ventricle also hypertrophied and bent round the cone of the left ventricle. Pulmonary valves normal and competent. Tricuspid valves competent, and admitting four fingers easily. Both auricles dilated and filled with dark blood."

I had an opportunity of examining this patient during life. He was forty-six years of age, was a tall, powerfully built man, exhibited a basic diastolic and apex systolic bruit with enlarged area of cardiac dulness, and powerfully heaving action of the heart. The following sphygmogram which I made shows that the action of the valves during life was comparatively competent, and that the chief impediment to his heart's action was the small but firm band of pericardial adhesion at the apex discovered after death.

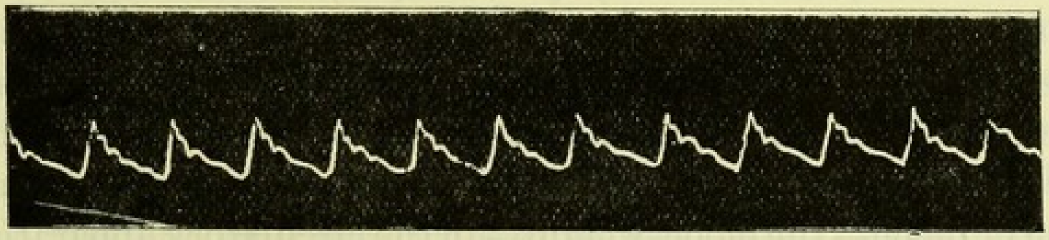


FIG. 40.

It would have been an ideal triumph of modern surgery could this limited tethering have been divided and the labouring heart freed from its mooring. It is, perhaps, too much to expect that such interference will ever be possible, but the day may come when exploratory operations may bring even the pericardial sac within their sphere. A largely adherent pericardium would of course be beyond remedy, but it appears to me that were the finger swept round the cardiac apex, and so small yet so fatal a cord discovered, it might be divided, and the sac sewn up like the wall of any other cavity.

PART III.

SECTION I.

THE GENERAL TREATMENT OF CARDIAC FAILURE.

It may be gathered from the preceding Part of this book that cardiac failure is attributable (1) to general or local, or to both general and local exhaustion of nervous energy, manifested by diminished force, or abnormal action of the heart, and this may be termed the neural factor; (2) to failure from defective nutrition of, and loss of tonicity in the cardiac muscle itself, which may be called the muscular factor; (3) to embarrassment of the pulmonic factor in the circulation; and (4) to the influence of abnormal distribution of blood—the blood-weight—in the circulatory apparatus—a condition intimately associated with the effects of gravitation and posture upon the circulation, and which has been treated as the hæmic factor.

Inasmuch as the therapeutic portion of the book will have special reference to the treatment of cardiac failure by baths and exercises, it is not intended to enter more fully into the general treatment of the condition than to indicate in outline the other agencies and measures which have been found efficacious in coping with disturbances of the factors named. These cannot, however, be dismissed without some discussion, as they may necessarily precede, accompany, or follow balneological and gymnastic treatment. With regard to the latter, its essentially physiological or non-pharmaceutical character has necessitated a short preliminary consideration of many physiological questions, without a reference to which the argument would not have been so clear.

The Treatment of the Neural Factor.—In using the term neural factor in this connection, it is, of course, understood that it is difficult to exclude this from every mode of influencing a living organism into all the actions of which it of necessity enters. But there is a convenience in discussion in separating the more evidently neural elements in a case from others in which, although their participation is real and necessary, it is not so evident. Neural conditions naturally play a more pronounced part in the case of neurotic subjects. The tendencies of the individual and the circumstances of life, which together result in emotions of a disturbing or calming character, are, in a great measure, beyond the power of the physician to control, by whom the inculcation of philosophy is to be preferred to the practice of hypnotism. This, aided by the natural submission to and carelessness of the inevitable, which is fortunately a human property, will, in most cases, do much to limit the power of the emotions for evil. The avoidance, so far as possible, of palpably exciting circumstances is too necessary a condition of safety in cases of cardiac failure to require further comment. Neural stimulants, which ultimately depress, such as tobacco and alcohol, and which are more or less in common use, require enlightened regulation, but the routine prohibition of the moderate use of these in the case of those accustomed to them, may in many cases aggravate the condition their restriction is intended to improve. That it may be necessary absolutely to abandon them is too well known to require more words, the direct and indirect consequences of their abuse being a frequent cause of cardiac failure.

The treatment of SLEEPLESSNESS in cardiac cases is always an important question, and into its consideration so many elements enter, that any rule of thumb prescription is to be deprecated. The hypnotic which will suit one case may be worse than useless in another, and attacking so far as possible the most evident cause of insomnia in a given case, is the only rational process which can be indicated. It is a point of the first importance, however, when an hypnotic has been selected and been found of some service, be it sulphonal or bromide, opium or chloral, that it should be given in sufficient quantities to render the securing of its effect certain, and thus of inspiring confidence of its efficacy in the patient. Such a confidence in the potency of a narcotic drug is necessary to a gradual abandonment of its use. My own experience causes me to place most confidence in sulphonal when emotional excitement plays a large part in the disturbance of the sleep of cardiac patients, and failing this, in opium, should there be no gross contra indication to its use, such as serious renal complications. But, whatever means be adopted to secure sleep, experience must have convinced all, that when cardiac failure is great, sleep *must* be obtained. Without it, the most enlightened use of well-proved remedies will frequently prove futile. To quiet the tumultuous action of an irregular and accelerated heart, especially if the general force of the patient, as indicated by a temperature normal or above normal, be not too low, the use of ICE to the head, and if necessary to the precordium, may be confidently recommended. Personally I prefer the application of ice to the head and forehead, when this proves sufficient, and have noted its rapid operation in the production of sleep, of a more regular heart's action, and in the disappearance of pulmonary engorgement due to cardiac failure. The recent investigations of Ramon y Cajal (*Beitrag z., Stud d. Med. Oblongata*, Leipzig, 1896, p. 43 *et seq.*) into the origin of sensory roots of the trigeminal nerve and its connection with motor fibres of the vagus, should they be confirmed, will place the employment of ice under these circumstances upon a scientific basis. Ice so used, apart from its general effect, seems at times and in neurotic patients to act in a measure as an hypnotic on the lines of so-called "hypnotism," the constant impression on one nerve territory leading to slumber. When ice is applied to the precordium it cannot with comfort to the patient be used so continuously as upon the head, but its intermittent use for periods of ten minutes at a time has a marked influence in calming a tumultuous heart, and in retarding and amplifying respiration.

In cases in which the heart has so far failed that the surface temperature is sub-normal, while the rectal temperature is somewhat higher, it may be normal, or somewhat above normal, the external application of heat may be of some use, provided the degree employed be considerable—100 to 103 degrees Fahr.—and used in waterproof material or Leiter's tubing. I have not, however, found heat so powerful for good under the circumstances mentioned, as cold, when the latter is indicated. As a powerful local stimulant, however, in some cases of lowered vitality, with cardiac failure, the possible utility of heat has to be borne in mind.

It has already been pointed out that a defective quality of blood circulating in the coronary system is almost, if not quite as deteriorating a factor as serious occlusion of these channels. Subject as these vessels are to the double pressure of systole and of the aortic tension which follows systole, vascular impediment at the orifices of the coronary arteries must be very great not to allow a sufficient entrance of blood into them, and once in, their general anastomosis, at one time disputed, even although not excessively free, serves to convey sufficient nutriment to the cardiac muscle. It is for these reasons that the muscular fibres of the heart escape degeneration in many cases of even considerable coronary impediment, as already pointed out.

On the other hand, an ever active organ requiring constant nutritive repair cannot long survive the circulation through it of an imperfect quality of blood, however pervious its vessels. Hence the importance of determining the presence or absence of anæmia by clinical signs in common use, and by the hæmoglobinometer and hæmocytometer, in order that hæmatinics and a suitable nitrogenous dietary may be employed, alone or in combination with agents found to have a more direct effect upon the activity of the cardiac muscle, such as digitalis and strophanthus. The use of iron in an anæmic case may be observed to act rapidly as a cardiac tonic in improving the action of the heart and in removing its flaccid or atonic displacability.

The Drug Treatment of the Muscular Factor.—Among the "digitalis group" of cardiac stimulants (Digitalis, Strophanthus, Scilla, Apocynum Cannabinum, Convallaria, Spartein, Adonis Vernalis, Cactus Grandiflorus) experience has placed in the first rank digitalis and strophanthus (which practical medicine owes to Professor T. R. Fraser, of Edinburgh), and the beneficial effects producible by their therapeutic congeners may in most cases be brought about by a careful dosage of these two. Indeed, but for the more rapid assimilability of strophanthus in some cases, and its greater suitability for hypodermic injection, because of its active principle being soluble in water, the aqueous, solid, and spirituous preparations of digitalis can in most cases effect more than other cardiac stimulants of this group. When renal complications, other than those attributable to the cardiac failure of the moment, exist, and there is a probability of arterial changes of longer standing, the comparatively small effect produced by strophanthus as an arteriole spastic appears to indicate its superiority in some cases over digitalis, and under these circumstances I have found it at times a very potent remedy. Withering (*op. cit.*, p. 190) regarded squills as "one of the best preparatives to the adoption of digitalis," and its combination with that drug or with strophanthus appears to facilitate their action in some cases. The combination of digitalis, ipecacuanha, squills and blue pill, acts as an efficient diuretic and cardiac stimulant at times, by its tendency to relieve pulse tension while it increases blood-pressure—a distinction in vascular physiology to which I shall have occasion to refer again.

The manner of using digitalis which I have found most successful has been, to use the infusion in slighter forms of cardiac failure and in such as have not been very frequently recurrent, and in more severe cases to commence with the same in larger doses, passing on, if necessary, to the powder, and finally to the digitoxin-holding tincture. This, if the case will permit of tentative treatment. If urgent, I begin with the tincture, and if it be not successful in varying doses, reverse the order indicated in the first instance, or combine digitalis with strophanthus or squills. The combination of all these drugs with strychnine appears frequently to enhance their potency by raising the irritability of the neural factor. Some cases habituated to tincture of digitalis, like seasoned topers, do not improve on a weaker drink such as the infusion, and in these, even slight attacks of cardiac failure are better treated by reduced doses of the tincture than by other preparations of the drug. It is important to remember that the failure of a drug to produce expected effects may be owing to its administration in too small quantity, just as unfavourable symptoms may be due to an overdose, and a cautious progress to larger doses under these circumstances is advisable in many cases, before its abandonment.

It is in its bearing upon the question of increased dose that the kind and situation of valvular lesion when associated with cardiac failure appears to possess some importance. In the opinion of many trustworthy authorities, the fact rather than the valvular cause of cardiac failure is the determining factor in the employment of digitalis, and its effects when injurious are attributable in most cases, according to Dr. Geo. W. Balfour, to over dosage (*B. M. J.*, *loc. cit.*). This is probably true in many instances, but there is still some difference of opinion as to its comparative utility in different cardiac lesions. Both Withering and Balfour consider that the point of saturation with digitalis is approached when an amount equal to 30 grains has been continuously consumed, and that at this point additional caution is necessary not to overstep its safe and beneficial administration. A very much larger amount may, of course, be continuously taken under proper precautions. The conclusion I have come to from my own experience agrees with that of those who have found that in the case of arterial (sigmoid valvular) lesions digitalis must be used more tentatively, and the dose increased less boldly, than in the case of atrio-ventricular lesions.

Contemporaneously with an injurious influence of digitalis in sigmoid valvular disease, there may be some retardation of cardiac action noticeable, which allows time for greater reflux, and this is probably the rule under these circumstances, but such retardation may not be present, and digitalis still prove injurious in such cases. When this occurs, I believe that the ill-effect is due to an aspirative action of the ventricle in addition to other causes, as I maintained in a paper on the treatment of aortic valvular disease on a former occasion (*British Medical Journal*, 1896).

The form of lesion in which the drug has to be used with most caution is that of sigmoid valvular reflux, and I have been led to this conclusion not only from experience with it in aortic, but also in a rare case of pulmonary arterial inadequacy (*Trans. Path. Soc.*, Vol. xxvii.) Dr. Herbert Davies and Professor Haughton have computed with assumed data that during the diastolic pause the aortic reflux is to the atrio-ventricular inflow as "rather more than one-third is to rather less than two-thirds of the whole ventricular contents" (*The Mechanism of the Circulation through Diseased Hearts*, p. 51), and it is conceivable that any circumstance which would impede systemic arterial on-flow or favour aortic reflux would act more injuriously and immediately in the absence of the great barrier against systemic arterial reflux than in cases in which the aortic valves are perfect. It does not follow from this that digitalis is not beneficial at some stages of sigmoid valvular reflux, but merely that when it has not in a certain dose proved of some benefit, it cannot be increased with the same confidence in its therapeutic power as in atrio-ventricular reflux, and especially in mitral regurgitation. In the latter 10, 15, or even 20 minim doses of the tincture may in some cases be given every four hours by gradual increments with increasing utility and evident advantage. What we require in aortic inadequacy with compensation lost to a serious degree, is increased ventricular propulsion with an easy peripheral outflow and a limitation of venous return to the heart. These conditions are probably best fulfilled by the use of strophanthus in combination with belladonna and the nitrites, and a more or less orthopnœic posture during an access of circulatory embarrassment. With relief of the latter, even a short period of recumbency has hydraulic advantages, but the persistency with which patients from this distressing malady assume the erect or semi-erect position, points to greater ease in the orthopnœic posture. The combination I have mentioned I have found of use in such cases, even when digitalis had acted injuriously; but Dr. G. W. Balfour maintains that, given in sufficient quantity and carefully watched, some of the most brilliant results of the action of digitalis are to be met with in cases of aortic regurgitation (*Diseases of Heart and Aorta*). In some cases of cardiac failure in which the infusion has failed, digitoxin in doses of $\frac{1}{120}$ of a grain administered per rectum has been found of use (Weuzel, *Centralbl. für innere Med.*, No. 19, 1895), but the employment of so potent an agent involves a certain risk. Like the tetanic effect of ergot in producing excessive uterine contraction, digitoxin may enable cardiac action to escape our control. Between the uterus and the heart there is, indeed, a comparable likeness in some respects. Uterine failure and cardiac failure are frequently associated, and the latter with the former not merely as a consequence of uterine hæmorrhage, but simultaneously with it, apparently from a contemporaneous neuro-muscular failure. Moreover, in some forms of cardiac failure, some, especially French authors (Huchard, *Malad. du Cœur*), have found ergotin more useful than digitalis. Retardation of pulse, especially with coupled beats (pulsus bigeminus) appearing while digitalis is in use, is an indication for the abandonment of the latter (*Traité de Med.*, Charcot et alii, Vol. v., p. 215), as also is a notable fall in the urinary secretion; while one must ever be on the watch for evidences of gastro-intestinal irritation. Like every agency potent for good, digitalis and its congeners require knowledge and judgment in their employment, but so used, the experience of a century has but added lustre to the laurels won by Withering, when he turned to scientific uses the empirically employed foxglove. The closing words of his preface, "Time will fix the real value upon this discovery, and determine whether I have imposed upon myself and others, or contributed to the benefit of science and mankind," may be fitly associated with a passage recently written by so great an authority as Dr. George W. Balfour, which is full of a sapient enthusiasm that passes like a vivifying breath through the "thiergerippen" and the "todtenbeine" of the cautious sentences of science: "Dotted all over our upland pastures, there is no nobler plant in our indigenous flora than the digitalis purpurea, and there is no more potent benefactor to mankind among the many constituents of our materia medica" (*B. M. J.*, Dec. 14th, 1895, p. 1485).

As a useful but evanescent cardiac stimulant which may at times be combined with other agents having the same object, namely, increase of peripheral blood pressure, mention may be made of citrate of caffein, as also of ammonia and ether, and, under rationally indicated circumstances, of alcohol.

The Belladonna Group of Cardiac Stimulants (Belladonna, Stramonium, Hyoscyamus).—The danger of generalising in so important and practical a field of observation as clinical medicine, is the establishment of a "rule of thumb" with its natural consequences, unreflecting and frequently unsuccessful practice. Believing as I do with Goltz and Gaule (*Pfluger Archiv. f. Physiologie,* 1878) that the heart exercises both the powers of propulsion and aspiration, experience has impressed upon me the conclusion that the dominant feature in some cases is the failure of propulsion, and in others that of aspiration. Of the former, aortic inadequacy is the most important and most usual type, and of the latter mitral regurgitation. From what has already been stated it will be gathered that my own experience has led me to believe that the digitalis group of remedies, and especially digitalis itself, can be pushed most safely and most successfully in aspirative failure. In propulsive failure, that is, in aortic regurgitation, I believe, in opposition to some writers, and notably Dr. George Balfour, of Edinburgh, that the *rôle* of digitalis is a more limited one, and that its beneficial action in some such cases is attributable largely to the increased tone and greater resiliency of the extra cardiac vascular system, that is, the arteries, and moreover, that when the drug has begun to have a decided action upon the heart itself, usually indicated by a fall in systolic frequency, we are on the verge of adding a diastolic aspiration of the aortic blood, coupled with excessive peripheral resistance, to the reflux due to arterial elasticity. Under the circumstances the appropriate agent is a cardiac stimulant which is at the same time an accelerant. The danger of this group of agents is the loss, under their continued influence, of peripheral (arterial) aspiration, as in the digitalis group it is in certain cases the injurious increase of central (cardiac) aspiration which is to be feared. Thus qualified, the generalisation that the digitalis group is most suitable in aspirative failure and the belladonna group in propulsive failure, is, I think, guarded against degenerating into a "rule of thumb."

Withering sagaciously remarks (*op. cit.*, p. 187) that "if inadvertently the doses of the foxglove should be prescribed too largely, exhibited too rapidly, or urged to too great a length, the knowledge of a remedy to counteract its effects would be a desirable thing." He appears to have used various stimulants, that is, accelerants, with comparatively unsatisfactory results. Had he suggested the use of belladonna under these circumstances, I believe he would have added still further to the debt which posterity owes him.

That belladonna and its alkaloid atropia, as also its congeners, are cardiac stimulants, not depressants, when used in certain doses, has been proved experimentally and witnessed in practice. Dr. John Harley, in his excellent work on *The Old Vegetable Neurotics*, published in 1869, which some still consider the most interesting and important work on the subject, states that "the effect (of belladonna) on the heart itself is obvious to the touch. Pulsations which before a dose of atropia are only faintly felt through the chest wall, afterwards become each one very strong, distinct, and still regular, and no artificial contrivance is needed to demonstrate increased pressure of the arterial current, nor, after excessive doses, is the hæmometer required to prove loss of power in the cardiac contractions and diminished arterial pressure" (p. 221-222). "The stimulant effect," he also relates (p. 217) "is so intense that if the dose be excessive signs of exhaustion soon manifest themselves. The maximum effect is observed after moderate doses only; generally $\frac{1}{96}$ of a grain of sulphate of atropia used subcutaneously will be sufficient to produce it; and, as a rule, the dose should not exceed $\frac{1}{48}$ of a grain if we want to induce stimulant effects alone." I have myself saved life by the use of belladonna when the cardiac pulsations had fallen to 10, 15, and 20 in the minute, respiration become for an infant very rare (12) and stertorous, and the surface quite cold (*Trans. of Med. Soc.*, Vol. xvii., p. 48, 1894).

Such results of physiological experiment and clinical experience prove the potency of belladonna as an accelerant stimulant, and the drug has justified its reputation by successful use in those cases in which the digitalis group is contraindicated, or having effected the good possible to it, is about to do harm if continued.

With belladonna may be classed the nitrites in their stimulant and accelerant effect, but the latter is in their case much more evanescent, and the necessity for a frequent repetition of the drug for any but a temporary and urgent purpose is therefore inadvisable. That, however, they do not act merely as peripheral vaso-dilators is shown by their general effect upon the vascular system as already stated. The *nitrates* have been found by Dr. Bradbury (*Lancet*, Vol. ii., 1895) to have a more sustained vaso-dilator action than the nitrites.

In the treatment of cardiac failure it is possible to combine the retardant and accelerant stimulants, but it is well to remember that belladonna in combination with other drugs is apt to assert itself at the expense of that with which it is combined, and to prescribe it in sufficiently small quantity to prevent its undue preponderance.

The Pulmonic and Hæmic Factors.—While the essential cause of cardiac dyspnœa has been stated in this work to be the provocation of a cardio-respiratory reflex by an engorgement of the chambers of the heart with more than their normal complement of blood, the original stimulus to the dyspnœa associated with cardiac failure is none the less the over accumulation of blood referred to.

The recumbent position, while it favours the return of blood to the heart, renders its escape into the systemic arteries more difficult. This fact is easily demonstrable on hydraulic principles and from clinical facts. The greater difficulty of propelling a horizontal as compared with a perpendicular circulation is, moreover, proved by the necessarily greater development of the heart in horizontal animals, that is, in quadrupeds, as compared with the biped, man. This is a fact which I pointed out in 1878 (*Edinburgh Medical Journal*, 1879 and 1880), and an important paper on the influence of gravitation in the circulation of the blood has recently been contributed by Dr. Leonard Hill (*Journal of Physiology*, 1895). A consequence of the easier access of blood to the right heart during recumbency is that, when additional impediment is offered to the escape of blood into the systemic arteries by cardiac failure from any cause, the patient is compelled to sit up or even to stand up, that the return of blood to the right heart and lungs may be limited in amount, and that time may be afforded the left heart to remove blood accumulated in the pulmonic circuit and to propel it into the more easily permeable arteries of the erect circulation. The lungs thus saved from engorgement, moreover, can exercise more powerfully both their aspirative effect on the dextrocardiac blood and their propulsive influence upon the systemic arterial circulation. So long as the blood supply from the inferior caval and the venous system generally is in excess of the disposing power of the left heart by aspiration and propulsion, a steady pressure of blood is maintained in the right heart with continuously increasing distension of its cavities and engorgement of the pulmonic circuit and systemic venous system. To remove this, we have already seen that we can act in various ways upon the neural and muscular factors in the circulation. But it may be necessary to act upon the pulmonic and hæmic factors in cardiac failure directly, by posture, blood-letting, and the inhalation of oxygen gas. It may be shown experimentally that controlling the supply of fluid to a cavity favours aspiration from it. Fig. 41 represents an apparatus which I used for illustrating a paper on the treatment of aortic valvular disease, which appeared in the *British Medical Journal* for March 14th, 1896. *a*, is a mercurial manometer; *b*, a cistern containing water; *c*, is a tin box representing the heart; and *e*, a bottle capable of acting as an aspirator after the establishment of a vacuum within it; *f*, *g*, *h* connect the heart with the manometer, the cistern and tubing representing

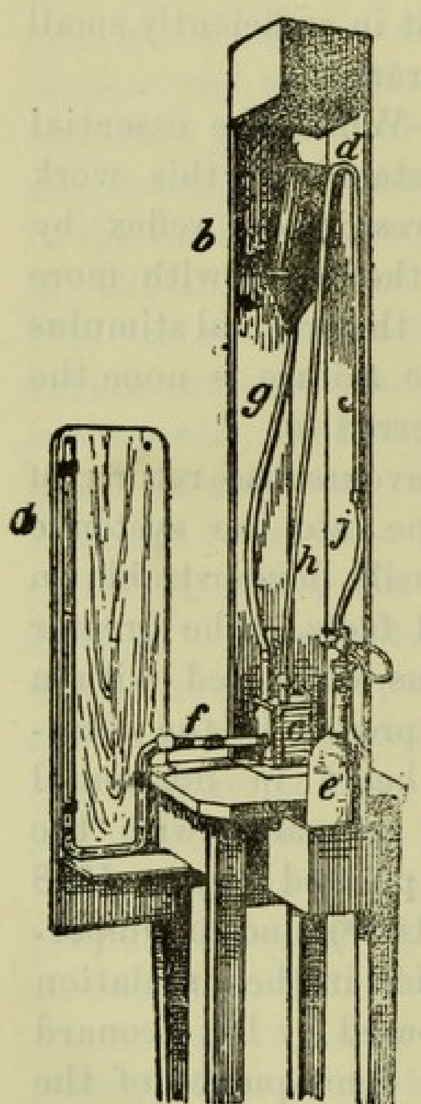


FIG. 41.

the vascular system. The aspirating bottle may be placed either in the box *k* above the level of the heart *c*, or in *m*, below it. It will be found that while fluid is continuously descending from *b* to *c*, the aspirator *e* produces no effect upon the manometer *a*, and of course none upon the heart, *c*. But, the instant the flow from *b* through *g* is interrupted, the aspirator at once acts powerfully upon the contents of *c*, as is shown by a rapid fall of the mercury in the manometer. Thus any measure which reduces the pressure in the venous or supply section of the circulation is calculated to increase the aspirative power of the left heart and the resilient systemic arteries, and to enable the acts of inspiration and expiration to exercise their full influence upon the circulation of the blood.

How may pressure in the right heart and venous system when excessive be advantageously reduced? The means employed in increasing the aspirative and propulsive power of the heart itself have been already discussed. The more direct means of dealing with the venous circulation are by diet, purging, bleeding, and posture. The question of *diet* in heart disease has long been recognised as one of much importance, and the tendency to advise extreme measures has been evinced in this as in almost every other sphere upon which the human mind has been brought to bear. This tendency imparts undue importance to points nevertheless important in their own place and degree, and is as human as it is to err. Against such human errors, fortunately, natural processes are so constructed as in a manner to protect themselves. Thus, if a large quantity of fluid food be administered to a patient whose venous system is already too turgid, the nutriment given is more likely to escape from the intestine than to be absorbed by it. Enough fluid may, nevertheless, be absorbed to prevent the removal of fluid collections in closed cavities. Even in Hope's time that author found (*op. cit.*, p. 409, 3rd ed.) that "both diuretics and hydragogues equally failed" to remove dropsies "until the patient was put upon a dry diet." Subsequent writers, such as Dr. Thomas King

Chambers, have dwelt upon the advisability of a reduction of fluid nourishment in the case of cardiac patients; and Oertel, of Munich, carried the restriction of fluids, some think, to an extreme from which there has been a natural reaction. *In mediis tutissimus ibis.* Physiology and experience alike prove the advisability of such a restriction of fluid in the food of cardiac patients, as is found to be most conducive to adequate renal action, which is a delicate test of the cardiac capacity for dealing with the blood in the body. The amount, naturally, differs in different cases, and it is the duty of the physician, here as elsewhere, to be guided by observation in his prescriptions, and not by rule of thumb. One patient may require more, another less, fluid with his food. For the rest the diet in cardiac failure should always contain a fair amount of nitrogenous material for the repair of muscular tissues, and a limitation of fat-forming material in the case of the obese. It must always, however, be remembered that it is quite possible to starve a patient scientifically to death, and, on the other hand, to kill him by too liberal an amount of meat and drink unreflectively prescribed.

The following table, copied from Dr. Burney Yeo's work *On Food in Health and Disease* (p. 489), concisely exhibits the principles of fat reduction followed in three well-known "systems," and allows comparison with a trustworthy normal average:—

	Albuminates.	Fats.	Carbo-hydrates.
Normal Average in Grammes —Moleschott	130	84	404
Banting...	170	10	80
Ebstein	100	85	50
Oertel	155–179	25–40	70–110

Of these Oertel's proportions appear on the whole to be the most rational.

The action of the *purgatives*, like that of the diuretics found most potent in cardiac failure, is indirect. Fluid accumulations from closed cavities, such as the peritoneum, pericardium, and pleura, are not swept out of the body by way of the bowels, but by the withdrawal of a certain amount of fluid from the blood-vessels, by all avenues for the escape of water; the absorptive power of the pneumo-cardiac mechanism is thus increased, and collections of fluid are then voided by the more vigorous action of the heart upon the emunctories.

Such collections, of which ascites is much the most common in connection with cardiac failure, may, of course, require direct removal by aspiration or trocar puncture, and may, when they embarrass respiration and circulation notably, be so removed with much benefit; but experience alone can fully convince the physician of the rapidity with which digitalis and strophanthus may remove collections which the surgeon considers only amenable to operative measures.

Mercury in moderate doses is highly recommended by Sir William Broadbent (*The Pulse*) as an agent in reducing pulse tension and facilitating the action of cardiac tonics. The use and dosage of mercury in these cases require almost as much skill as that necessary to the effective use of the digitalis group, but its separate or combined prescription, as in the pill already mentioned, rests upon frequently observed beneficial results in practice.

In reducing the turgidity of the venous system, however, there is no means so direct, and at times so useful, as cautious and moderate *blood-letting*.

The human law of an addiction to extreme views is in no sphere so perceptible as in the use and disuse of bleeding. The slaughter by exsanguination, which formerly had the approval of honoured names in medicine, has its correlative or opposite in the death allowed to ensue by a timid shrinking from blood-letting, in accordance with the fashion of the present day. That the truth lies here, as elsewhere, in a rational and happy mean may be argued physiologically and observed clinically. The cases in which I have observed most benefit to arise from judicious blood-letting by venesection or leeching in cardiac failure, have been those in which there has been a pronounced and, so to speak, active turgidity of the dextro-cardial and venous section of the circulation, rather than in the adynamic plethora of a failing circulation. The venous blockage of a strangled circulation, due to emphysema or other pulmonary obstruction, and the pressure of growths or aneurisms on the returning circulation, as well as the distended heart of valvular disease, is more likely to be benefited by moderate blood-letting than the stasis due to myo-cardial degeneration.

"Venesection," writes Walshe (*op. cit.*, p. 41), "as first shown by Piorry, will very sensibly diminish the extent of precordial dulness, especially towards the right side, in persons whose right cavities had previously been loaded with blood. I can," he adds, "from my own observations, vouch for this fact (rarely nowadays to be substantiated, blood-letting is so seldom resorted to.)" It is this relief of tension in the venous section of the circulation, so beneficially brought about in some cases by cautious blood-letting, which permits the aspirative forces in the circulation to re-establish the normal balance in accordance with the physical principles illustrated by the simple experiment I have already related.

That the overleaping of the tricuspid barrier against retrograde stasis is the main indication for most beneficial blood-letting by venesection or leeching is also shown by the experience of the "good old days" of fearless bleeding. Thus Mr. Kinglake (*London Medical Journal*, Vol. x., Part IV., 1789) mentions the case of a young woman with contracted pulmonary artery and polypous concretions in the right auricle and ventricle, who underwent 312 venesections of four ounces each time within two years, that is, she thus lost on an average about eight gallons of blood every six months. A loss of less than four ounces, that is, about a heartful, was found to be useless, and Mr. Kinglake remarks that "To describe the benefit gained by each bleeding would be to exhibit the difference between the most affecting pain and comparative ease." Dr. Hodgkin, writing on "Retroversion of the Aortic Valves" (*London Medical Gazette*, Vol. iii., p. 442), inferred from his experience that bleeding was unsuitable in aortic regurgitation. It would be hazardous to lay down an absolute rule in the matter, and it is probably correct to state that the justification for moderate blood-letting in the present day will be found in a certain degree of dextro-cardial repletion, in a heart of fair general strength, and which is not otherwise relievable.

Similarly the *orthopnœic position*, whether sitting or standing, retards the venous inflow, and enables the heart to equalise a preponderantly venous accumulation of blood. The drugging of an orthopnœic patient into the recumbent position, as has been advocated by some, appears to me for this reason neither to be scientific nor useful. Even though the sitting posture should induce anasarca of the limbs, the latter is to be regarded rather as a natural provision for withdrawing a certain amount of blood from a turgid circulation than as a morbid symptom to be combated by elevating the legs. Anasarca is in these cases a natural form of Junod's pneumatic boot, and may, like the application of that disused instrument, be beneficial. When the heart has redistributed the blood accumulated in the venous system, the patient will of his own accord lie down, and any means which will hasten that process in the orthopnœic position are rational, and will be found useful. But, while dragging the orthopnœic patient into recumbency, may not, on this showing, be advisable, he must on no account be allowed to remain both orthopnœic and persistently sleepless. Sleep must be secured by all the means at our disposal, and the sufferer be permitted to indulge in the sweet oblivion of temporary unconsciousness in any position whatever, and totally regardless of scientific hydraulics.

When, however, the active distress which impels the patient to sit up has subsided, and engorgement of the right heart, as evidenced by a diminution of the signs of dextro-cardiac distension, is less, there is no greater aid to a recuperation of cardiac and general strength than rest in the recumbent position. In this position not only is the return of blood to the heart easy, but the intracranial nerve centres receive their blood supply with more facility, and, last but not least, a slightly raised pressure in the general systemic arteries due to their horizontal course, acts as a gentle stimulant to the left ventricle, and induces a more vigorous coronary circulation. With the greater stimulation by resisted movements of the heart which has failed, we shall have to deal at greater length in a subsequent section. It only remains in this general sketch of the treatment of cardiac failure to mention the utility of the employment of *oxygen gas* as an inhalation when the cyanosis of the patient or his dyspnœic distress is great. For this purpose Brin's cylinders of oxygen gas are convenient reservoirs for it, and its direct use in this manner has recently been more advocated than for some time. The employment of oxygen gas for this purpose is, however, no novelty, for Hope (*op. cit.*, p. 413) quotes Beddoes and others as highly recommending it, and adds, "It is natural to think that, in suffocating dyspnœa from retardation of the blood in the lungs, it would relieve the anxiety and straightness by causing a more perfect arterialisation."

PART IV.

THE TREATMENT OF CARDIAC FAILURE BY BATHS AND EXERCISES.

SECTION I.

THE BALNEOLOGICAL TREATMENT OF HEART DISEASE.

The medium in which a creature habitually lives has an influence upon its organs. They adapt themselves to its environment. This is true in healthy nature, and within certain limits in what man chooses to term "disease," or unhealthy nature. The delicate structures of the mollusc at the bottom of the sea are protected by a powerfully resistant case or shell. The turtle has its carapace and plastron ; the bony fish its scales. The cartilaginous framework of the deep-diving shark encases in gristly channels the abdominal aorta and inferior cava of that animal, while its triple tier of valvular guards at the orifice of the bulbus arteriosus are among the most remarkable evidences of the enormous pressure to which its circulatory apparatus is submitted.

Among animals which live in the rarer medium of air, there is, relatively to their size and habitual altitude, less evidence of natural protection against the weight of the medium inhabited, while birds, used to soaring in still thinner air, exhibit still farther modifications of skeleton and of organs to suit their environment. Such great differences are naturally related to greatly differing circumstances, and a man sufficiently under water, like a pearl-diver without a diving dress, feels as uncomfortable as a fish appears to do when it has recently left its native element. Finally, the phenomena of caisson disease, on the one hand, of the mountain sickness on the other, also show the influence upon the circulation of excessive increase and excessive diminution of atmospheric pressure.

To pass from the contemplation of such extremes to an examination of the effect upon the circulation on man of his being immersed in a depth of about two feet of water with his head comfortably above its level, seems a descent from the sublime in height to the ridiculous in depth! It will be found, however, that such immersion is not without effect, but it will also, I believe, be found that, under circumstances which do not try the organism injuriously, the immediate apparent influence of such will not be so striking as we are sometimes led to believe, unless there be some condition of hyper-sensitiveness in the subject which tends to magnify the influence of stimuli, gentle in degree, and slow yet certain in action.

The properties through which water can thus influence an organism are its temperature, specific gravity, and chemical constitution. Winternitz (Von Ziemssen's *Handbook of General Therapeutics,* English translation, p. 394) considers he was the first to point out the initial *accelerant* effect of cold upon the circulation, which is ultimately retardant, just as the first effect of heat is to slow the heart and finally to quicken it. But here also we are dealing with degrees of cold and heat which as baths find no practical application in cardiac failure, although, as we have already seen, there is a useful and almost indispensable place for both cold and heat in the treatment of heart disease. Professor Beneke, of Marburg and Nauheim, appears, by his writings, to have been the first to remove from the professional and public mind the prejudice against the use of baths in the treatment of cardiac failure. His writings on the subject appeared at intervals between 1859 and 1875. In 1860, the late Dr. Sutro, of the German Hospital, published an abstract in

English of the work on Nauheim of his former colleague—for Beneke appears at one time to have been attached to the German Hospital in London—in which he insists upon the *invariable* occurrence of a retardation of the pulse after the use of the saline baths. But, it must be remembered that at that time Beneke saw very few cases of heart disease at Nauheim, and his observations on the retardant effect of these waters on the pulse and respiration must be regarded as applying *then* chiefly to those without organic heart disease. In his later pamphlet (*zur Therapie des Gelenk Rheumatismus und der mit ihm Verbundenen Herzkrankeiten*, Berlin, 1872), which is a model of candid observation and reflection, he gives a short history of 55 cases out of a total of 101, many of which ultimately benefited from the use of the baths and waters ; but in many of these instances the pulse rate and heart signs of which are given, he expressly states that little immediate effect was observed in these respects. To this important fact, which agrees with my own observations, I shall have to refer again. In 1878 Dr. Groedel published a case of apoplexy with paralysis in connection with heart disease (*Berliner Klin. Wochenschrift*, p. 137), in which he substantiated Beneke's general conclusion as to the strengthening effect of the baths upon the heart and circulation. In 1880, Dr. August Schott published a paper on the effect of these baths upon the heart (*Berliner Klin. Wochensch.*, 1880), and in 1884 Dr. Theodor Schott contributed an article in the same journal on the Nauheim baths, well worthy of perusal (*Die Nauheimer Sprudel und Strom-sprudel Bäder*).

The literature of the subject is now extensive, but the writers named may be regarded as those who have been largely instrumental in bringing into vogue the balneological treatment of cardiac failure, and the first place in having rendered this service must undoubtedly be conceded to Beneke. The general conclusion at which they arrived was, that the effect of baths skilfully employed is to strengthen the force while reducing the rate of the heart's action. All these physicians made their observations and practised, as two of them still do, in Nauheim, and with this town the bath treatment of heart disease is now intimately associated. Before discussing, therefore, the effect of these baths upon the action of the heart, and considering their mode of employment and utility in cardiac failure, it will be of interest to state somewhat concerning the town itself and the character of the waters which have given it a world-wide reputation. It is the more necessary to do this because artificial baths used for this purpose elsewhere are prepared in imitation, so far as possible, of the natural waters of Nauheim.

The pleasant little town of Nauheim in Hesse Darmstadt, intersected by leafy avenues, is situated on the north-eastern slope of the Taunus range, at an altitude of 460 feet above the sea level. From its situation and the disposition of its buildings, a visitor to the town is sensible of a certain freedom in the circulation of the air and a freshness in the atmosphere recalling health resorts at a greater altitude. Even in hot and sultry weather there seems to be an absence of the oppressive heat experienced in situations of a more sheltered character. Built as it is at the foot of a hill, there is a gradual ascent in the street gradient hillwards, which the pedestrian may convert into a climb by gaining the summit of the Johannisberg or exploring the hill country in the neighbourhood.

The waters of Nauheim for our present purpose may be roughly divided into the bathing and the drinking waters, of which the former are much the more important, and the use of the latter does not concern us while discussing the treatment of cardiac failure.

The sources of the bathing waters are the Grosser Sprudel, or Spring No. 7, and the Friedrich Wilhelms Quelle, or Spring No. 12. Of these the latter is the more copious, the warmer, and contains the larger percentage of solids, while the former contains most carbonic acid. The following particulars issued by the Grand Ducal Commissioner at

Nauheim afford useful information as to the nature and constitution of these waters. The analyses of these springs are those of Professor Will, of Giessen.

SPRINGS.

Constituents in 1,000 grammes of water.	No. XII.	No. VII.
Chloride of Sodium ...	29·2940	21·8245
,, Lithium ...	0·0536	0·0492
,, Potassium (Cæsium and Rubidium)	1·1194	0·4974
Chloride of Ammonium ...	0·0712	0·0550
,, Calcium ...	2·3249	1·7000
,, Magnesium ...	0·5255	0·4402
Bromide of Magnesium ...	0 0083	0·0060
Iodide ,, ,, ...	Traces	
Sulphate of Calcium ...	0·0352	0·0347
Sulphate of Strontium (with Baryta)	0 0499	0·0390
Bicarbonate of Calcium ...	2·6012	2·3541
,, Iron ...	0·0484	0·0383
,, Manganese ...	0·0069	0·0065
,, Zinc ...	0·0089	0·0104
Silicic Acid	0·0213	0·0325
Arseniate of Iron	0·0002	0·00036
Phosphate of Iron... ...	0 0007	0·00046
Oxide of Copper	Traces	Traces
Chloride of Thalium / Oxide of Lead ...	Traces	Traces
Nitric Acid	Traces	Traces
Organic Substances ...	Traces	Traces
Total Solids	36·1696	27·0886
Free Carbonic Acid*	1·0074=574 c.c.m. at 35·3 deg. C.=95·5 deg. F.	1·2634=738·4 c.c.m. at 31·6 deg. C.=88·8 deg. F.
Further particulars.		
Specific Gravity	1·02757	1·02088
Temperature Celsius ...	35·3 deg.	31·6 deg.
Temperature Fahrenheit	95·54 ,,	88·88 ,,
Outflow in 24 hours in cubic metres.		
1. Normal	1725	782
2. Valves half closed ...	780	490
Depth of Well in Metres ...	180	159·5

A Nauheim Sprudel bath of 500 litres, Spring No. 12, temperature 35 degrees C., contains 18·17 kilogrammes of

* More recent estimation of the quantity of carbonic acid in the springs shows a higher percentage.

solid constituents; 517 grammes = 294 litres of free carbonic acid gas.

A Nauheim Sprudel bath of 500 litres, Spring No. 7, temperature 31 degrees C., contains 13·43 kilogrammes of solid constituents; 644·3 grammes = 376·3 litres of free carbonic acid gas.

A Nauheim Thermal-brine bath of 500 litres, Spring No. 12, temperature 30 degrees C., = 86 degrees F., contains 254 grammes =127 litres of carbonic acid gas.

A Nauheim Thermal-brine bath of 500 litres, Spring No. 7, temperature 30 degrees C., = 86 degrees F., contains 571 grammes = 324 litres of carbonic acid gas.

The water which is not required for bathing purposes is conducted to the salt works in the neighbourhood, where the Gradirgebäude or evaporating screens form a grateful shelter from the heat in warm weather. From these salt works is obtained the *mutterlauge* or motherlye, the supernatant fluid with uncrystallisable ingredients in the vats in which the salt is deposited. By the action of the evaporating screens referred to, the water reaches its final stage for treatment in a much concentrated condition. This mutterlauge is used for adding to the thermal baths and increasing their saline potency, and their temperature may be further modified by the addition of ice when it is desired to reduce their normal warmth. The analysis (see opposite page) of the motherlye obtained from the same source as that already quoted is of interest.

Although an ordinary brine bath of any temperature or strength, artificially regulated, may be had at Nauheim, those chiefly used by patients are: (1) the "Thermal bäder," or thermal brine baths, either from both springs combined or from one only. In these there is a minimum of carbonic acid, and, coming as they do from the open reservoirs, they have a turbid, yellow-red and not very inviting appearance, from ferruginous salts present; (2) the "Sprüdelbäder," or effervescent baths, which, being conducted from the bowels of the earth directly into the baths, are clear, have the

ANALYSIS OF MOTHERLYE.

Constituents in one litre.	
Chloride of Sodium	21·957
" Lithium	14·588
" Potassium ... (Cæsium and Rubidium) ... Chloride of Ammonium	60·830
" Calcium...	382·104
" Magnesium	76·518
" Strontium	8·408
Bromide of Magnesium	1·506
Sulphate of Calcium	0·376
Carbonate of Calcium	5·415
Nitrate of Calcium	4·427
Total Solids	576·129 grms.

The specific gravity of the motherlye is 1·392.

normal warmth of the springs, contain a maximum of carbonic acid, and are as inviting to enter as the turbid baths are repellent. There is, however, within the depths a deeper still, and (3) "the Strom-sprudelbäder," or the baths in which, in addition to warmth and carbonic acid, there is a constant current of salt water entering and escaping from them, are the most powerful of the therapeutic baths at Nauheim, and usually the last to be prescribed. To those in health they are at once a novelty and a joy.

Inasmuch as only a moiety of mankind can find their way to Nauheim, it is fortunate that the main qualities of its waters may be sufficiently reproduced in any place in which water containing a certain proportion of their chief ingredients, raised to a certain temperature and caused to effervesce by the liberation of carbonic acid, can be obtained.

Artificial Saline Effervescent Baths.—Taking the Nauheim waters as the type for the therapeutic brine baths used in the treatment of cardiac failure, it will be observed, from an examination of the analyses given, that the chloride of sodium and the salts of calcium are its main solid constituents, while the temperature of these waters and their containing a considerable amount of free carbonic acid are their other important characteristics. It will be observed also that the material employed for increasing their solid contents (motherlye) contains, per litre, more than 18 times as much of the salts of calcium as of sodium, and twice as much of the former as of all the other constituents taken collectively. Chloride of calcium is a very deliquescent substance, with a bitter, acrid taste, which was at one time regarded as stimulant to the glandular structures, and a tonic and deobstruent, and its use as an addition to these baths is probably due to its stimulant action upon the skin. It is unquestionably a more irritant salt than the chloride, and its addition to the artificial baths is calculated to increase their stimulant effect upon the sensory structures in the skin. Its use, therefore, in regulated proportions, cannot be regarded as a superfluous addition to the strengthened brine bath. A litre of motherlye, containing as it does about 12 ounces of chloride of calcium, and six ounces of the other solids contained in the Nauheim waters, the addition of that quantity of the calcium chloride and of six ounces of sodium chloride to the artificially prepared baths, or of multiples of these according as the effect of one two, or three litres of motherlye is desired, will reproduce the conditions obtaining at Nauheim when this addendum is made to the natural waters. But the artificial imitation of the natural waters, of course, also contains a certain proportion of chloride of calcium apart from that added to represent the motherlye.

In the preparation of artificial baths, an element of the first importance is the receptacle for water, or the bath itself. It should be so constructed, that entering and leaving it should be possible without undue exertion on the part of the patient, and that reclining in it should be comfortable and without constraint. When baths are not specially constructed for balneological purposes, or are not otherwise of a luxurious type, it is possible by foot rests and so forth to render their use easy, while the help of a nurse or attendant may greatly aid the patient in these particulars.

The quieting influence of the bath may be largely undone if undue exertion in any of these respects be imposed upon the patient. In fact, a violent form of gymnastics may thus be inflicted upon him, and all the acceleration of circulation characteristic of active exercise be thus brought about. This is not the end in view.

Mineral carbonated baths are not usually put into metal receptacles. Those at Nauheim are of wood. Even when of marble it is customary to empty them as soon as possible after use to avoid the chemical action of some of the ingredients upon the receptacle. It is especially necessary in the case of artificially prepared baths that metal should be protected from the action of acids by wood lining, enamel, porcelain jars or other expedient. An ordinary full-sized domestic bath, however, such as can be obtained, or exists in most houses of the present day, even of a modest type, will answer every purpose, provided it be sufficiently long, deep, and broad, and protected in some way from corrosion. A very usual kind of bath is one which is about five and a half feet long in its highest plane, about two feet deep, and rather more than two feet wide. The usual reclining angle in such a bath is about 40 degrees, and the average lateral angles 20 degrees. If, therefore, the trunk of a patient, to the level of the clavicles, and at right angles to his legs, measure about 24 inches, the perpendicular dropped from the same point, in a position reclining at about 45 degrees, will be 3-4 inches less. The depth of the water, therefore, for a full bath must be about 20 inches. In considering, therefore, the amount of water to be placed in a bath of the above description, we must have regard to the size or displacing power of the patient's body. This may be roughly guessed in any case, and easily determined by experiment in every case. In a bath of the dimensions stated, to raise the level of the water without the displacing influence of the patient's body to a height of 8½ inches requires 30 gallons, for 10 inches 37 are required, for 11½ inches 44, for 13 inches 52, for 14½ inches 59, for 16 inches 67, for 17 inches 74, and for $17\frac{1}{2}$ inches 82 gallons of water. The larger baths at Nauheim contain 500 litres, or about 106 gallons. The temperature of artificial baths is, of course, easily regulated by means of an ordinary bath thermometer.

The question of the amount of saline and other ingredients is for many reasons the most important. In the first place, the price of a systematic course of saline and gaseous baths is a matter of importance to those in whom the inconveniences of disease are complicated by poverty. The less, therefore, of purchasable ingredients necessary for an effective bath the better for them. Now, in the chemistry of nature, the solution of ingredients is effected under conditions in which a fairly high specific gravity may be attained by mineral waters, without their stimulating the skin too much, but an endeavour to attain a like specific gravity in artificial baths will be found to entail the use of large quantities of solids, and, when attained, the bath will be found to be too irritating to be comfortable. It is fortunate, therefore, for many reasons, that a sufficiently stimulating bath can be made with a comparatively small quantity of material.

The waters of Nauheim have, as has been stated, a specific gravity of 1020 to 1027 at their normal temperature, and it is, naturally, somewhat higher when the water is cold. The waters of the Atlantic Ocean and North Sea, which surround our shores, contain about the same proportion of solids as the Nauheim springs, namely, 3 per cent., and have about the same specific gravity. A specimen of sea water obtained at Worthing had a specific gravity of 1·027 at a temperature of 55 degrees F., and warmed to 90 degrees would fall about two points. Sea water, with effervescing tablets, and a certain amount of chloride of calcium, would make an excellent artificial Nauheim bath, but it is frequently difficult to obtain and warm a sufficient quantity of sea water in private houses, although doubtless the time will come when this will be a comparatively easy matter.

In the absence of such natural solutions we must resort to cruder methods of mixture. To produce a bath having a specific gravity of 1020 in a 50 gallon bath at a temperature of 96 degrees F. requires about 13½ lbs. of salt, while to produce a similar specific gravity in a bath 16 inches deep, or equal to 67 gallons of water, takes more than 21 lbs. of salt and will then be found too irritating for use. A bath having a specific gravity of 1·010 to 1·015 will be found to be sufficiently stimulating, and this may be secured by adding chloride of sodium to water in the proportion of about 8 lbs. to 40 gallons of water at a temperature of about 90 degrees.

The proportion of chloride of calcium in the natural springs at Nauheim is, as will be seen (p. 113), about $\frac{1}{13}$th of the amount of chloride of sodium. If, therefore, we use about 8 lbs. of salt in the artificial bath we shall require about 8 ounces of the chloride of sodium in a 40-gallon bath, and more may be added to represent mutterlauge. As has been already stated, a pint of mutterlauge contains (p. 115) about 12 ounces of chloride of calcium, and that amount may be tentatively added and its effect on the skin noted. A pint of water dissolves about 5 ounces of pure anhydrous chloride of calcium, with the evolution of about 20 degrees Fahr. of heat. Five ounces added to a pint of water at 50 degrees F. caused the temperature to rise to 72 degrees F., and yielded at a temperature of 56 degrees F. a specific gravity of 1·150. It is most convenient, therefore, to dissolve the added calcium chloride before it is put into the bath, especially if the harder fused variety be used, which takes longer to dissolve. Leith (*Lancet*, March 28, 1896, p. 841) found that the addition of calcium chloride or barium chloride to artificial baths in the proportion of 1½ to 2 ounces for 10 gallons had no appreciable effect, but, inasmuch as acute dermatitis may be induced by the addition of mutterlauge to baths, I do not think that calcium chloride in sufficient amount can be regarded as an inert ingredient.

The third essential ingredient of the artificial Nauheim bath is carbonic acid, which may now be conveniently employed in the form of acid tablets and packets of powder patented by Sandow, a chemical manufacturer of Hamburg.* The quantity of gas capable of being generated by a boxful of these substances is said to be 4,000 to 3,500 cubic centimetres per gallon in baths of 45 and 55 gallons respectively, equal to a total amount of 180 to 192 litres per bath. The volume of the gas, naturally, increases with the temperature of the water, and cannot, in the artificial bath, attain quite the intimate admixture which obtains in nature; but it will be observed by comparison with the analyses given (p. 113) that per gallon the quantities evolved artificially are greater than at Nauheim. Dr. Gröedel informs me that in processes patented by Keller and Lippert and Ploch larger quantities of carbonic acid are absorbed by the bath water than in Sandow's process, and considers that in any case the Nauheim waters contain a larger proportion of therapeutically active carbonic acid than the artificial baths. Thus, taking the water of Spring XII. at 95 degrees F., a bath of 45 gallons of this water would contain 124 litres of free carbonic acid, whereas an artificial bath with the whole boxful at the same temperature would contain 180 litres. Spring VII., which contains the larger proportion of carbonic acid, would, under similar circumstances, yield about 147 litres per 45 gallons. In the Strom-sprudel, or current effervescent natural bath, the quantity of carbonic acid is more constant than in others, from its being constantly replenished in steady quantities, and it would be quite easy to devise means for administering a similar bath artificially by means of a reservoir of warm water charged with gas at a certain pressure, but such an apparatus does not at present, so far as I know, exist, and it might be worth the while of an engineer to devise one. A half to two-thirds of a boxful of Sandow's material will, therefore, be sufficient for ordinary use, and may at first be employed in even smaller quantities, and induce the superficial stimu-

* The tablets consist of bisulphate of soda with an acid reaction, and the powders of bicarbonate of soda.

lation which is one of the effects of the carbonic acid evolved. Care must be taken to secure the admission and circulation of a sufficient quantity of atmospheric air during the evolution of large quantities of carbonic acid, and as carbonic acid is heavier than atmospheric air ventilation must be such as to keep it towards the ground and not drive it upwards.

Just as in using the natural waters it is customary gradually to increase their saline and acid potency, so, when employing artificial baths their ingredients may be gradually added to and their superficial and vascular effects noted. The hydrometer is as essential an instrument of the medicinal bath-room as the thermometer, and a valuable check upon the correct use of the scales, provided a table of specific gravities be available. I have already given a few notes which may be serviceable in this respect.

Mode of Administration and Dosage of the Baths.—The Nauheim baths, as has been stated, contain 500 litres of water, that is about 106 gallons. These are the so-called "full baths," but in the case of those with a greatly embarrassed circulation it is deemed advisable to prescribe a "half bath," that is one in which the water reaches a considerably lower level on the body of a patient, who is in a sitting posture in the bath, the object being to diminish the water pressure on the patient's surface, and especially upon his thoracic region. At the commencement of a course it is customary to prescribe baths at their normal temperature of 35 to 31 degrees C. (95·5 to 86 degrees Fah.), and the patient is directed to remain in them for short periods of seven to ten minutes, which are gradually lengthened to fifteen or twenty minutes. With the increased duration of the baths their temperature is gradually lowered if the condition of the patient permit it, until it reaches about 28 degrees C. (80 degrees F.); their carbonic acidity, and their salinity by the addition of motherlye, being *pari passu* increased also. One, two, or even three litres of motherlye may be added. Beneke at times used six and even nine litres as an addition to the brine baths, but was well aware of the irritant action of chloride of calcium in large quantities on the skin, and deprecates its "too frequent and indiscriminate employment" (*The Warm Saline Springs of Nauheim*, p. 9). At the beginning of a course the pauses between the baths are more frequent than later, and the condition of the patient should at the same time be carefully noted, so that bathing may be entirely prohibited if necessary. It is not unfrequently necessary for a patient to rest quietly for some days before any bath is taken. That these precautions are not superfluous is proved by the fact that, like most agencies potent for good, the baths unskilfully employed are likewise capable of exercising an evil influence. It is of interest in this connection to state that in an old account of the mineral springs of Nauheim, written by Dr. Rotureau, of Paris, and translated by Dr. F. Bode in 1856, it is expressly stated that, far from benefiting cases of organic heart disease, the waters of Nauheim had been found to be actively pernicious, causing disorders of the circulation, blood-spitting, etc. This, however, can only be regarded as indirect testimony to their possible utility under the conditions of wiser use which now prevail.

The general mode of life of the patient is also regulated. He goes early to bed, and has frequently to rise early for his bath, as the number of applicants for immersion is great. In the case of those with specially embarrassed circulation, however, it is usually possible to arrange some hour in the forenoon or about mid-day, when the force of the patient, recuperated by a night's rest, is greatest, and this is a point which ought never to be overlooked. Dietetic considerations did not appear to me to receive so much attention at Nauheim as is sometimes the case, and there is no excessive restriction of fluids. But as I have elsewhere stated (p. 104) a judicious application of the laws of diet, both as regards quantity and quality of food and drink, is applicable in these as in all other circumstances, and are probably adhered to more or less. The patient is directed to rest, generally in a recumbent position, for an hour or two after the bath, to avoid excitement and circulatory constriction, and to be cautions in the use of tobacco and stimulants. Experience has caused physicians at Nauheim to draw a rational distinction between the saline baths with and those without carbonic acid, and the indications for the employment of one kind or the other are clearly stated in an article upon these baths by Dr. August and Theodor Schott, which was published in the *Berliner Klinische Wochenschrift*, Nov. 19, 1884. It is there pointed out that the chief object of using carbonic acid is to increase the stimulating effect of the baths upon the skin, and that this stimulant property is more evanescent as well as more quickly produced than by the use of the saline baths alone. It is useful, therefore, under circumstances in which a more prolonged saturation of the skin by the brine baths would be productive of persistent skin irritation with eczema and broken rest. As employed in the treatment of cardiac failure, it is advised that carbonic acid be added to baths either when the case is one of moderate severity or when it is sufficiently convalescent, and they remark that "It is quite necessary, to secure the full effects of the 'Kur,' even more than in other cases, to use the stimulating ingredients in such quantities, and gradually so to increase them, that beyond a transient and wholesome sense of fatigue—and this only exceptionally—every other sense of discomfort is avoided as a sign of over-irritation." In consequence of this specially stimulant quality of the gaseous baths it has been observed that the anæmic with a comparatively cold surface tolerate the full brunt of the carbonic acid stimulation better than those of a more plethoric habit and a higher degree of vascular and nervous irritability.

The Effect of the Nauheim Baths.—The impression on the skin on first entering a bath of about 90 degrees F. is a pleasant degree of coolness, which generally gives place to a sensation of increasing warmth. When much free carbonic acid is present the immersed surface becomes covered with minute bubbles of gas, and on leaving the bath the skin is observed to be very distinctly reddened. The circulation of a person with a sound heart and vessels becomes slower, and this, as a rule, out of proportion to the normal retardation of recumbency, provided there be no emotional excitement to counteract this effect. The elimination of the latter factor is best secured by examining those in whom the first novelty of the baths has passed of. The results of a *first* bath are not, on this account, trustworthy.

With a view to determining for myself the effect of the Nauheim waters on the circulation in normal and diseased conditions of the circulation, I paid a visit to Nauheim in the summer of 1896, and through the courtesy of Medicinalrat Dr. Gröedel and Dr. Theodor Schott, I had an opportunity of examining some cases in the baths. The majority of the bathing cases which I observed were in the practice of Dr. Gröedel. For the opportunity of observing the effects of manually administered gymnastic exercises, so intimately associated with his name, I was chiefly indebted to Dr. Theodor Schott, and shall refer to this in its proper place.

SECTION II.

THE BEHAVIOUR OF CASES DURING AND AFTER BATHS.

BEFORE summarising my conclusions as to the effects of the baths in cardiac failure, I shall follow Beneke's example by relating shortly in a few cases the facts observed both at Nauheim and in England. Having to deal with patients who only kindly permitted me to accompany them, I could not always make a detailed examination, and have deemed it best to transcribe short notes made at the time.

CASE I.—Male, æt. 61. Denied having had rheumatic fever, although his history of an attack suffered 30 years previously resembled that disease. Had served in the Austro-Prussian and Franco-German wars. Had come to Nauheim on account of dyspnœa, lived carefully, taken the baths, and benefited. He had the apex systolic bruit of *mitral reflux*. After walking to the bath a quarter of a mile, pulse 120. Sprudel bath; temp. 32 degrees C. Full bath, 15 minutes. In bath R. 24; P. 96; regular. Immediately after dressing P. 96; slightly irregular. After sitting a few minutes P. 90; regular.

CASE II.—Prof. D., æt. 70. Met him at bath-house. Sprudel bath. Before the bath, P. 120; no bruit; no valvular lesion. Sphygmogram taken.

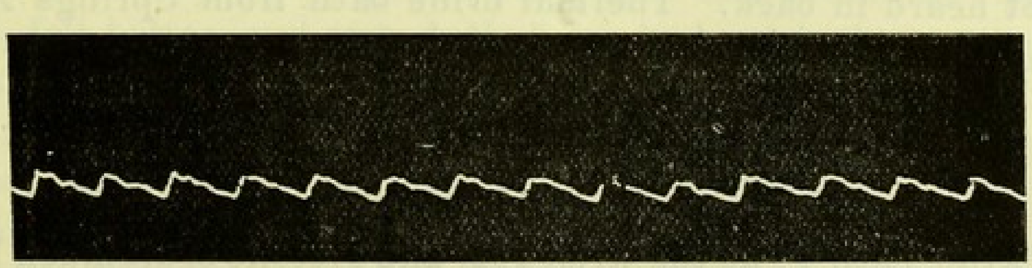


FIG. 42.—Before the Bath.

Immediately after the bath and drying P. 108, and occasionally intermittent. After resting a short time P. regular, 108. Sphygmogram taken.

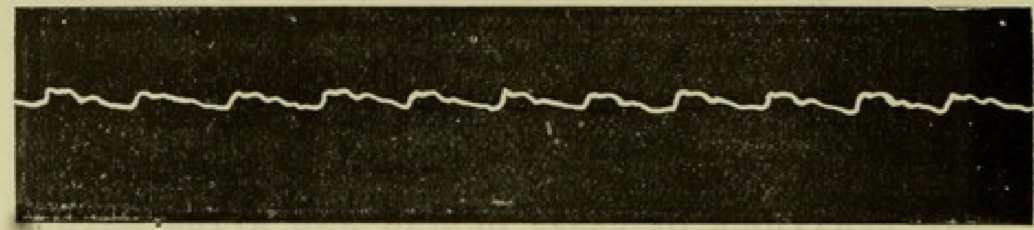


FIG. 43.—After the Bath.

CASE III.—Myself, æt. 45. Note made at hotel. "Just returned from Bath-house No. 5, where I lay for fifteen minutes in a Stromsprudel bath of Spring XII.; water at a temperature of 32·5 degrees C. Half an hour before entering the bath, having fasted and walked about since early breakfast of coffee and bread and butter at 7 a.m., and having been out at 6 a.m. to see Prof. D. in his bath, at 11 a.m. I took coffee and rusks and butter, and smoked a light cigar, so that for half an hour before I entered the bath my pulse while sitting was 90, and quite regular. It became quieter in the bath, which I entered about 11.30, and remained quite regular. Immediately after the bath, after drying and while sitting, it was 60 to 66. Five minutes later, while partly clothed, it was 72. After fully dressing and walking through a long corridor and then sitting down it was 78. It is now (12·40) 78-84, which is my normal pulse."

CASE IV.—Herr R., æt. 55. Weight 189 lbs. Two campaigns. Never had rheumatic fever. Urine normal. Before the bath, pulse at wrist 78, intermittent; at heart, 102; systolic bruit at apex, not constantly, but frequently heard; not heard in back. Thermal brine bath from Springs XII. and VII. Temperature 33 degrees C.

In bath 5 minutes, P. 90; more regular.
" 10 " P. 90.
" 14 " P. 90-102 at wrist.

After bath P. at the wrist 102, and systolic bruit much less frequently heard.

CASE V.—Herr W., æt. 66. After walking quarter of a mile pulse 120, regular, before entering bath. *Systolic apex bruit* not heard in back. Sprudel bath reduced by ice from 33 degrees C. to 31·75 degrees.

In bath 5 minutes,	P. 90,	regular;	R. 30.
„ 10 „	P. 90	„	R. 24-26.
„ 13 „	P. 90	„	R. 24.

After bath *bruit* more distinct and prolonged. Skin reddened on coming out of bath. Energetic, neurotic little man, with considerable sense of humour.

CASE VI.—The following is in many respects an interesting and important case. On July 3rd, 1896, I saw, with Dr. Gröedel, Herr T., æt. 58, who had never had any serious illness, and had served through three campaigns. In Berlin, where he resides, had been under the care of Prof. Gerhardt on account of anginal pains with swelling of the lower extremities and dyspnœa, which forced him to sit up at night and prevented sleep. He was treated with digitalis and squills, but without benefit. On Prof. Gerhardt's recommendation he came to Nauheim, where he continued to take the remedies prescribed for him in Berlin.

Under Dr. Gröedel's supervision he began the use of Sprudel baths at a temperature of 33 degrees F., having at first "half baths," the level of which was gradually raised. Soon after the commencement of this balneological treatment he urinated freely, and began to experience an amelioration of his condition. So much so that he abandoned the use of his medicines, but forthwith relapsed into his former condition. Resuming his cardiac tonics and continuing his baths, he again soon experienced benefit, and at the time when I saw him his pulse rate had fallen, he slept well, felt better, and stated that he had not had an attack of angina since his arrival in Nauheim. On examination the area of cardiac dulness was increased, the cardiac impulse exaggerated, and the pulse had the characteristic "water-hammer" sensation of aortic incompetency. There was a well-marked double aortic bruit with some mitral regurgitation. Up to the date of my seeing him Dr. Gröedel had observed no alteration in the dimension of percussion dulness. Next day I accompanied Mr. T. to his bath at 10 a.m. He took a "half bath" of a temperature of 32 degrees C. Before entering the bath his pulse was 90 and regular.

On first entering the bath, P., 90; R., 28.
In bath 5 minutes, P., 90; R., 26.
" 10 " P., 90; R., 24-26.
" 15 " P., 90; R., 24.

After the bath, after drying and partially clothing, his pulse was 84.

The patient still has some anasarca of the legs, but much less than formerly. He has lost much weight, but his urine contains neither albumen nor sugar. On July 5th I again accompanied Mr. T. to his bath, which was a "thermal bath" from Spring No. 7, of a temperature of 33 degrees C., and with 2 litres of mutterlauge added. Before undressing his pulse was 82, the bruits the same, and I noted their loudness.

After he had been in the bath 4 minutes, P., 82; R., 30.
" " " " 8 " P., 82; R., 30.
" " " " 11 " P., 82; R., 30.
" " " " 13 " P., 80; R., 30.

But the pulse at the last stage of the bath was variable—its rate in ten seconds being sometimes 14, sometimes less. After the bath his pulse rate determined by me was 82; by his son, who was a medical student, 84.

Before the bath, percussion of the heart yielded the following results:—Upper point of left ventricular border, the 4th left rib; apex, 6th space, 13 centimetres from the mid-sternum. Upper border of liver, 6th rib.

After the bath, left ventricular border and liver line in the same position; apex beat 12 centimetres from the mid-sternum. The bruits a very little more audible than before the bath.

On July 12th I again examined Mr. T., and made the following note:—Apex, 6th space, chief impulse $9\frac{1}{2}$ centimetres from mid-sternum. Outer limit of apex percussion dulness 12 centimetres from mid sternum. Upper limit of left ventricular border coincides with the upper border of the 4th left rib; the upper liver line with the upper border of the 6th rib; the right auricular outline with the right edge of the sternum. Area of cardiac dulness 16 centimetres × 12. *Bruits.* Double aortic basic; apex systolic (mitral). Still some œdema of legs, but much less. The left more swollen than the right. Feel much better in every way. To-day for the first time has been able to lie comfortably on a sofa. Has taken in all 17 baths. I had no further opportunity of examining Mr. T., but met him taking gentle exercise with his son through the town, and learned from him that he was progressing favourably, and had abandoned the use of his drugs.

Case VII.—Dr. K., æt. 67. Slow pulse with slight cardiac dilatation. Sprudel bath from No. 12. Temperature 31·5 degrees C. Duration 15 minutes. Before: Pulse 66. The left ventricular border was in the third interspace. Apex, 5th space, 11 centimetres from mid-sternum, determined by auscultation; could not be felt. Second sound reduplicated.

In bath 4 minutes, P., 60; R., 18; occasional intermission of pulse.

„ 10 „ P., 56; R., 14.

„ 15 „ P., 55.

Immediately after, while sitting, P. 54, regular. Area of cardiac dulness, apex beat, and reduplication the same as before the bath.

Dr. K. came to my hotel at 6.30 on the evening of the same day. Lying on the sofa, his pulse was 54; sitting 60. A little later, while sitting on the sofa leaning back, his pulse was 52, and sitting up also 52. The reduplication of his heart was as in the morning. He had when I saw him taken 20 baths, and his pulse had throughout been 54.

It might be thought that we had, in this case, to deal with an unimpressionable case of what Dehio calls cardial bradycardia, but, on the day after I accompanied him to his bath, we paid a visit to Marburg together, and during our ascent of the steep hill which leads to the castle, I made the following observations on his pulse. Half-way up the steep hill his pulse was 102, and regular. After seeing the castle, and when about half-way down, it was 60. In the train on the journey between Marburg and Nauheim, his pulse was also 60, and he stated that he had enjoyed the whole afternoon, climbing included, and felt well. The following are sphygmograms of his pulse before and after the bath.*

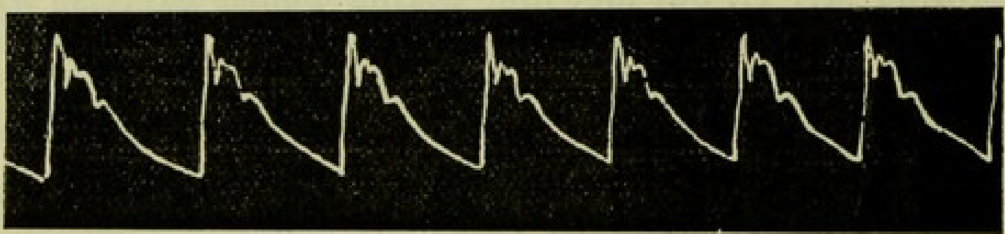


FIG. 44.—Before the bath.

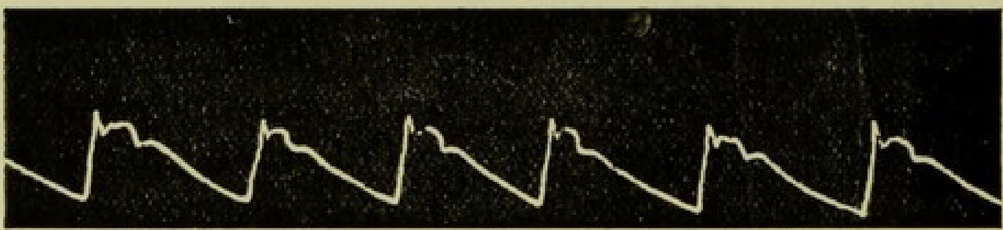


FIG. 45.—After the bath.

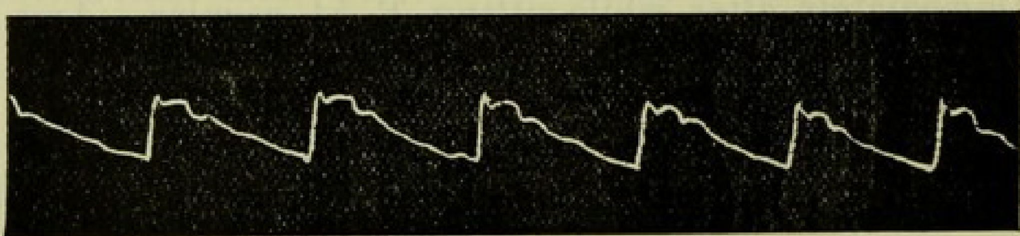


FIG. 46.—After the bath.

* Dr. Gröedel informs me that Dr. K. had previously suffered from paroxysmal tachycardia and irregular heart, and that he only experienced one such attack at Nauheim and that after a feverish bronchitis (Influenza ?).

The character of the curve in the sphygmograms taken after the bath is the same, although the systolic stroke differs slightly. The higher systolic stroke and greater vibration of that taken before the bath is partly due to the pressure with which the instrument was applied, for the arteriometrical measurement of the radial before the bath was 1·4 and after 1·3 to 1·4. The diameter of the artery was not quite so great after as before the bath.

Case VIII.—Herr W., æt. 44. Had "typhus" when 15 years of age. Since the age of 17 had had irregular heart's action. In December, 1895, his factory was burnt down, and the mental anxiety and annoyance caused thereby, had produced a deteriorated condition of health with increased irregularity of the pulse. On the first occasion on which I saw him, he had just returned from his bath. His pulse at the wrist was 78, and at the heart 102; the apex beat was diffused and difficult to localise; on auscultation there was no bruit. On July 7th I met him at his bath, and made the following observations between 9.15 a.m. and 9.50 a.m. Sprudel bath: temperature 31 degrees C. Left ventricular border and apex beat determined. Before bath pulse at wrist 72, and at heart 84. More regular than when last seen. He had had a better night than usual. On getting into the bath, respiration 24.

In bath 10 minutes, P., 60-66; R., 18-24.

„ 14 „ P., 72-84, and still irregular.

After bath, P. 72 to 84, and the same at the heart. No notable change in the left ventricular border (third space); apex beat weak and diffused 4 inches from mid-sternum before and after bath. Heart sounds about the same, action rather more regular; has been five weeks at Nauheim, and has felt decidedly better for a week. Before that, his sensations of well-being varied.

Case IX.—Mr. L., æt. 25. Had had rheumatic fever with valvular endocarditis. Apex beat in the 5th space and in the nipple line; aortic diastolic bruit. Saw him in his bath. Dr. Newton Heineman, a coadjutor of Dr. Schott, present. Thermal bath: temperature 30·5 degrees C. Two litres of mutterlauge added. The pulse in the bath remained steadily from 90 to 96. The apex beat, which was easily observed, was quite unchanged in position, before and after the bath. The loudness of the bruit was a little greater after than before the bath, and the pulse after the bath was 84. The observations on the pulse were made by Dr. Heineman in my presence. Pulse pressure after the bath with Bach's sphygmomanometer, 15·75 mgrm., as compared with 14·5 to 15 mgrm. before the bath. Calibre of radial artery as determined by Oliver's arteriometer, 2·3, 2·6, 2·7 after, as compared with 2·1 and 2·3 before the bath.

Case X.—Herr H., æt. 54. A farmer who had been a great beer and spirit drinker, came to Nauheim on a former occasion cyanotic and suffering from anasarca. The area of his cardiac dulness was increased, and there was a doubtful murmur of mitral incompetency. He only took baths at Nauheim, abandoned drinking, and improved greatly. He was under Dr. Schott's care. Examined by me on July 10th, 1896, the area of cardiac dulness in the standing posture was 16 centimetres × 10 centimetres; the apex beat was in the 5th space 10 centimetres from mid-sternum, P. 126 and no bruit. On July 12th, I met him at bath house No. 1. Bath temperature 31 degrees C. Before bath pulse 132; after having been 11 minutes in the bath, pulse 132. The general outline of the heart remained the same before and after the bath. The apex beat after the bath was not more than 1 centimetre nearer the middle line than before the bath, and examined a second time two minutes later about the same distance above the other two points. Dr. Heineman made the upper point of the left ventricular border ·75 centimetres lower than I did. The patient was somewhat emphysematous, and had a dilated heart, and was also anasarcous.

Case XI.—Dr. G., æt. 62, stout, came to Nauheim in a very feeble condition, suffering from cardiac dilatation. He had also had attacks of angina pectoris. On his arrival, he was too weak to take the baths, and rested for two days. He then took his first bath. On the occasion of taking his first two baths he was accompanied by two medical men, who found no change in his area of cardiac dulness, and he, no alteration in his sensations. On the occasion of his third bath, being accompanied by the same gentlemen, *he* experienced a sense of relief in his breathing, and *they* determined a shrinkage in his area of cardiac dulness. From that time he continued to improve, and was allowed a fortnight later to commence manual gymnastic movements. When I first met him, he had been six weeks at Nauheim, was capable of considerable exertion in walking and public speaking, and of the latter did too much. On July 10th, 1896, I went with him to his bath, together with Dr. Rives of New York. I determined his A.C.D. to be 21 centimetres by 12½ centimetres. His pulse while in his bath was found by me to be 96, regular, and of good strength. The apex beat could be distinctly felt about the level of the nipple and about 5 centimetres to its outer side. I had then to leave him to keep another appointment, and Dr. Rives found his pulse after the bath to be 82-84, and his respiration 14. I saw him again at 9 p.m. the same evening, and found his area of cardiac dulness to be 20½ centimetres by 11 centimetres, his apex beat 12½ centimetres from mid-sternum; his pulse 84, and his respiration 17. In addition to the baths, Dr. G. took on Dr. Theodor Schott's prescription, a pill containing 1 gr. of quinine and 2 grs. of powder of digitalis, three times a day, gradually reducing the amount of digitalis. Between May 28th and June 13th he had taken in all 30 pills., *i.e.*, 60 grains of powdered digitalis. This patient appeared to improve in many ways, as evinced by his activity, and the disappearance of œdema of the feet. His condition, however, appeared to me precarious, and I accompanied him to England, fearing that the journey might try him. He spent a week in London, more or less actively engaged, and convinced of the benefit he had received at Nauheim, but on his journey to Scotland caught a slight cold, confessed he had not taken too much care of himself, and died suddenly in the beginning of August, 1896.

CASE XII.—Mr. M., æt. 43, suffered no inconvenience from an aortic incompetent valve, but, having been at Nauheim before, returned in 1896, and took the baths without consulting any physician. I met him at my hotel, he introduced himself to me, and invited me to accompany him to his bath, which I did on July 13th. Sprudel bath. Temperature 31·5 degrees C., with 2 litres of mutterlauge added. Before entering the bath I determined his area of cardiac dulness to be 15 centimetres by 12 centimetres; left ventricular border in the 3rd left intercostal space; right auricular border at the right edge of the sternum; apex beat in the 6th space 11·5 centimetres from mid-sternum. Pulse 78. Bruits aortic-systolic and diastolic, not very loud. When he had been in the bath 7 minutes, pulse 74-78, respiration 18. After 12 minutes, pulse 72, respiration 18. After 14 minutes the pulse became weaker and rose to 84. He then left the bath. After the bath, pulse 84. Apex beat and area of cardiac dulness quite unchanged, but apex beat less visible than before the bath. The liver line, which before the bath was at the upper border of the 6th right rib, fell very slightly, as the percussion note over the 6th rib was somewhat clearer than before the bath. The bruit had not altered at the base, but at a spot near the lower portion of the left edge of the sternum at which its intensity had been gauged before the bath, the diastolic bruit was somewhat louder after the bath. I took the following sphygmograms :

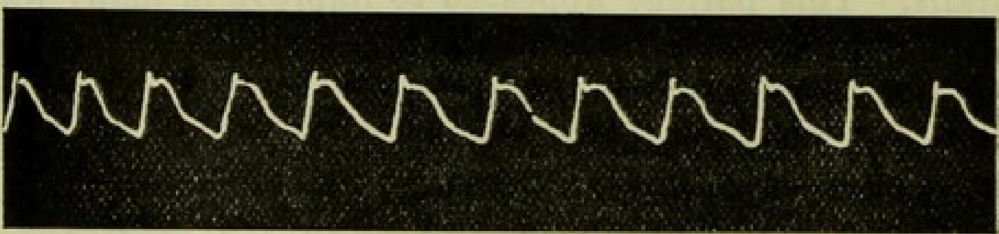


FIG. 47.—Before the bath.

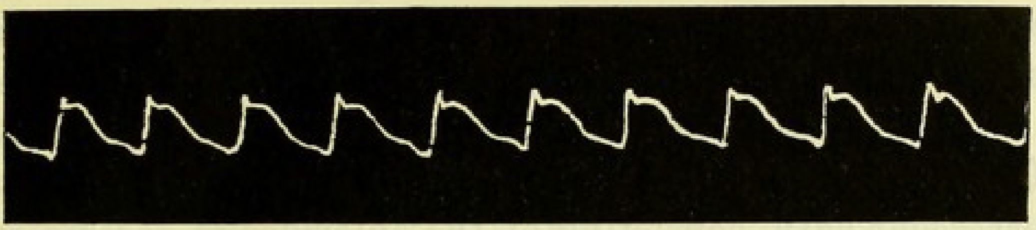


FIG. 48.—After the bath.

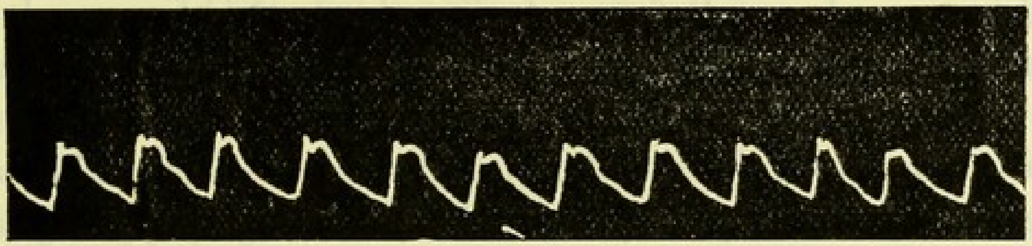


FIG. 49.—After the bath.

CASE XIII.—E. J. C., æt. 50; shopman. First consulted me at the St. Marylebone General Dispensary on January 6th, 1896, for dyspnœa on walking. He had been more or less ill for a year, and had three times suffered from rheumatic fever, the last attack having occurred in 1876. His apex beat was in the sixth space about 12 centimetres from mid-sternum. There was a systolic bruit best heard at the apex, less so at the left base, and not audible in the back. On February 11th I noted that, in addition to the systolic bruit, the heart had a triple rhythm at the apex. On the 10th of March the *bruit de galop* was still present, but less distinctly so. On the 16th the systolic bruit was also audible at the point of left scapula. On the 24th, the bruit is noted as being louder, almost free from triple rhythm, and the cardiac impulse stronger. He was under treatment by infusion of digitalis and liq. strychniæ. On the 21st of April the triple rhythm had disappeared. On June 2nd and 21st the *bruit de galop* is noted as still absent. On July 28th there was some return of dyspnœa; the apex beat was in the sixth space, 4½in. to 5in. (measured by the back of a middle finger 4½in. long) that is, 12 to 12½ centimetres from mid-sternum, and the bruit at the apex was noted as being double and cantering. He again improved under treatment. On August 15th it was observed that his thorax was comparatively fixed, the range of movement on inspiration and expiration being less than half an inch.

On November 9th I gave him an artificial saline and effervescent bath, consisting of the chlorides of sodium and calcium, and having a specific gravity 1010 at 95 degrees F. The carbonic acid was evolved by two of Sandow's tablets and two powders. Before entering the bath his apex beat was in the sixth space, 10½ centimetres from mid-sternum; his area of cardiac dulness measured 15 centimetres by 12½ centimetres, and the systolic apex bruit had a detectable but slight degree of triple rhythm. The following sphygmogram was taken:—

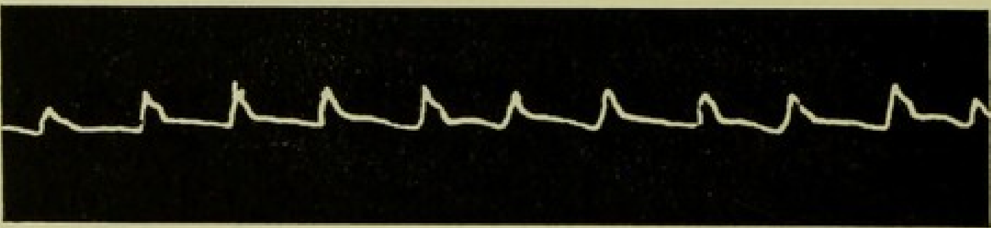


FIG. 50.—Before the first bath.

On first lying down in the bath his pulse-rate was 112. He was immersed fifteen minutes, and just before leaving the bath his pulse had fallen to 100. After partially dressing, and while seated, his pulse rate was 108, and the following sphygmogram was taken:—

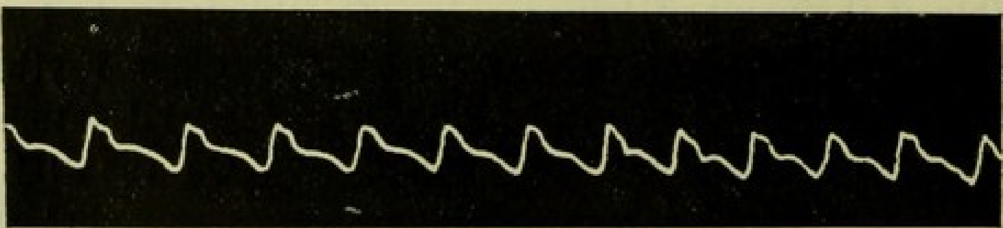


FIG. 51.—After the first bath.

The apex beat and the area of cardiac dulness were unchanged. Neither on standing nor on lying down was there any triple rhythm at the apex after the bath. Dr. Cecil Morgan and Dr. Forbes Ross were present.

On November 12th he took a bath containing 7 lbs. of chloride of sodium, of a sp. gr. 1010 at 95 degrees F., which on cooling had a sp. gr. of 1013. Examined after Sandow's powders and tablets had been added to the bath (four tablets and two powders being used) and had done effervescing, the sp. gr. of the water at 90 degrees was 1017. *No chloride of calcium was used.* Before entering the bath his pulse was 90, his respiration 20 ; the position of his apex beat was as before, 12 centimetres from mid-sternum in the sixth space, and at a point in the fifth space somewhat internal to the line of the apex beat, a well-marked *bruit de galop* was determined. Other conditions being as at the time of the last bath. In the bath a larger quantity of carbonic acid was disengaged than before, and continued to evolve briskly throughout the bathing time. His pulse rate in the bath varied from 96 to 102, and about ten minutes after immersion it was at its best, after which its force somewhat abated, and he left the bath in about twelve minutes, feeling in all respects comfortable. Immediately after the exertion of drying himself and partially clothing, his pulse rate was 120, regular, and of good force. After being seated for about three minutes on a chair his pulse was 90, his respiration 20, and a sphygmogram was taken.

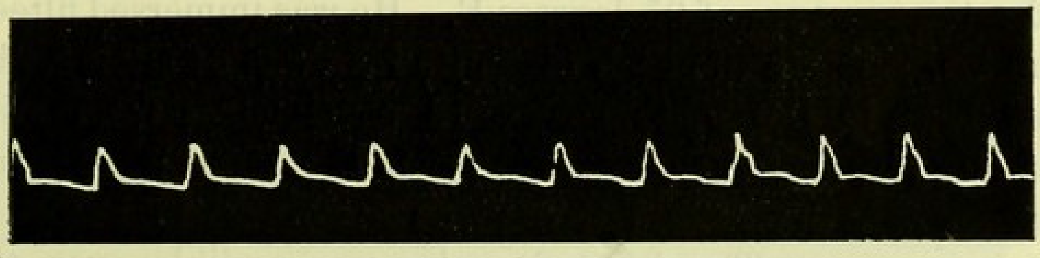


FIG. 52. - Before the second bath.

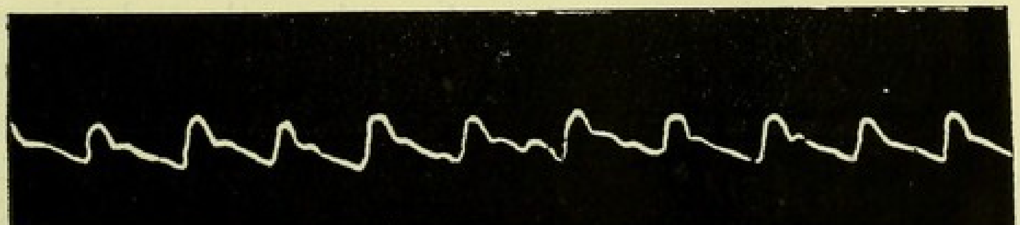


FIG. 53.—After the second bath.

On examining the heart in the same position in which I examined it before the bath, I found the apex beat and cardiac outline unchanged, but at the marked spot where the *bruit de galop* had been well heard before the bath *no bruit de galop was to be heard.* About ten minutes later it returned, and remained until I left him. The following sphygmograms were carefully taken, and represent his pulse before and aft·r the bath.

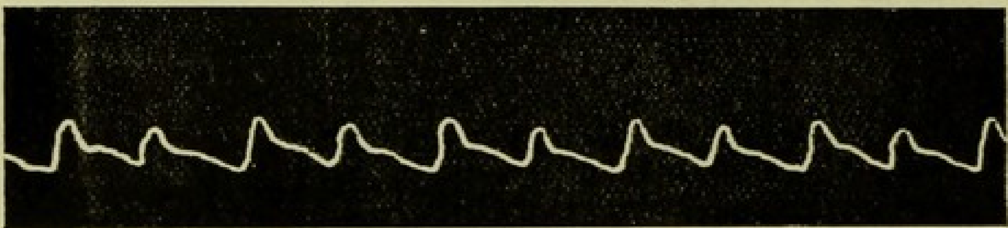


FIG. 54.—Before the third bath.

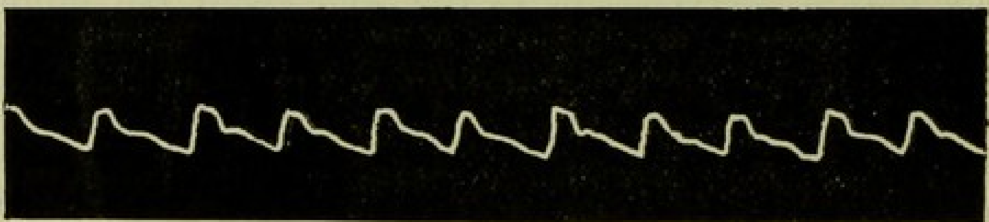


FIG. 55.—After the third bath.

On November 15th, 1896 (Sunday), he took a bath containing chloride of sodium only, having a sp. gr. of 1010 and a temperature of 95 degrees F. He was immersed fifteen minutes. Before the bath his pulse rate was 84 sitting, the apex beat in the sixth space, 12 centimetres from mid-sternum (nipple 8·5 centimetres from the same point), and the upper limit of the left ventricular dulness in the third left interspace. The *bruit de galop* was audible over the visible apex beat in the sixth space, and also in the fifth space. The patient has a depression at the lower part of the sternum, where, and in the epigastrium, the pulsation of the right ventricle can be felt. On first entering the bath his pulse rate was 102 and respiration 24. While immersed it fell to 98, 96, 92, and 90, and the respiration to 20 and 22. After drying and partially dressing, and while standing, the pulse was 120, and fell soon afterwards to 96, and still later while sitting to 84, when the post-balneal sphygmogram was taken. The *bruit de galop* at the visible apex beat was all but absent for a time after the bath, while it persisted more distinctly in the fifth interspace. The patient stated that since taking the baths he had experienced a sense of increased comfort in the precordial region, and maintained that in saying so he was not deceived by his imagination. The position of the heart in other respects remained unchanged.

The sphygmograms resembled one another closely, and also those taken *after* the baths on previous occasions.

November 17th, 1896.—E. J. C. took a bath of tepid water without any of the ingredients previously used, at a temperature of 96 degrees F., which had fallen to 94 degrees at the end of a quarter of an hour when he left it. Before the bath, sitting, the pulse rate was 96, the apex beat standing, as on previous occasions, 12 centimetres from mid-sternum, and the *bruit de galop* and systolic bruit well heard over the marked apex beat. L.V.D. third space left. On entering the bath, pulse 114, while in the bath it gradually fell to 96. After drying and partially clothing, pulse 120. The *bruit de galop* soon after, while standing as on former occasions, was quite absent, and the bruit louder than before the bath. Sitting, his pulse rate was 86. The following sphygmograms were taken in the same position before and after the bath:—

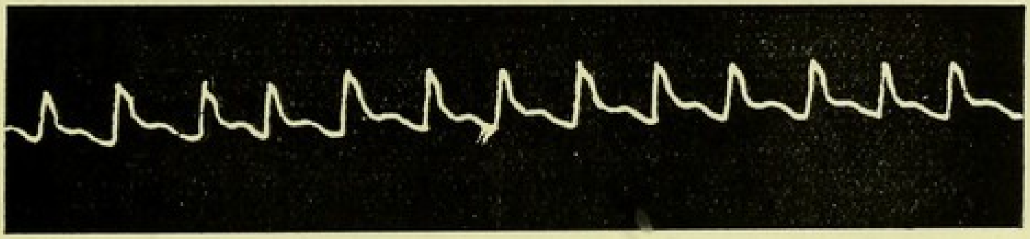


FIG. 56.—Before the fifth bath.

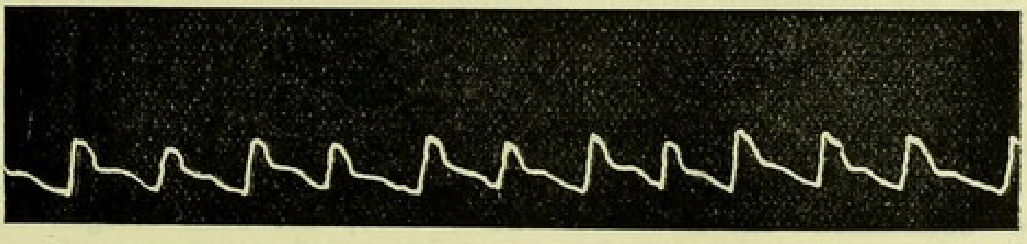


FIG. 57.—After the fifth bath.

Although there was little mobility in the chest walls of this patient, this was far from being the case with his heart. For, on lying on his back, the apex travelled outwards in the same (sixth) space for 2·5 centimetres, and when he lay on his right side it came nearer the mid-sternum by 3·75 centimetres. The L.V.D., which was at the third rib while standing, sank 3·75 centimetres in the recumbent position, and the liver dulness fell 3 centimetres while lying, from the point it occupied in the erect position. It was very interesting, also, to note that the triple rhythm, audible at the visible and palpable apex beat 12·5 centimetres from mid-sternum, was loudest while lying on his back at the more outward position occupied by the apex, and was heard while he lay on his right side at the more inward position over the cartilage of his sixth rib, whither the apex had also travelled. These facts, taken in connection with the comparative immobility of the thoracic parietes, are interesting and suggestive.

Gymnastic movements in this case rendered the systolic apex bruit louder and the systolic impulse more powerful, but the situation of the apex beat and outlines of the area of cardiac dulness remained practically unaltered, and any

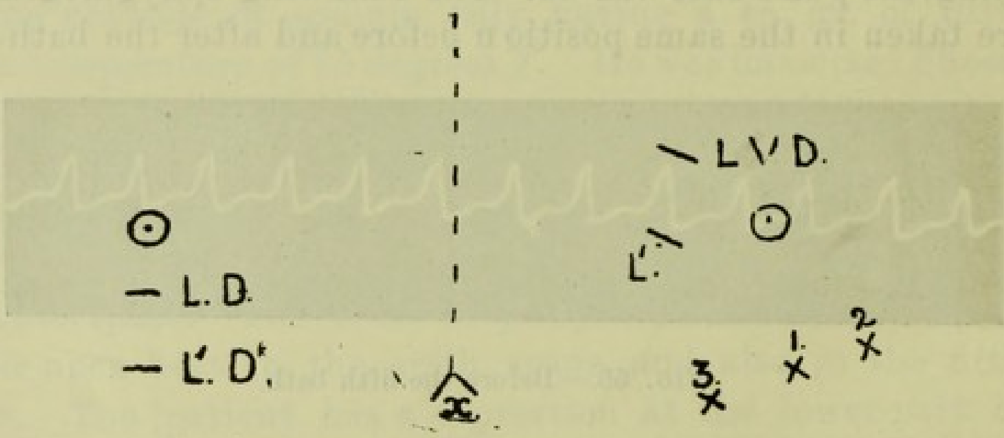


Fig. 58.

x = xyphoid cartilage. N = nipple; L.V.D and L.′ = upper percussion limit of left ventricle. 1 = apex while standing; 2 = while on back; 3 = when on right side. L.D. = liver line standing; L.′D.′ = liver line lying. These facts were determined on November 24th, 1896, Dr. Cecil Morgan being present.

gentle exercise which accelerated the heart's action likewise abolished the triple rhythm and increased the loudness of the bruit.

Case XIV.—Dr. W., æt. 42, had for some years suffered from diabetes and albuminuria. On May 16th, 1896, I saw him in consultation with his family physician. The area of cardiac dulness was increased; the apex beat was in the fifth space, 4½ inches from mid-sternum. At the lower end of the sternum at its left edge there was a systolic bruit, which was audible at the apex. The rhythm was triple, and pulse 120. The legs were anasarcous, and the presence of ascites doubtful. The respiratory murmur was feeble at the lung bases posteriorly. I prescribed Tr. Strophanth., ♏x.; Tr. Scillæ, ♏x.; Sp. Æth. Nit., ♏xx., t.i.d.; and also a pill containing calomel, ipecac, and rhubarb, and a morning aperient of sulphate of soda. I again saw him October 15th, 1896. The strophanthus mixture prescribed at the last visit acted well, and all anasarca disappeared. About a month before my second visit, however, his condition had again deteriorated, and I then made the following observations:—Pulse 120, small but regular. Respiration 22. Area of cardiac dulness, 14½ by 12½ centimetres. Systolic bruit audible from the right edge of the sternum towards the left for four inches, loudest to the left of the sternum. *Bruit de galop* at apex audible, not tactile. Upper liver line lying, fourth right interspace; lower edge not felt on account of tympanites of the epigastro-hypochondriac region of the abdomen. Ascites to two inches above the umbilicus. Legs swollen, but less so than at last visit. Thinner in the face. The urine was said to contain no sugar, and only a trace of albumen. He takes strophanthus for three or four days, when gastric irritation compels him to abandon its use. I advised him to increase the Tr. of Strophanthus to ♏xv. three times a day, and to try the effect of artificial Nauheim baths with 5 lbs. of chloride of sodium, 8 ounces of chloride of calcium, and one of Sandow's powders and tablets. I also demonstrated a mild series of Schott movements which might be employed. On November 2nd, 1896, he wrote me to the following effect:—"I have continued with ♏xv. strophanthus and have borne it well, taking it for over a fortnight without nausea, and then one day's interval sets me right again. I am ever so much better, sleep fairly well and have a slightly better appetite. There is not the slightest trace of œdema about my limbs, and if there is any fluid in the abdomen it must be very little. The umbilical circumference is 42½in., at one time 49, and the belly quite flaccid and soft." He then adds: "What has done all this for me? Strophanthus, baths, exercises, or rest? I believe strongly in strophanthus, also baths, but distrust the exercises, and prefer gently walking about my room." My patient is a man of more than average ability and powers of observation, and his opinion, even of his own case, carries weight.

I visited Dr. W. on November 8th, and found him sitting up in an easy chair. Pulse 96, regular but small. Area of cardiac dulness 16 by 12½ centimetres. Apex beat in the fifth space about 10 centimetres from mid sternum; its position was ascertained by auscultation and percussion. The right auricular dulness was 1·5 centimetres to the right of his sternum. The systolic apex bruit was not heard so distinctly as before, nor over so extensive an area. The *bruit de galop* was much less audible, and chiefly heard over the apex beat. The respiratory sounds were good, and free from moisture. The upper liver line was at the fifth rib, sitting, and its lower edge smooth and easily felt owing to the disappearance of abdominal tympanites. The vertical length of the liver was 15 centimetres. There was no ascertainable ascites, and the œdema of the legs had gone, the lower leg being merely somewhat indurated from long-continued swelling. On lying down the position of the heart was not noticeably altered; the *bruit de galop* was more audible than when sitting up, but decidedly less so than at my former visit. I examined his urine. The quantity was 50 ounces in 24 hours; sp. gr., 1016; albumen,

$\frac{1}{3}$; sugar was detected. Bile colouring matter was present in considerable quantity. Although Dr. W. had not had a good night, he took an artificial mineral bath in my presence, consisting of 7 lbs. of salt, 6 ounces of chloride of calcium, and two of Sandow's powders and tablets in 40 gallons of water at 95 degrees F. He was immersed about fifteen minutes. His bath was somewhat short and not very wide, and his circulation in a recumbent and rather cramped position, was not free. His cheeks became cyanotic, and on leaving the bath both hands and feet were rather blue. After the bath his pulse rate was 96 to 108 with occasional intermissions. I mention these particulars for further comment. The following sphygmograms represent the character of the pulse before and after the bath :—

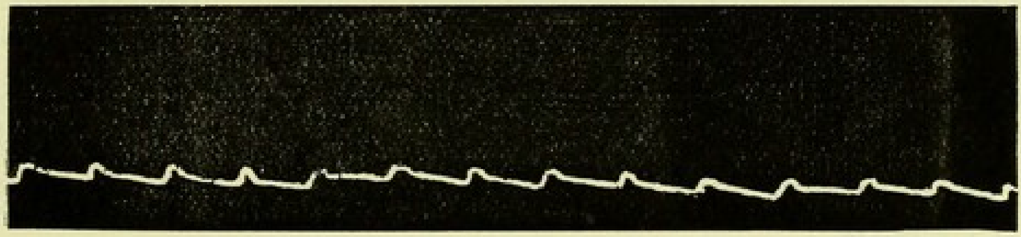


FIG. 59.—Before the bath.

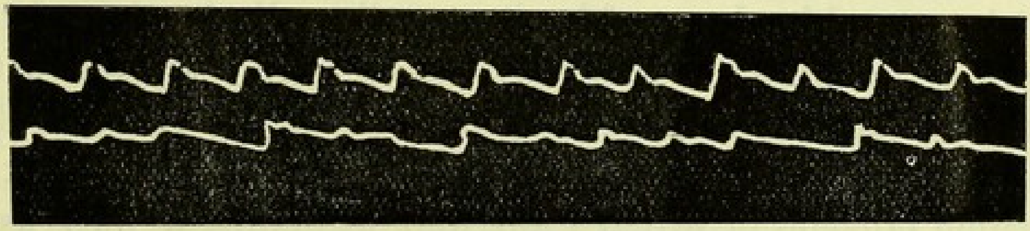


FIG. 60.—After the bath.

The general conclusion at which the majority of observers have arrived as to the effects of mineral baths upon the *circulation* is, that they raise the blood pressure, and with this general conclusion the facts I have mentioned from my own observation are in agreement. This is well shown in the tracings made in Case XIII., in which one after another of the chemical ingredients was eliminated until tepid water pure and simple was reached. The low tension traces of the first two days of bathing, however, did not recur. The means taken to determine this point have been (1) manual and instrumental pulse-palpation and a general examination of the heart, and (2) experiments on the lower animals. Retardation of the pulse, however caused, may, except with a syncopal heart, be regarded as evidence of increased vascular pressure, and even in the latter case is probably significant of a preponderance of obstruction in the vessels over driving power in the heart. More or less retardation is sufficiently frequently observed after baths, as Beneke indicated, to constitute it one of the evidences of increase of vascular pressure and heart force. The examining finger may determine at the same time in these cases that the lumen of the artery is increased. With some acceleration of the pulse, there may also be an increase of cardiac force, but clinical observation, and the teaching of physiology, justify our concluding that, in most of such cases, there is either mental emotion or local (cardiac) excitation to account for the phenomenon, and both these conditions may contribute to the result.

The central evidences of varying force in the heart muscle have already been sufficiently discussed in a previous section, and increased loudness of bruit as well as diminution of the signs of functional inadequacy have been observed after bathing. As regards the instrumental determination of this point I have myself chiefly used the sphygmograph, with the possible fallacies of which I am well acquainted, but, used with attention to the points which have been impressed upon those who have had much experience with this instrument, its results are by no means so unreliable as we are sometimes led to imagine. Of the *degree* of pulse pressure it tells us little or nothing; of the *fact* of *variations* in actual pressure, I think it may tell us much. With few exceptions I believe the tracings published will be recognised by those in the habit of using the sphygmograph as trustworthy. The care necessary in the use of the sphygmograph applies also to that essential to the proper use of sphygmomanometers, Bach's or any other. The results given by these may be no less fallacious than that yielded by the sphygmograph, and their combined use may result in a multiplication of fallacy, or in a combination of accurate observation, according to the experience and care with which these instruments are used. Of the experimental determination of increased blood pressure after baths in animals submitted to them, I have no personal experience, but Dr. August Schott believed that he had by this means also proved the fact.

He, as also his brother Dr. Theodor Schott, and some others who have written upon the subject, believe that they can determine as an immediate and by degrees lasting effect of the baths in many cases, that the volume of the dilated heart is diminished. That the volume of the heart is diminished *pari passu* with the improved condition of a cardiac patient, I, and I presume all others who have dealt with such matters are prepared to concede, but I confess that even the apparent immediate shrinkage of the organ as a consequence of bathing, has not been perceived by me in any such degree, as to attribute it to any other circumstance than the varying position occupied by the organ, regulating its own pulsations under the disturbing influence of the exertion, and changing conditions of temperature and gravitation, incidental to the act of bathing. I readily grant that my experience of the bath treatment is much less than that of some others, but with all modesty claim some experience in clinical methods, and in speaking as I do, I express what the evidence of my own senses has borne in upon me. Alteration in the cardiac area on percussion is more evident, in those cases in which it occurs, after exercises than after baths, and it is interesting in this connection to find that Dr. Theodor Schott's experience is, that after the bath the shrinkage of the boundaries of the heart is often insignificant, but of longer duration, while after exercises it is frequently very notable, but often lasts for a much shorter time (*Herzkrankheiten*, p. 11).

The effect of the baths usually observed upon the *respiration* is diminution of frequency and increase of depth, but at times, as in Case VI., the pulse may maintain an equality of frequency at rather a high rate (90) and the respiration steadily fall, while on other occasions, as in the same patient, a lower pulse rate may be associated with a respiration rate of high and maintained frequency. The average ratio of respiration to pulse rate being about 1 to 4, its range of variation is equally limited, but in the absence of pulmonary complications is quite as significant of the blood state and circulation as the blood and circulatory apparatus themselves. Thus, upon the occasion on which Case VI. showed a steady respiratory rate of 30, and an average pulse rate of about 80, the patient had slept better than usual, and some reflex or metabolic element which I do not pretend to disclose was in all probability active in preventing the usual retardation observed. I make this remark to indicate the necessity for bearing in mind *all* the circumstances of a physical or moral nature which operate upon the individual when we attribute to this or that agency the objective signs we observe. Gröedel ascertained by pneumatometric observations on the influence of different baths upon respiration (*Berl. Klin. Wochenschr.*, 1880, No. 22) that respiratory power, especially in its expiratory phase, was increased during bathing, and believes that such increase bears a direct ratio to the saline contents of the bath.

The *skin*, as has been stated, is reddened in some of the Nauheim baths. The temperatures at which these baths are taken are not sufficient to account for the degree of reddening observed, nor do we see the same amount of reddening after a sea bath of the same temperature, the specific gravity of which is exactly that of the Nauheim bath. There can be but little doubt, therefore, that the chief reddening element, when the bath has not a greatly enhanced salinity and pungency from added mother-liquor, is the carbonic acid gas. It is especially noticeable after the Strom-sprudel or current effervescent bath, as Drs. August and Theodor

Schott have stated (*Berl. Klin. Wochenschrift*, 1884, No. 19) and I noted the same fact myself at Nauheim. Being, therefore, independent of temperature, it must be due to vaso-dilator influences, the reflex consequence of superficial stimulation, and the important question comes to be, Is this reflex merely skin-deep? or Has it a further reach?

It has frequently been observed that the *urinary secretion* has been increased by bathing, which, in the absence of any proof of cutaneous imbibition (and, as is well known, physiologists have not satisfied themselves that such takes place to an appreciable degree), must be ascribed to a raising of propulsive blood pressure. It is in fact, as in the case of the employment of digitalis and other cardiac stimulants, an evidence of beneficial action. In Case XIV. the urinary secretion was always observed to be diminished on the day after the bath was taken, and I do not consider that in this case the bath had a good effect. The receptacle in which the patient lay was ill-adapted to accommodate him; be became cyanotic in face and limb and took some time to recover. These effects could not, of course, be justly laid to the charge of the bath water, but to the inconvenient method of taking it. Any other cause, however, explicable or otherwise, which in a cardiac case regularly reduces the urinary output, should be regarded as contra-indicating that mode of treatment. I have introduced Dr. W.'s case as an instance of the great and beneficent power of cardiac tonics properly used, and the dangers attending *uncomfortable* bathing. This leads me to remark that there is no essential incompatibility between the balneological and drug treatment of heart disease, and that these at times very usefully supplement one another. Case VI., which was under Dr. Gröedel's care, is a case in point, and Case XI., which was under the care of Dr. Theodor Schott, took in 16 days, as I have stated, 60 grains of powdered digitalis. It cannot be too emphatically stated, great as has been the service rendered to practical medicine by the labours of Stokes, Beneke, Oertel, the Schotts, Gröedel, and other physicians, in pointing out the benefit to be derived in the treatment of some phases of cardiac failure, by the scientific and cautious use of baths and exercises, that the necessity for scientific precision in the examination of cardiac cases, and skill in the employment of those double-edged weapons the well-proved pharmaceutical agents, which have come into use since Withering's day, are no less needed now than at any previous period. Indeed, it may be said they are even more necessary; for there is a tendency in some quarters to regard the late developments in curative cardiology as a panacea, a sort of "treatment of heart disease made easy." It is to be hoped that the mere therapeutist, who frequently combines a minimum of scientific caution and insight with a maximum of philanthropic zeal, will always be rare among us. That this is the attitude towards all curative methods, which would have been assumed by Stokes, will, I think, be acknowledged by those acquainted with his writings. Because he advised graduated exercises in some cases, he did not in any way minimise the beneficial operation of wisely used pharmaceutical agents, which, under circumstances of great gravity, have so often, and will so often again, prove the sheet anchor and saviour of otherwise hopeless cases. With the expansion of his curative activity, the physician's pathological and physiological knowledge must keep pace, and, necessary as this is in all cases, in none is it more so than in the proper use of baths and exercises, which are nothing if not an instance of applied physiology.

SECTION III.

THE MODUS OPERANDI OF MINERAL BATHS.

TEMPERATURE, specific gravity, and chemical constitution being the factors we have to deal with in these baths, it remains to enquire shortly how they exert their influence. Beneke found that in mineral baths of 31 to 32 degrees C. the temperature of the body fell somewhat. After the first five minutes the temperature in the mouth was observed to fall to 0·6 and 0·4 degree C., and during the last twenty minutes to 0·1 degree C. Virchow had in cold sea baths noted a fall of 1·6 to 2 degrees C., and to this fact attributed the slower respiration which was observed to be coincident with the fall of temperature (Beneke, *op. cit.*, Trans., note p. 42). Beneke, however, does not regard the trifling fall noted by himself in the case of the mineral baths to be a sufficient explanation of this phenomenon, and regards the weight of the circumambient water as the chief cause of respiratory retardation. Winternitz considers the pressure which the weight of water exerts upon the body as not inconsiderable, and quotes Mauthner as having estimated that in a column of water two feet high the water pressure adds $\frac{1}{16}$ to the atmospheric pressure, or a total increase over the body of about 2,280 lbs. (*op. cit.*, p. 447). While in figures this amount does not appear inconsiderable, it is questionable whether a human being submerged in a medium of such density, and freely respiring air of the normal weight and character, would feel much increased effect in breathing. Dr. Leith, in a thoughtful paper on the Nauheim waters and methods (*Lancet*, March 21st and 28th, 1896), dwells upon the retracted abdomen which may in some cases be observed in the bath, and it has also been observed that flatus is by abdominal pressure expelled under the same circumstances; but, any sense of thoracic oppression soon yields to comfortable respiration, and the patient, unless very feeble, experiences no sense of respiratory restriction. It appears, therefore, more probable that the specific gravity of the water, like the temperature and chemical constituents, acts indirectly and even insensibly to the individual by its effect upon the peripheral and then central nervous system. As has been already stated, the imbibatory theory is untenable. Dr. Michael Foster remarks on this point that "In the case of the sound human skin, the balance of conflicting evidence is in favour of the view that soluble non-volatile substances are not absorbed, and that volatile substances such as iodine, which may be detected in the system after a bath containing them, are absorbed, not by the skin, but by the mucous membrane of the respiratory organs, the substance making its way to the latter by volatilisation from the surface of the bath" (*op. cit.*, p. 366). Beneke further determined that no chloride was imbibed in the bath, and at the utmost some carbonic acid. At most, the greatest amount of water taken up by the body in the bath was 32 grammes (*op. cit.*, p. 44). Beneke, therefore, concluded, and the Schotts and others have come to the same conclusion, that the effects of the waters are due to their irritative effects upon the cutaneous nerves, and that all other functional changes may be explained by this primary action (p. 44). This conclusion is in no way invalidated by the fact stated in connection with Case XIII. of the preceding series, namely, that a bath of tepid water, pure and simple, has a distinct influence upon vascular pressure, and while the loss of body temperature is but slight in such a bath, that little, by its influence upon the nervous system, may quite reasonably be argued to have an effect, less in degree, but the same in kind as that maintained by Virchow to result from a cold sea bath. Another factor which cannot be lost sight of in this connection is the alternating exertion and repose involved in the *act of bathing*. It is, in fact, a minor mode of gymnastic movement, and, as I shall have occasion to state presently, August Schott so defined bathing.

It would probably be erroneous to conclude from these observations, however, that the chemical constitution of the baths was without effect as an emphasising element in them. A perusal of the section on the neuro-muscular factors in heart disease will explain, how a maintained peripheral stimulation of the superficial nerves may, by its cumulative and reflex effects upon the central nervous system, also bring about effects in the ganglionic and intrinsic nervous mechanism of the heart, out of proportion to the original stimulus, and thus serve to explain in a measure the comparative durability of results obtained from causes apparently inadequate to effect their purpose. It has also been suggested that carbonic acid as a volatile substance may be inspired in considerable volume during a carbonated bath, and thus act upon the central and cardiac nervous system through the nerves of the respiratory mucous membrane, or even by way of the blood (*Lancet,* 1896).

I need scarcely add that in making these suggestions I have no desire to speak dogmatically, but by reasonable processes to arrive at a working hypothesis in explanation of the indubitable fact that vascular blood-pressure is raised by the act of bathing and still more by the use of mineral baths constituted in the manner stated, and that such effects are not so evanescent as might *a priori* be imagined.

I have carefully refrained, in treating this subject, from using the language of enthusiasm, and have contented myself by narrating a series of objective facts, and endeavouring to draw the conclusions to which they seem to me to point. If, however, I have displayed no sensational sphygmograms, nor noted extraordinary consequences of single baths, an examination of the pulse-tracings of E. J. C. (Case XIII.) typifies a common experience, namely, that a defective peripheral blood-pressure can, by these measures, not only be remedied, but the improvement maintained, explain it how we may. The most cautious estimate of the value of the balneological treatment of cardiac failure is thus, in my opinion, justified in regarding it, skilfully and patiently administered, as a method which may, singly in some cases, and in combination with other remedies in others, effect much good. But believing as I do, with August Schott, that baths are "a kind of gymnastics," I do not consider that they have either the power or the scope as a therapeutic agent of the more active movements to be described presently, but that they may be used with benefit when the latter are inadmissible, as will be stated in the context, or together with these when they can be safely employed. It might be argued that if the baths are but a milder form of gymnastics, as the greater includes the less, gymnastics alone should be able to accomplish all that the baths do. But such a conclusion would be erroneous, as it loses sight of the effects of temperature and gaseous and mineral stimulation of the peripheral nervous system. This is not unimportant, for a cumulative stimulation of the central nervous system by reflexion or continuation into the intrinsic nerve centres of the heart, and a general effect upon the vaso motor nerves may, as I have already stated, render more lasting, impressions which might otherwise be fugacious.

SECTION IV.

THE GYMNASTIC TREATMENT OF HEART DISEASE.

THOSE desiring to consult a careful historical *résumé* of the growth and development of medical gymnastics will find such in the introduction to his treatise on "General Orthopædics, Gymnastics and Massage" by Professor Friedrich Busch, in Vol. v. of Von Ziemssen's *Handbook of General Therapeutics,* translated by Mr. Noble Smith. For our present purpose, the history of gymnastics begins with the life-work of Peter Henrik Ling, who was born in 1775, commenced the formation of his "system" in 1805, and practised it until his death at Stockholm in 1839. The method which essentially owes its origin to him was what he termed "Compound Gymnastics," and consisted in the co-operation of two persons. Regarding the patient or pupil as the centre of movement, this was again subdivided into a series of "concentric" and "excentric" movements. In the former the patient was resisted by the gymnast in making the inward movements, in the latter the gymnast resisted the patient in making the outward movements. Ling not having been a physician it is unnecessary to dwell upon his therapeutic ideas. He appears, however, to have been a man of great ingenuity and considerable insight. Dr. Busch considers that Ling was mistaken in ascribing "to every single muscular movement a special effect upon the general health" (p. 39, *op. cit.*), and his criticism on this point appears to be just; but when he instances as an erroneous opinion of Ling's, the belief he entertained that an arm movement while standing had quite a different effect from an arm movement while lying or sitting, I am inclined to agree with Ling that the effect considered as a matter of degree is different, and that in the treatment of heart disease the distinction is an important one to be borne in mind by the practical physician. The observer to whom the palm is usually conceded as having been the first to recommend exercise in the treatment of heart disease, is one whose originality in this department of medicine manifested itself on many occasions, William Stokes of Dublin. In his classical work on *Diseases of the Heart and Aorta*, published in 1854, at p. 357, he states, "that, for the treatment of incipient fatty degeneration of the heart, the patient must abandon luxurious habits, adopt early hours, and pursue a system of graduated muscular exercise," and guards the employment of this prescription with his wonted sagacity. He also mentions a curious and interesting case of ultimately fatal abdominal aneurism in which great temporary relief followed violent exercise (hunting) prescribed in ignorance of the nature of the case by another physician (*op. cit.*, p. 639).

The views of Stokes as regards exercise were not shared by the more influential of his contemporaries, who thus lost the opportunity of guiding opinion concerning it into useful channels. The very natural result was, that the good in the principle maintained by Stokes was perverted by the ignorant into false channels, and exercise as a means of treating disease ran the deplorable gamut of a popular craze and perished in the contempt and oblivion it deserved. My late friend Dr. Walter Hayle Walshe, with the raillery and literary charm of which he was a master, was one of those who gave exercise abused its merited quietus.* It is just possible that a similar fate may overtake the present revival of exercise as a means of treatment unless the lesson of Stokes's generation be laid to heart.

* *Diseases of the Heart*, 4th Ed., p. 323.

Dr. Busch mentions (*op. cit.*, p. 258) that Dr. Gustav Zander, of Stockholm, recommended "slight gymnastics" in the treatment of heart disease in a pamphlet published in 1879. He states that "some conditions of disease, if they are not too far advanced, may be quite overcome and others may be stopped in their development and all are alleviated as regards their symptoms." Of the employment of Zander's ingenious instruments for this purpose I shall have to say more presently. Up to this date, however, the opinion that exercise, not perpetual rest, was the appropriate treatment for heart disease was shared only by a few, and the merit of having given greater publicity to the regulated use of exercise for this purpose must, as regards priority, be naturally given to him or to those who first published their views on the subject. In a pamphlet by Dr. Jacob, of Cudowa (*Zur Therapie der Herzkrankeiten*), which was read in December, 1891, and republished in 1892 (Glatz. L. Schirmer), he states that Dr. August Schott used his "Widerstandsgymnastik" in the treatment of heart disease shortly before he himself and Oertel recommended hill climbing for the same purpose. Oertel's excellent monograph on the Therapeutics of Circulatory Derangements (Ziemssen's *Handbook of General Therapeutics*, Vol. vii.) was certainly published in 1884, but the material on which it was based was observations made between 1875 and 1884. His work, however, was rather a resumption of that of Stokes than identical with that with which the names of Drs. August and Theodor Schott are inseparably connected, and from various circumstances it has come about that to these two physicians of Nauheim Europeans and especially Anglo-Saxons owe their present knowledge of the place of gymnastic exercises in the treatment of heart disease. Papers by Dr. Theodor Schott in Anglo-Saxon journals, and Dr. Bezley Thorne's book, illustrated with striking delineations of physical changes said to occur after these methods of treatment, have largely contributed to this result.

These exercises thus supplement the effects of the waters of Nauheim, and their work, as well as that of Dr. Oertel, Dr. Gröedel and others who practice intelligently the balneological and gymnastic treatment of heart disease, is a continuation and fitting complement to the labours of Stokes and Beneke. To the further description of the movements first used by the Schotts, including the self-resisting or "Selbst hemmungs gymnastik," which is, so far as I know, peculiarly their own creation, I shall also refer later.

Passive Exercise or Massage.—As a transition, however, to the consideration of gymnastics of a more active character, mention should be made in this place of passive exercise or massage, as this may in some cases be advisable when more active exercise cannot be taken, and may even with advantage at times be combined with that and other modes of treatment. We are only concerned with it in this place in so far as it can influence cardiac failure. The technique of this procedure consists in patient and systematic stroking, rubbing, and kneading of the soft textures of the body, of which the muscles are the most important, and nearly always in the direction of the returning blood-current and lymph-stream. To these manœuvres may be added a percussion or hammering, with chopping, sawing and slapping of the surface. A more detailed account of these processes will be found in the 5th volume of Von Ziemssen's *Handbook of General Therapeutics.* The manipulations referred to, increase the peripheral blood-flow and stimulate the central nervous system and processes, including metabolism, directly or indirectly dependent upon it. Like many other procedures within and outside the domain of medicine, in which there is possible and sometimes great benefit to mankind, and which are at the same time not in all respects detrimental to those who apply them, massage has at times been abused ignorantly or otherwise, and in such cases has become justly discredited. That, however, is not the fault of massage, and it is the duty of the physician not to allow a procedure capable of effecting much good in appropriate circumstances to fall into desuetude on that account.

To become convinced of the utility of any means of cure from the general statements of others, is like faith at second hand, sometimes both reasonable and necesssary, but personal experience alone carries full conviction. "This," as Carlyle has said, "is belief; all else is opinion" (*Sartor Resartus*), and I shall relate in its proper place the case which first convinced me of the value of massage as an aid in the treatment of cardiac failure.

Zander's Gymnastics.—Dr. Gustav Zander's system of gymnastics may be said to be Ling's system carried out by mechanism, the power to produce some movements and effects, and the resistance to be overcome in others, being supplied by mechanism or instruments capable of being controlled in their motion or in their inertia. From the expensive nature of the instruments, and the great variety necessary for effecting all the purposes of this "Heilgymnastik," they are usually collected into one building, or, as it is usually called, "Institute" from the presumably scientific uses to which it is put. It is evident from these considerations that every village cannot provide a Zander Institute, and hence one of the limitations to the general employment of this system of medical gymnastics. When, however, the instruments are available, they are capable, under responsible supervision, of effecting much good, not only in various ailments affecting the power and mobility of joints and muscles, but also in stimulating metabolism and improving the scope of respiration and the power of the heart. Dr. Theodor Schott (*Herzkrankheiten*, p. 17) does full justice to the possible utility of Zander's therapeutic gymnastics by mechanism, although he considers them inferior to manually administered gymnastics both in their range, variety, and controllability. But I find no indication either on his part or on that of any other physician who has had experience of the gymnastic treatment of heart disease to exalt these differences in such a manner as to justify Dr. Bezley Thorne's emphatic utterance that "Physical exercise, practised by means of mechanical appliances, forms no part of the system (Schott's), and introduces principles which are not only foreign to its conception, but essentially opposed to it" (*The Schott Methods of the Treatment of Chronic Diseases of the Heart*, 2nd Edit., 1896, p. 68).

Zander's machines are divided into three great classes, with sub-divisions in each for their individual identification and separate prescription. The following is a list of the apparatus at Nauheim, and similar collections exist at Wiesbaden, Baden-Baden, and elsewhere :—

I. ACTIVE MOVEMENTS.

A. Arm Movements.

A 1. Arm lowering (Arm-senken).
A 2. Arm raising, shoulder-raising (Arm-heben, Schulter-heben).
A 3. Arm lowering and bending (at the elbow) (Arm-senken und beugen).
A 4. Arm-raising and straightening (at the elbow) (Arm-heben und strecken).
A 5. Bringing the arms together (Zusammenführen). Adduction of the arms.
A 6. Carrying the arms held horizontally outwards. Abduction of the arms (Seitwartsführen d. Arme).
A 7a. Circular movement of the arms round the shoulder, as a centre (Arm-schleudern).
A 7b. Circular movement of the hand round the wrist (Handkreisen).
A 8a. Pronation and supination of the arm (Arm-drehen).
A 8b. Rotation of the arm backwards and forwards on both sides (Arm-wechseldrehen).
A 9. Flexion of the arm at the elbow (Unter-arm beugen).
A 10. Extension of the flexed arm at the elbow (Unter-arm strecken).
A 11. Dorsal and palmer flexion of the hand at the wrist (Hand beugen und strecken).
A 12. Dorsal and palmar flexion of the fingers at the metacarpo-phalangeal joints (Finger beugen und strecken).

B. Leg Exercises (Beinübungen).

B 1. Flexion of the thigh on the pelvis (Hüftbeugen), the leg being extended.
B 2. The extended leg is carried downwards and backwards (Hüftstrecken).
B 3. Simultaneous flexion of the leg at the hip and knee (Hüft-Knie-beugen) or raising the extended leg with the hip as a centre (Hüft heben).
B. 4. Simultaneous extension of the raised and bent leg at the hip and knee (Hüft-knie-strecken).
B 5. Adduction of the separated legs (Bein-schliessen).
B 6. Abduction of the approximated legs (Bein-spreizen).
B 7. Velocipede-treading (Velocipedtreten).

B 8. Rotation of the extended leg outwards and inwards round the hip-joint (Bein-drehen).

B 9. Flexion of the leg at the knee (Knie-beugen).

B 10. Extension of the flexed leg at the knee (Knie-strecken).

B 11. Dorsal and plantar flexion of the foot at the ankle (Fuss-beugen u. strecken).

B. 12. Rotation of the foot round the ankle (Fuss-kreisen).

C. Trunk Movements.

C. 1 Bending the body forwards at the loins while seated (Rumpfvorbeugen).

C 2. Sitting up from the bent forward position while seated (Rumpfaufrichten).

C 3. Raising the trunk from the lying to the sitting posture (Rumpvorbeugen liegend).

C 4. Lying down slowly from the sitting posture (Rumpfaufrichten liegend).

C 5. The body being bent back with adjusted straps to an angle of 45 to 60 degrees, and the thighs fixed against a leg cushion, the trunk is slowly brought to the upright position, and the legs being down, it is further carried forwards as far as possible (Rumpfaufrichten stehend).

C 6. Lateral flexion of the trunk (Rumpfseitlich beugen).

C 7. Rotation of the trunk while the pelvis is fixed (Rumpfdrehen).

C 8. Rotation of the lower portion of the trunk while the upper portion is fixed (Becken-drehen).

C 10. Bending the neck either backwards, forwards, or laterally (Nackenspannen).

D. Balancing Movements (Balancirbewegungen).

D 1. In which the patient, seated either as in a chair or on a saddle, preserves his balance without using his hands or by the aid of a foot band or stirrups.

D 2. Movements necessary to preserve equilibrium while seated as on a chair the bottom of which is constantly changing its angle in all directions (Rumpfrotiren im Quersitz).

D 3. Movements of the same character while seated as in a saddle the angle of which is similarly constantly changing.

II. PASSIVE MOVEMENTS.

E 2. The hand is flexed and extended at the wrist by the action of the mechanism (Passive Handbeugung u. Streckung).

E 3. Passive radial and ulnar flexion of the hand by the instrument (Passive Radial u. Ulnar-flexion der Hand).

E 4. Passive finger-flexion and extension (Passive Fingerbeugung u. Streckung).

E 5. Circular movement of the leg passively effected with the hip-joint as a centre (Beinkreisen im Hüftgelenk).

E 6. Passive widening of the thorax as in the act of inspiration (Brustweitung).

E 7. Passive rotatory movement imparted to the lower portion of the trunk (Passive Beckendrehung).

E 8. Passive elevation of the pelvis (Becken-hebung). "This apparatus consists of a sofa divided into two portions, the front part being fixed; the back part is so constructed as to rise and fall in angular motion" (*Mechanical Exercise as a Means of Cure;* Churchill, London, 1883, p. 73).

III. MECHANICAL IMPRESSIONS.

(Mechanische Einwirkungen).

F *Vibratory or concussive movement* (Erschütterungen).

F 1 Instruments so constructed that a rapid vibratory movement is imparted to different parts of the body.

F 2. Vibratory movement when astride a saddle (Reitsitz-Erschutterung).

G *Percussive action* (Hackungen). (Chopping, Hacking).

G 1. Instruments consisting of light hammers covered with guttapercha or leather wherewith a succession of quick percussion strokes is inflicted on various parts of the body.

G 2. Percussion of the legs (Beinhackung).

G 3. Trunk percussion (Rumpfhackung).

G 4. Percussion of the head (Kopfhackung). (!)

H *Kneading movements* (Knetbewegungen).

H 1. Abdominal kneading (Bauchknetung).

J *Rubbing and Stroking movements* (Walkungs und Streichbewegungen).

J 1. Arm shampooing (Armwalkung).

J 2. Leg shampooing (Beinwalkung).

J 4. Foot and hand rubbing (Fuss und Hand-reibung).

J 5. Stroking the back by means of rollers (Rückenstreichung).

J 6. Circular friction of the abdomen by rollers (Kreisende Unterleibsstreichung).

K *Reclining apparatus* (Lagerungs apparate) on which the patient may lie in any position desirable for counteracting mechanical defects.

Finally, there are "Universal Apparatus," or apparatus which call into action the whole body.

a. Rowing movements (Ruder-Bewegung).

b. Sawing movements (Säge-Bewegung).

c. Raising and extending movements (Hebe-und-streck-Bewegung).

d. Pulling and pushing movements (Zieh und Schieb-Bewegung).

The instruments being all numbered, and their general effect known, the physician can prescribe in individual cases the use of those which he considers appropriate to the case, and indicate at the same time the duration of the exercise or number of movements to be executed with each apparatus. The patient may thus go from one to another guided by his marked schedule and the letters and numbers on the instruments. It would occupy too much space to enter into details of construction and of the anatomical structures involved in the different movements; but it may be stated generally that the dosage of the active movements is regulated by weights and graduated levers, and the patient directed to put forth his chief muscular effort during the period of expiration, to avoid arrest of respiration during exertion. When, however, as in the movement of abducting the arms, the natural tendency is to promote inspiration, that phase of respiration is emphasised by the patient. The indications for the use of these instruments I shall consider after describing more fully the manually administered gymnastics which are preferred under most circumstances by Dr. Theodor Schott, of Nauheim, to the Zander Apparatus. Of the latter, however, under responsible direction, Dr. Schott also speaks in terms of approval, and regards Zander's inventions as better than those of others who have devised apparatus on the same lines. (*Herzkrankheiten, Beitrag*, Dr. Theo. Schott, Wien und Leipzig, Urban and Schwarzenberg, 1890, p. 17). By Gröedel of Nauheim, under the supervision of his assistant, the apparatus are constantly used in appropriate cases of cardiac failure, although he also makes more use of manual than of instrumental gymnastics.

The Schott Methods.—Just as to Beneke belongs the chief credit for having drawn attention to the favourable effects upon the circulation of saline and carbonated baths, so a careful examination of the literature of the subject has convinced me that the first place in having advocated the combined use of baths and exercises in the treatment of cardiac failure undoubtedly belongs to August Schott. At the Medical Congress held at Wiesbaden in 1888 (*Verhandl. d. Congress f. In. Med. Wiesbaden*, 1888, p. 27) Professor Oertel, while claiming priority for having reintroduced the active treatment of heart disease advocated by Stokes, with the dignity and frankness which only those, secure in the consciousness of their own power can exercise, upheld August Schott, not only as the first to combine the active with the bath treatment of heart disease, but also as the first to extend Beneke's doctrine of the use of the baths in rheumatic heart disease to cases generally in which the cardiac muscle is affected. In this connection, and as establishing the link between Schott's muscular movements with Ling's, or the Swedish system of gymnastics, some passages in his writings are of interest, and exhibit him as a physician of penetrative insight too soon lost to his profession. "I myself arrived at the gymnastic treatment of heart disease," he states, "by the way of balneo-therapy. I had many opportunities of observing the excellent effects of natural and artificial, gasless and gaseous mineral baths upon the diseased heart. All observations on particular points as to the *modus operandi* of baths seemed to contradict this conclusion, as these unquestionably suggested that baths called forth increased effort on the part of the heart. That the blood pressure was increased by the bath was shown by prominent balneo-therapeutists, and especially by Lehmann in Rehme. I myself had directly established the fact of this increase of blood pressure in animals submitted to the baths; but how could the enfeebled heart endure its increased labour? And that it did endure it, that it attained thereby quiet, powerful pulsation, and under the quickly ensuing subsidence of stagnant phenomena, diminished in size, was a circumstance of regularly repeated observation. No other conclusion remained but that the heart under the influence of increased work strengthened, and that the bath was only another and a milder form of stimulation than the hill-climbing so highly spoken of by Stokes, *that baths operate as a form of cardiac* *gymnastics*. (The italics are mine.) Thus it was suggested to investigate methodically the effects upon the heart of gymnastics of the skeletal muscles. I had for years found the *Swedish gymnastics* useful in the dyspnœa and palpitation of the hysterical, and now began to extend my investigations also to other cases of heart disease, and to-day, after six years of assiduous observation, must state, that *gymnastics almost like the bath*, and in a certain sense, on account of the convenience with which they may be employed everywhere, in even a greater degree than the bath, appear to be one of the most general remedies for cardiac insufficiency" ("Die Bedeutung der Gymnastik fur Diagnose Prognose und Therapie der Herzkrankheiten," *Verhandl. der Gesellsch. f. Naturf. u. Aerzte in Strassburg*, 1885, p. 432). In the same paper he describes the movements he had found most useful, and remarks that, while the fully compensated heart can submit to great strain, the effort imposed upon the enfeebled organ with lost compensation has to be very carefully regulated. He also referred to the still contested question of organic shrinkage in a notable degree, which some have stated to follow the use both of baths and exercises. In his general appreciation of August Schott's work, Oertel (*loc. cit.* p. 27) notes this conclusion of his with a mark of interrogation. With August Schott's conclusion, however, Dr. Theodor Schott of Nauheim, who combines with the affection of a brother the devotion of a disciple, is in agreement, and to this point attention will no doubt be given in the future. But whether the diminution of the area of cardiac dulness will be shown to result from change of *size* or change of *position* of the heart, or from both these causes, in those cases in which it is noted, the fact one way or another will neither add much to nor detract much from the general interest of August Schott's labours in this field of enquiry; and, objectionable as a patronymic nomenclature usually is in medicine, in the eternal course of which the coming and going of units is only temporarily interesting except to the antiquary of a later age, one cannot grudge that the work of one of so much promise, and so early dead, should be perpetuated by having his name coupled with it.

The Schott movements, although suggested by the Swedish system, are not altogether identical with it. They fall into two categories—the "Widerstands gymnastik" or those movements alternately resisted by the patient and gymnast and corresponding in the main to Ling's compound gymnastics, and the "Selbsthemmungs gymnastik," or movements in which by the exercise of his antagonistic muscles the patient himself supplies both the resistance and the power to overcome it.

Before considering the dosage, effects, and uses of these movements, I shall shortly describe, by illustrations, those most frequently employed, and, for the purpose of identification, shall designate these alphabetically, and distinguish them by numerals, although the latter have not the fixed value which has been recognised as convenient in prescribing Zander's instruments, inasmuch as they refer in most instances to different phases of the same movement.

A 1, 2. Dorsal and palmar flexion at the wrist. The movement commences and terminates as in A 1. The half accomplished palmar flexion is seen in A 2.

B 1, 2. Flexion and extension of the arm at the elbow. B 1 illustrates the commencement of flexion; B 2, extension in progress.

C. Represents the commencement of pronation of the fore arm by the patient and the termination of supination.

D 1. The extended arm is raised forwards to any point of a semicircle of which the shoulder is the centre.

D d. The extended arm being moved forward from a point behind the patient to the point at which the semicircle referred to in connection with D 1 commences. The movement may be reversed, commencing with the line of the patient's body and moving backwards.

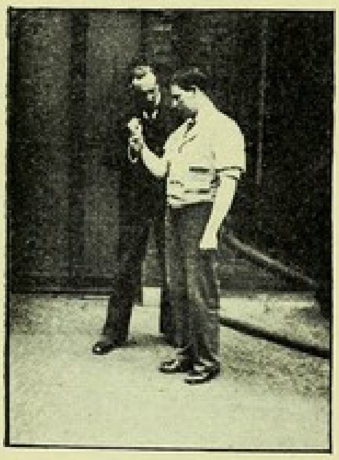
E 1 and E 2. Segments of a semicircle described laterally or outwards with the shoulder joint as the centre. It may be remarked that except in the case of comparatively sound hearts it is well not to raise the arm above the level of the shoulder in any of the Schott movements. Especially is this advisable when, in addition to a weakened cardiac muscle, we are dealing with aortic inadequacy, as in such cases the influence of gravitation combined with muscular exertion might act injuriously.

Plate I.

A 1.

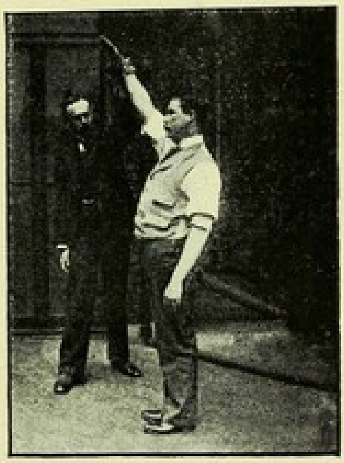
A 2.

B 1.



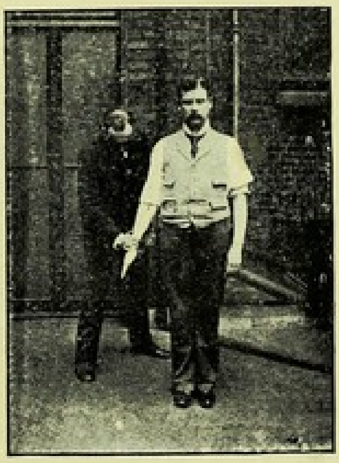
B 2.

C.

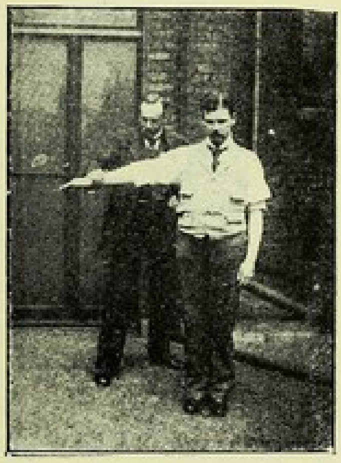


D 1.

D d.



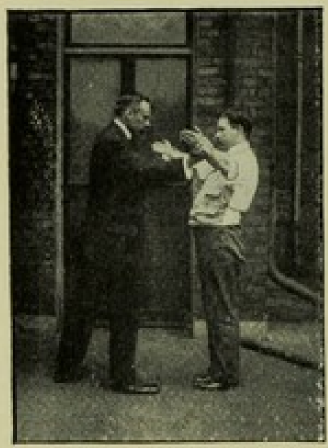
E 1.



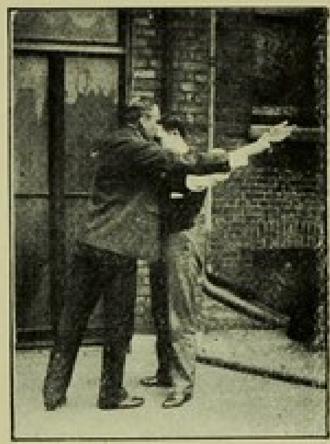
E 2.

Plate II.

F 1.

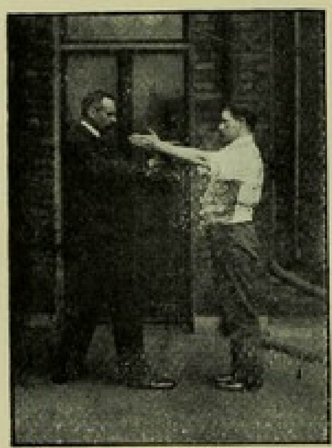


F 2.

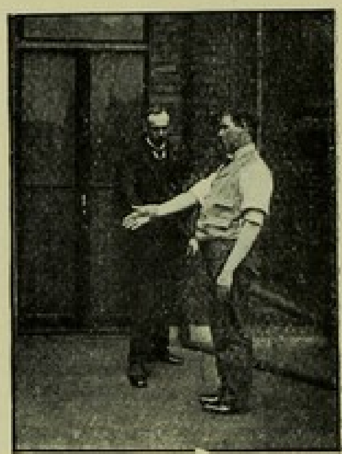


F 3.

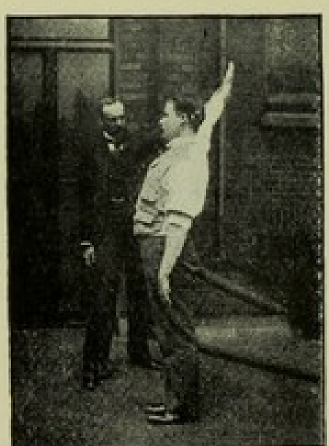
F 4.



F 5.



G 1.



G 2.

G 3.

H.

F 1-5. Represent abduction and adduction of the arms. Abduction commencing with F 1, continuing with F 2, and being completed with F 3, at which point adduction (F 4) commences and is all but terminated at F 5, from which point the gymnast should gently lower the patient's arms to his sides, where they rest till the commencement of the next movement.

G 1-3. Circular lateral movement of the extended arm round the shoulder-joint as a centre. G 1 illustrates the movement near its commencement, G 2 the same rather more than half completed, G 3 the movement nearly completed. It will be observed that the gymnast completes the latter half of the circle with the left hand, and the change of hands, if made, must be done with the utmost care to avoid a hitch or inequality in the muscular effort of the patient. On the completion of each movement the arms of the patient must be gently brought to his side and left there at rest.

H. Dorsal flexion of the ankle. For plantar flexion the hand of the gymnast grasping the distal end of the foot regarded as a lever, must naturally offer resistance by being applied to the sole.

J 1, J 2. Forward movement of the extended leg with the hip as a centre. J 1 represents the forward movement nearly completed, J 2 the return movement, which terminates at the line of the body, when the patient may "stand at ease." It is necessary during the execution of this and some of the succeeding movements that the hand of the patient *opposite* to the leg undergoing movement, should rest upon the back of a chair, in order to preserve the balance of the body without undue muscular effort.

Ja 1, Ja 2. Backward movement of the extended leg with the hip as a centre. Ja 1 represents the resistance offered to the first phase of the movement, Ja 2 that opposed to the second and final phase.

K 1, K 2. Outward movement of the extended leg with the hipjoint as a centre. The patient in this illustration (K 1) is represented as leaning rather too much towards his right. K 2 is the second or return portion of the same movement.

L 1, L 2. Movement of the extended leg across the perpendicular of the body with the hip as a centre. L 1 represents the first phase nearly completed. L 2, the second, near its point of ultimate rest. This movement is not inappropriately termed by some Celto-Anglo-Saxon patients at Nauheim, "the Highland fling!"

M 1. Flexion of the thigh upon the pelvis and M 2, extension of the same from the flexed position, the leg ultimately being brought to rest beside the stationary foot.

N 1. The patient, seated and *without* using his hands to support himself, as represented in the illustration, abducts his thighs; N 2, the second phase of the same movement in which he adducts them, the gymnast altering the position of his hands to oppose the movements. It may be mentioned in this place that other leg movements similar to those already described in the erect position may be executed in the sitting posture, and in many instances also when the patient is too feeble to sit up, while he is recumbent.

O 1. Rotation of the trunk from right to left on the pelvis as a fixed point; O 2, similar rotation from left to right, the gymnast offering a corresponding resistance, chiefly with his left or right hand, according as the patient's body is rotating towards the left or towards the right.

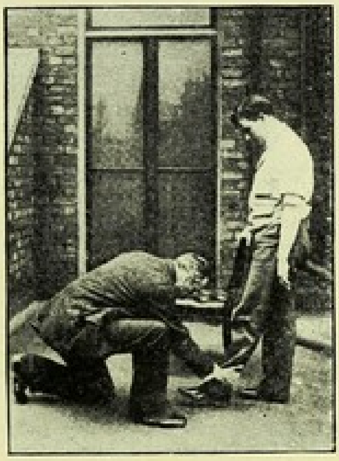
*P 1. Forward flexion of the trunk upon the pelvis as a fixed point. The arm with which the gymnast offers resistance is thrown across the anterior aspect of the patient's chest, while he steadies himself by placing his other hand on the lumbo-sacral region. P 2. Raising the body from the stooping to the erect position, the gymnast places the arm offering resistance upon the upper portion of the trunk-lever on the patient's back, and steadies himself by resting his other hand on the anterior aspect of the patient's thigh. This is a very powerful movement, and imposes considerable strain upon the patient.

Q 1 and Q 2. Similar movements to P 1 and P 2, executed in the sitting posture, which is easier for the patient. This illustration correctly represents the patient as avoiding the use of his hands. In Q 1 the gymnast offers resistance by pressing upon the anterior aspect of the shoulders, and in Q 2 applying his hands to the posterior aspect of the shoulders and the supra-scapular region. Lateral flexion of the trunk upon the pelvis as a fixed point may also be made both towards the right and the left. Other movements, such as flexion and extension of the neck, may also be made, as also rotatory movements of the head on the neck, but these are rarely used, as they are somewhat uncomfortable, and every useful end can be attained without their employment.

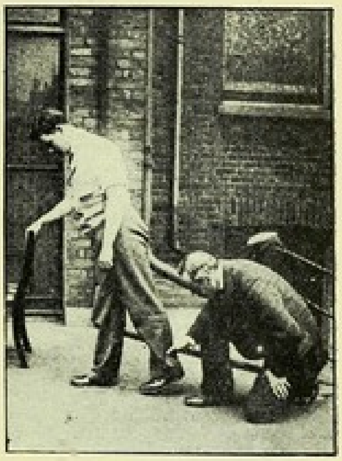
The Mode of Administration and Dosage of Gymnastic Movements.—It has already been stated that manual gymnastics may be administered to the patient either when lying, seated, or standing. Exercise with apparatus met with in a Zander Institute may likewise be taken in these positions, but the recumbent exercises of this kind involve considerable, and in some instances great muscular effort, such as the assumption of a sitting posture from one of recumbency, and may be excluded from those practicable for cardiac patients. The Schott movements, on the other hand, are capable of execution in any position, although in details posture may in some instances necessitate a variation in the plane of movement. Thus it might not be advisable in the case of a much enfeebled patient to administer the series of movements in which the extended arms are abducted and adducted at

PLATE III.

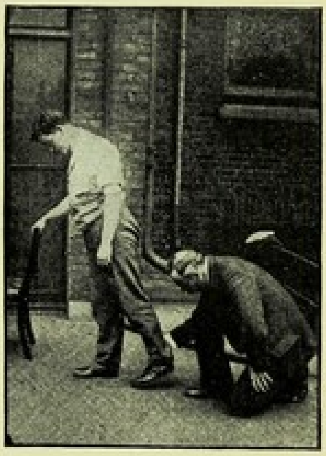
J 1.



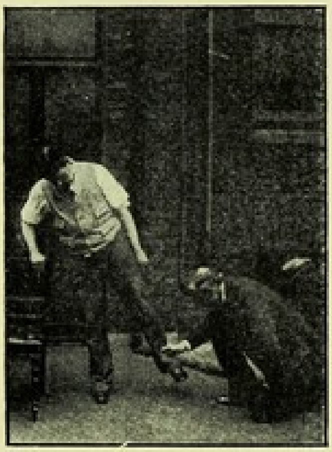
J 2.



Ja 1.



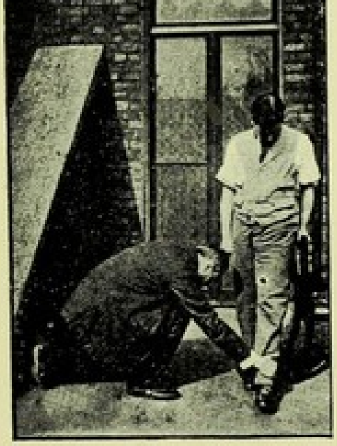
Ja 2.



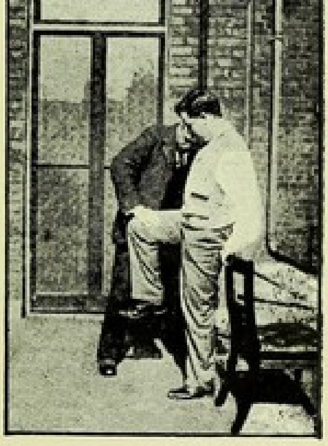
K 1

K 2.

L 1.



L 2.



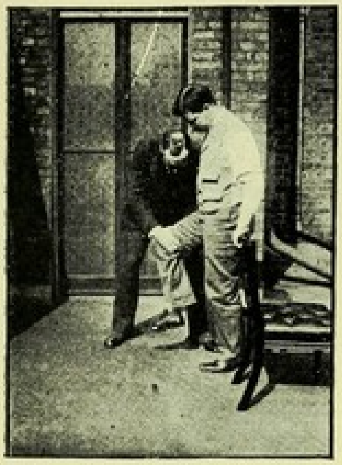
M 1.

right angles to the body, nor those on which the same limb sweeps a semicircle with the shoulder-joint as a centre. It may be necessary in the recumbent position to reduce the angle between the arm and the body, and keep the limb as nearly horizontal as is compatible with the convenient execution of the movement in question. If it be borne in mind that the influence of gravitation in the blood stream must be very cautiously added to the muscular efforts of the patient in some cases, desirable modifications of movement will suggest themselves under different circumstances.

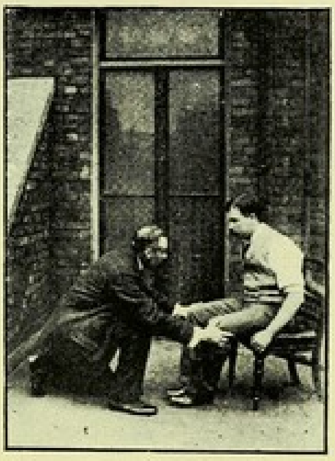
As with the baths, it is desirable in the case of an enfeebled patient that such an hour should be selected for exercises as that in which he is most calculated to undergo fatigue, such as it is, without exhausting his energy too much. In other words the gymnastic appointments must be regulated according to the patient's convenience and strength, and not in accordance with the necessities of a much-employed masseur who has only eight or ten hours at his disposal to go through the movements with twice as many patients as he can safely operate upon within the time. In many cases of considerable debility such an hour will be found to be either about mid-day, or two hours after luncheon, that is about three o'clock in the afternoon.

In a series of manœuvres, whether mechanical or manual, the effect of which is to promote the blood flow, it is scarcely necessary to dwell at length upon the care to be taken in avoiding constriction of the body by clothing, the grasping hands of the gymnast, and the arrested expiration of the patient. In an earlier portion of this book the influence of respiration upon the circulation and the propulsive power of expiration have been sufficiently indicated. It is for these reasons that the gymnast is usually instructed to watch the respiration of the patient or to note other signs of over exertion, as well as to avoid constricting with the hand the limb in movement. An intelligent man or woman may be trained to do this tolerably efficiently, but the gymnast scarcely less than the mechanical instrument requires to be checked from time to time by the physician. To secure adequate expiration during gymnastic movements, August Schott was in the habit of advising patients to count in a whisper up to ten (*Verhandl d. Gesellschfr. Naturf. u. Aerzte,* 1885). It will be found in different cases at different periods of exercise that a degree of effort will have been called forth which is provocative of *the best pulsations of the heart.* This reached, the exercises should either be terminated at once or gradually left off by administering a series of the milder movements. To follow that point of best pulsation with severer effort will be found to be productive of cardiac acceleration, irregularity, or intermission. It is this fact which renders the question of *dosage* so important in the gymnastic treatment of cardiac failure. In the case of the Zander instruments employed in such instances, which are chiefly levers of the first and second kind, the resistance is regulated by approaching the weight to or removing it farther from the fulcrum, on a graduated arm, in accordance with the law of mechanics that the influence of power and weight on levers is inversely as their distances from the fulcrum. In the case of the manually administered Schott movements the weight to be moved or resistance to be overcome is regulated by the will of the gymnast in the resisted, and by that of the patient in the self-resisting exercises. It is well, however, to bear in mind, that in the case of the movements of the limbs in man we are dealing chiefly with simple and compound levers of the third class, in which the power is between the joint-fulcrum and the limb-weight, and that the resistance may be regulated in this case also by the point at which, near to or far from the fulcrum, that resistance is offered. Now, while it is possible for the physician, capable of noticing central and peripheral changes in the vascular system, and of gauging the force of the patient generally, safely to regulate the degree of resistance by his volition, it is by no means so easy for him, even by muscular contact, to educate a gymnast or patient so as to enable them to put forth the required degree of

PLATE IV.

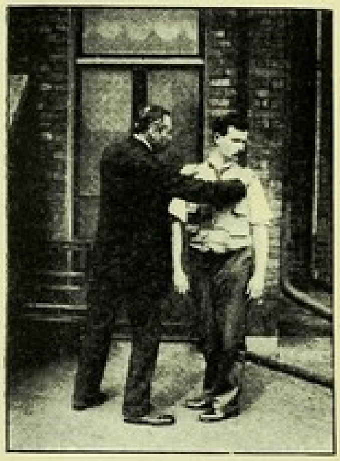


M 2.



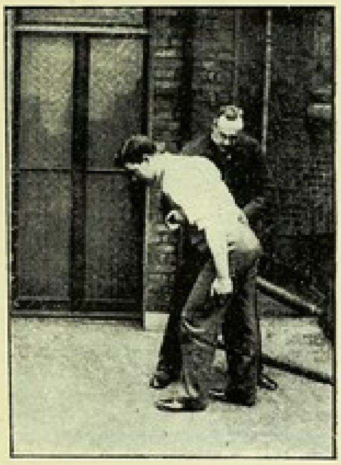
N 1.

N 2.

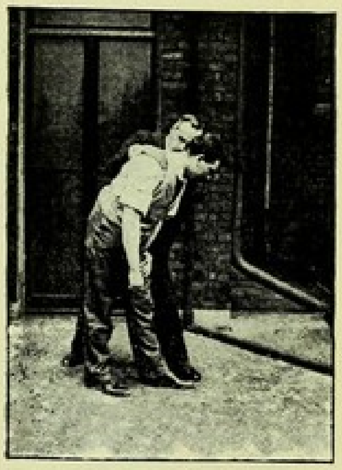


O 1.

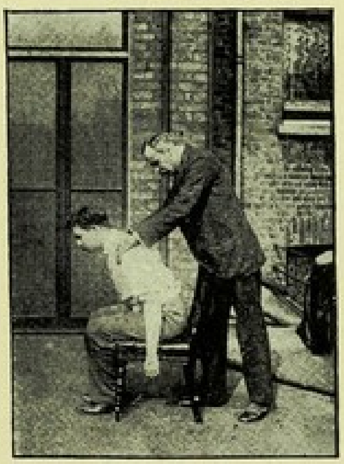
O 2.



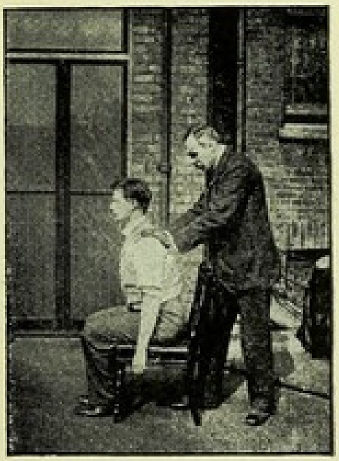
P 1.



P 2.



Q 1.



Q 2.

effort. The safe use of these movements under the circumstances becomes largely a matter of individual skill and judgment. As the physician cannot be present on every occasion to refresh the memory of impressions made upon gymnast or patient in instructing them, it seems desirable that there should be some means of aiding their observation by reference to some mechanical standard. With a view to supplying such aid I have had constructed for me a sensory dynamometer, which I have found very useful in practice.

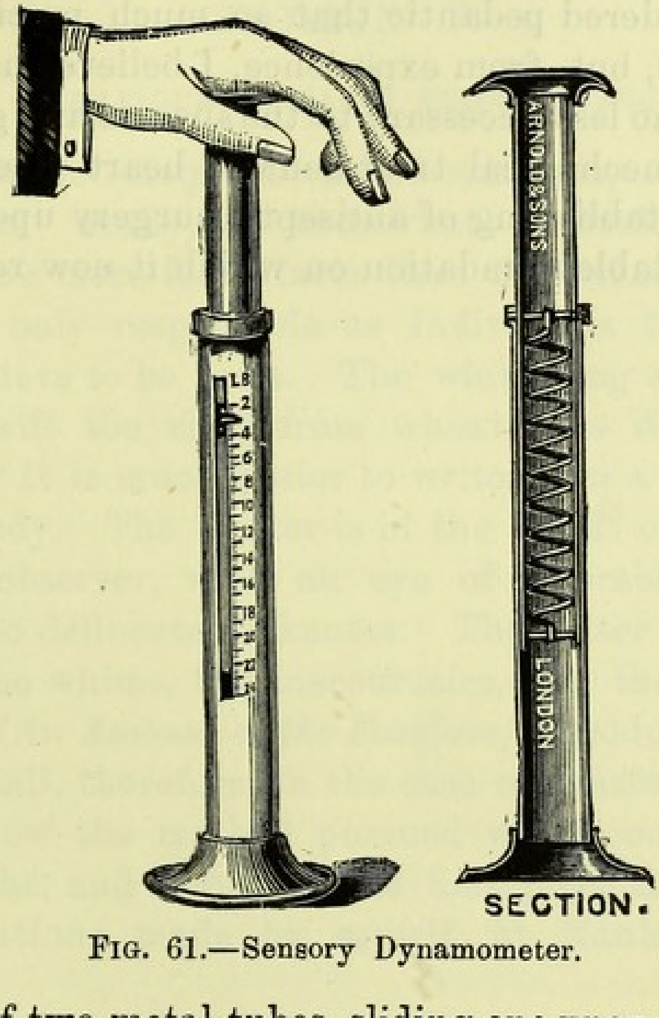


FIG. 61.—Sensory Dynamometer.

It consists of two metal tubes, sliding one upon another with a contained extension spring. The outer tube is graduated in pounds and quarter pounds, while the upper end of the inner is terminated by a smooth metal cup an inch and three-quarters in diameter, and offering a good sensory surface. The whole instrument is sixteen inches high, and may be used vertically as a stand or horizontally by the two hands. Having determined by his muscular sense the degree of resistance advisable in any case for particular movements, the physician may gauge and note such resistance, and, having done so, give the prescription to the gymnast or patient to ascertain by means of the sensory dynamometer the degree of force indicated. The instrument is thus a very simple one, and constructed on a well-known principle, which has frequently been employed in making weighing machines. It is calculated, I believe, to give greater precision in the prescription and knowledge of the resistance employed. It may be considered pedantic that so much precision should be inculcated, but, from experience, I believe that attention to details is no less necessary to the success and good regulation of the mechanical treatment of heart disease than it was to the establishing of antiseptic surgery upon the sound and incontestable foundation on which it now rests.

SECTION V.

THE BEHAVIOUR OF CASES UNDER EXERCISES.

Facts are more eloquent than comment, and although it has been wisely, if somewhat cynically remarked that there are more false facts than false theories, we are fortunately only responsible as individuals for recording what we believe to be facts. The winnowing sieve of time will surely sift the chaff from wheat. As Withering has remarked, "It is much easier to write upon a disease than upon a remedy. The former is in the hands of nature, and a faithful observer, with an eye of tolerable judgment, cannot fail to delineate a likeness. The latter will ever be subject to the whims, the inaccuracies, and the blunders of mankind" (*An Account of the Foxglove,* Introduction, p. 19, 1775). I shall, therefore, in the case of massage and gymnastics, follow the method pursued when considering the effect of baths, and record in the first place a few illustrative observations made by myself at Nauheim and in London.

Case I.*—Male, aged 43 years; tall, stout, married, and the father of a healthy family, who in early life had travelled in South America, where he had fever, and somewhat later contracted syphilis, had suffered for at least 15 years from drowsiness, and during 1886 and 1887 had become deeply somnolent. He would fall asleep while interested in and playing a game of cards, the cards suddenly dropping out of

* An account of this case appeared in the *Practitioner* for 1889.

his hands on to the table, he beginning to snore, and his face becoming darkly engorged until his companions succeeded in rousing him. On one occasion he fell asleep while standing on a door-step, to the imminent peril of his neck but for the aid of a bystander. I have myself observed him asleep in bed with an intensely cyanotic countenance, a condition from which he was roused after a snorting and choking sound had issued from his respiratory passages, the cyanosis then gradually disappearing. The patient had been more or less under my care for this condition for the two years mentioned, during which time he had been treated almost without result by antisyphilitics, antilithatics, a limited nitrogenous dietary, the injunction of exercise, and abstinence from or great moderation in the use of alcohol and tobacco; a regimen necessary to a free liver, and the son of a free liver, who had eaten, drank, and smoked without any knowledge of or regard for consequences.

During the two years he was under my care his urine was free from albumen, and his other organs were free from gross lesion. Within this period he also consulted two other physicians, one of whom considered his case malarial, and prescribed quinine, and another excluded malarial infection and prescribed Epsom salts. Neither the quinine nor the salts, however, had any effect upon the somnolent condition.

After an interval of nearly twelve months the patient again consulted me in November 1888, his friends being alarmed for his life on account of his insuperable drowsiness and the accompanying livid turgescence of his countenance. I then found that, in addition to his previous symptoms, his urine had become albuminous, and the muscles of his legs, and to a less extent those of his arms, subject to involuntary clonic contractions. The heart's impulse was weakened, its action was without bruit, his pulse 90, and his body free from apparent œdema, though his countenance was somewhat swollen, and his whole physique was gross. His respirations numbered 18 per minute, and his temperature was subnormal (97·4 degrees). His tongue was large and pale, and his bowels constipated. His urine was, as I have stated, albuminous (to about one-twelfth), and its quantity greatly diminished. He was also incapable of taking exercise, having soon to desist from a sense of feebleness and breathlessness.

Medicinally he was treated mainly with alkalies, including carbonate of ammonium, combined with digitalis and nux vomica. Two or three grains of calomel with compound rhubarb pill were also prescribed, and acted as an efficient purgative. As, however, this line of treatment had proved futile on previous occasions, I advised a systematic course of massage at the hands of a person trained to that procedure.

On *November* 19 I have a note that two days previously he fell fast asleep during vigorous massage, and note also that his drowsiness had diminished, and that he complained greatly of thirst and dry tongue. About a fortnight later (*December* 7) I note that his pulse was 84 and his heart regular, that he was passing large quantities of urine, and that his somnolence had almost entirely disappeared. His wife remarked on this occasion that he was better in this respect than he had been for five years. He could also walk farther and with less breathlessness. On January 11, 1889, he remarked that he felt "1,000 per cent. better." His muscular twitchings had disappeared, and his difficulty now was to fall asleep. He continued to pass large quantities of urine, and although I have not noted at this date the absence of albumen, it disappeared soon after the commencement of treatment, coincidently with the increased secretion. He mentioned the fact, however, that at the end of the year (1888) he drank one tumbler of champagne, which sent him off to sleep immediately, and in his own words "he got as blue as could be again." Until the beginning of *January*, 1889, the patient had undergone massage daily for five weeks, and had lost, so far as could be ascertained, 15lbs. in weight, for, whereas his weight at that time was 17st. 6lbs., he had weighed 18st. 7lbs. six weeks before treatment. As an evidence of his improvement I have also a note at this date, that on *January* 9 he went to a "party" and stayed till 3 a.m. on the 10th, that notwithstanding he rose at 6 a.m., walked during the day about ten miles, did his day's work, went the same evening to a music hall, whence he returned home at midnight and felt no drowsiness, in spite of his having taken a glass of champagne.

The specific gravity of his urine at this date was 1025, and it was free from albumen. In the general blunting of his sensibility his sexual appetite was almost abolished, and returned with his general improvement.

My note of his case on *February* 9, 1889, was that he had recently had occasional sudden attacks of giddiness, but notwithstanding felt "perfectly well," as he expressed it, that he had no abnormal sleepiness, that his bowels acted regularly, and that his urine was copious, and free from albumen and sugar. His pulse on this occasion was 78 and regular, and his cardiac and respiratory sounds normal. I may mention that about a year later the patient died during an attack of bronchitis, but before the end his old symptoms, with progressive debility, reasserted themselves more or less, and massage ceased to benefit him. The case manifested some of the phenomena of myxœdema, but the clinical picture was not complete, and did not suggest that diagnosis to those whom he consulted. Thyroid extract, which was not in such common use at that time, was therefore not tried. This fact, however, but serves to emphasise the benefit derived from massage as a cardiac restorative.

CASE II.—Herr ——, a man about 30, with a history of "adiposity, debility, and hæmatemesis," which might without injustice in all probability be more shortly described as alcoholism, underwent a series of exercises with the Zander apparatus at Nauheim on July 6th, 1896. There was no cardiac valvular disease, and the pulse both before and after exercises was rather slow. Opportunities for a more detailed examination did not present themselves. The following sphygmograms made before and after movements show their effect upon the pulse. In both, but especially in that taken after exercises, there will be observed a fine vibration in the tracing, which is due to muscular tremor at the wrist. The patient was under the care of Dr. Gröedel.

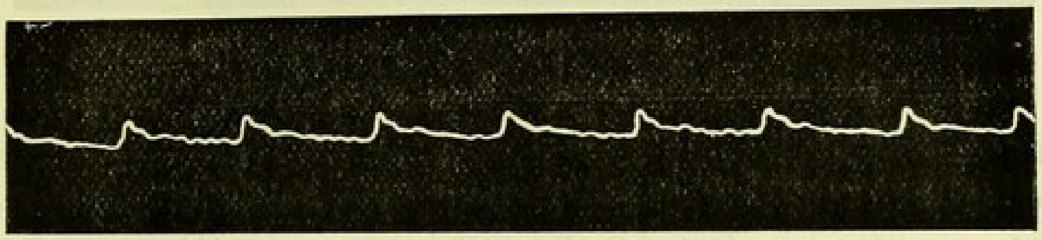


FIG. 62.—Before exercises.

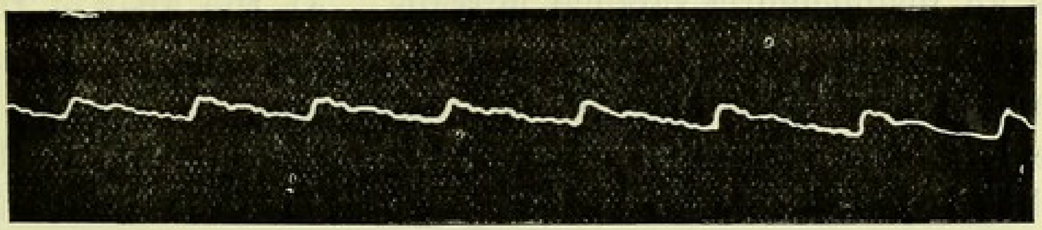


FIG. 63.—After exercises.

CASE III.—Count A., a patient of Dr. Gröedel's, on July 6th, 1896, took the following series of exercises at the Zander Institute:—

A 7a, A 7b, E 2, J 1, J 3.

B 10, B 11, B 12.

The character of these movements may be learned by referring to the section on Zander's gymnastics. I found a very remarkable difference in the character of the patient's pulse after exercises as compared with its condition before them. The following sphygmograms require little comment, and are certainly not explicable by defective sphygmography:—

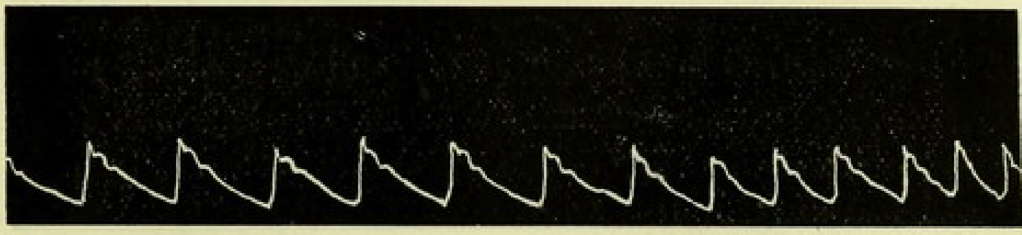


FIG. 64.—Before excercises.

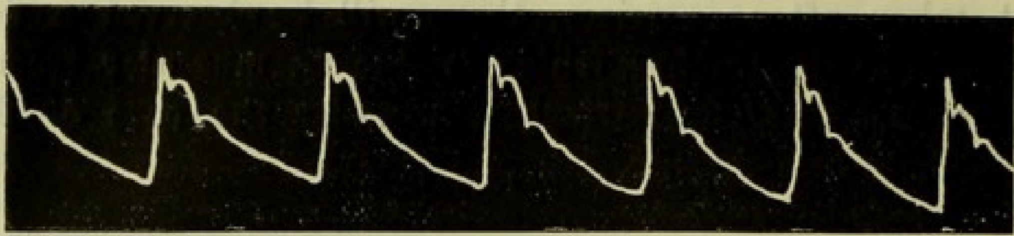


Fig. 65.—After exercises.

As I was unable in this case also to make a detailed physical examination of the patient, Dr. Gröedel has been good enough to write me the following particulars :—" In answer to your questions I have to inform you that Graf. A. has an insufficientia valvulæ mitralis. At the apex of the heart there is a weak systolic murmur, the pulmonary second sound is accentuated, the cardiac dulness is extended towards the left to the mamillary line, and towards the right to the right edge of the sternum; the apex beat is in the mamillary line. On account of this disease and rheumatic pains (Beschwerden) after acute articular rheumatism, he came here for the first time to undergo treatment in 1889, then in 1890, 1891 and 1896. The relations remain unaltered, that is, the condition at the heart has remained the same since the first visit. Palpitation and somewhat increased difficulty of breathing which existed before the present visit have disappeared during the 'kur.' He is now forty-six years of age."

Case IV.—Herr W., particulars of whose physical state before the following exercises will be found elsewhere (Case VIII. of the baths). The exercises in this case took place immediately after his return from the bath. I took the following sphygmograms before the exercises :—

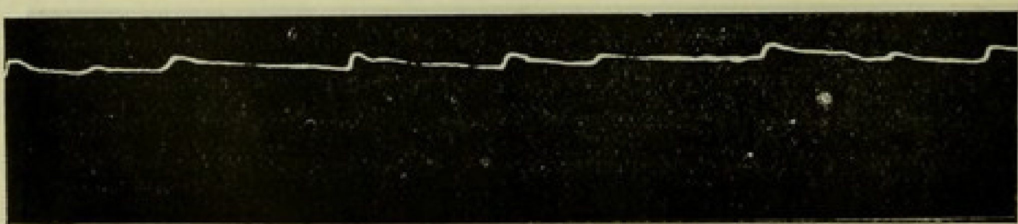


Fig. 66.—Before exercises.

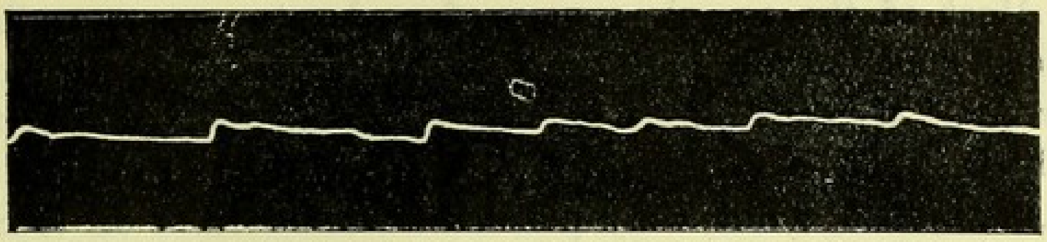


FIG. 67. –After exercises.

The gymnast administered movements of flexion, extension, adduction, abduction, and rotation of the arms and legs, at intervals of 10, 20, and 30 seconds, according to the severity of the movements, which lasted from 30 to 90 seconds. The following tracings were made after the exercises :—

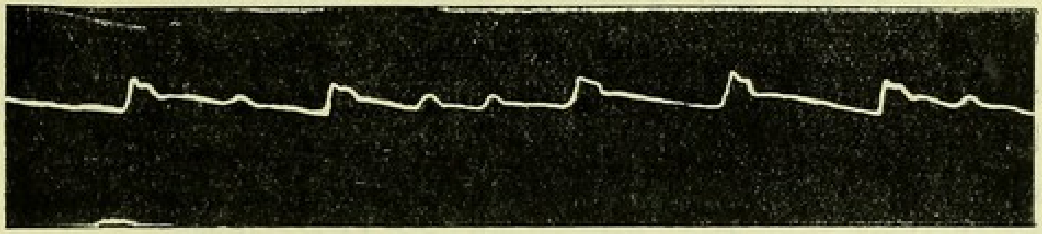


FIG. 68.—Before exercises.

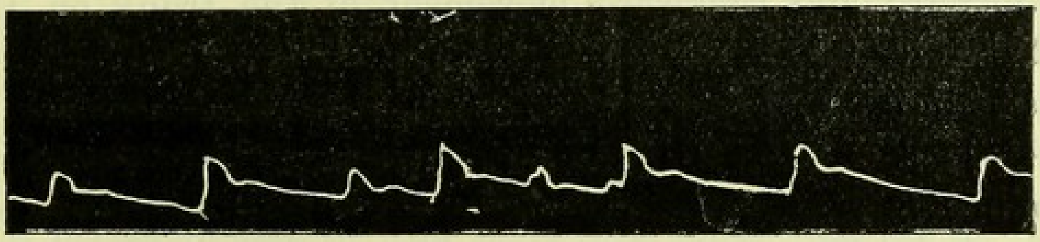


FIG. 69.—After exercises.

CASE V.—Myself, æt. 45 and organically sound. On July 9th, 1896, a gymnast much employed by Dr. Theodor Schott, administered a series of movements to me standing. Brigade-Surgeon Kees, of the Indian Army, was present, and noted my pulse rate at intervals, with the following result :—

7.33 a.m.	... ...	Pulse	84
7.42 „	... ...	„	82
7.54 „	... ...	„	86
7.57 „	... ...	„	82
8. 7 „	... ...	„	72
8.10 „	"very strong"	„	86

Most of the exercises were of moderate power, or that usually employed, and some were purposely made more severe. My perceptions indicated four degrees of severity, which might be rendered as *a*, *b*, *c*, and *d*, in an increasing ratio. With *a* and *b* my pulse rate varied from 82 to 84. With *c*, which I at once felt to be of considerable severity, it immediately fell to 72, and with *d*, which was still more severe and noted as very strong, it rose to 86. The exercises lasted, it will be observed, for 37 minutes, several movements being executed during the longer intervals noted in the table.

Case VI.—Herr H. (Case X. of the baths). Particulars of the physical state of this patient on July 10th, 1896, immediately before Dr. Theodor Schott administered a series of movements to him, will be found elsewhere. Dr. Newton Heineman, of New York, and myself were present. His pulse rate at the commencement of exercises was 126. After flexion and extension at the elbow and abduction and adduction of the arms the pulse rate was 114. After extension and flexion of the lower leg at the knee and seated, followed by forward and backward movement of the trunk on the pelvis standing, the pulse rose again to 126. The patient was then made to extend his arms from the perpendicular to the horizontal laterally, and to return them to the hanging perpendicular. It was noted that his respirations were deeper, and he stated that he felt his breathing easier. The pulse remained the same. Flexion and extension at the elbow was again made, and it was noted that pulse tension was rather less, while the pulse itself was somewhat fuller. Abduction of the arms horizontally was then made, and immediately after the position of the apex beat examined. It appeared to me to be *one* centimetre nearer the sternum, and at a rather higher level than before the exercises. Dr. Schott and Dr. Heineman considered the change amounted to *two* centimetres. The patient's chest was, however, somewhat emphysematous, and this rendered the determination of the point a little difficult. The patient drove, he did not walk to the house.

CASE VII.—Dr. G. (Case XI. of the baths), was submitted to a series of movements by the gymnast who operated upon me, and who is an expert at his work much employed by Dr. Theodor Schott. After abduction and adduction of the arms and the lateral and frontal up and down semicircle the pulse rate was 102. After anterior and posterior flexion of the trunk on the pelvis the pulse was 96 and fuller. After right and left rotation of the trunk on the pelvis, and forward and backward movement of the extended leg, the pulse was still 96 but smaller. After abduction and adduction of the leg and flexion and extension of the thigh on the pelvis, the pulse was 96, and again rather fuller. All these movements had been executed standing, and the limb-movements on both limbs. The patient now sat down with a pulse of 102, and began to perspire. After having been seated for a short time, abduction and adduction of the thighs and extension and flexion of the lower leg on the knee, in a sitting posture, were performed, when the pulse rate was 88 to 90. The patient then again stood, and circular movement of the arms round the shoulders and frontal and dorsal segments of circle were executed, the pulse remaining at 90. After flexion and extension at the elbow with the point of the elbow behind the perpendicular of the body, the pulse rose to 92, and after a somewhat powerful abduction and adduction of the arms horizontally, to 96. This was followed by lateral and frontal semicircular movements, when 98 was reached, and finally rotation of the trunk to right and left and flexion and extension at the elbow were again performed. This terminated the interview, and five minutes later the pulse fell to 84. On showing Dr. Schott this record he remarked that the exercises had been overdone.

After the exercises the apex beat was most audible over a space of 3 centimetres between points 13 and 10 centimetres respectively from mid-sternum. The position of the apex beat before exercise was considered to be 13 centimetres from mid-sternum. The beat was certainly not displaced outwards, but I considered its position was practically unchanged. Time, 4 to 4.30 p.m., July 12th, 1896.

Case VIII.—L. S., æt. 21. Cyanotic more or less since birth, and especially on exertion, with clubbed fingers and toes, has for the last two years been losing ground, becoming more dyspnœic and occasionally falling down while walking. The "apex" of her heart beats in the fifth space about one inch from the left edge of the sternum, the left ventricular dulness is at the third left rib. There is a systolic bruit, loudest at the apex, and traceable outwards to the left for some distance, but not audible in the back. It is also heard in the course of the pulmonary artery, and the pulmonary second sound is distinct. To the right of the sternum the bruit is less audible, and the second sound of the heart weaker. On November 10th I administered a series of arm and leg gymnastic movements over a period of a quarter of an hour, when she appeared to have exerted herself sufficiently. *During* the movements the systolic bruit was observed to assume a higher pitch, and the pulsation to be slightly accelerated; after the movements the timbre of the bruit returned to a lower pitch. It was observed that after the leg movement the pitch of the bruit was longer in returning to the lower note. Her general pulse rate before the movements was 78, after 72, and while the "apex beat" was noted as distinctly stronger, no change was observed either in its position or in that of the upper cardiac dulness. Dr. Forbes Ross was present. The following sphygmograms were made before and after movement:—

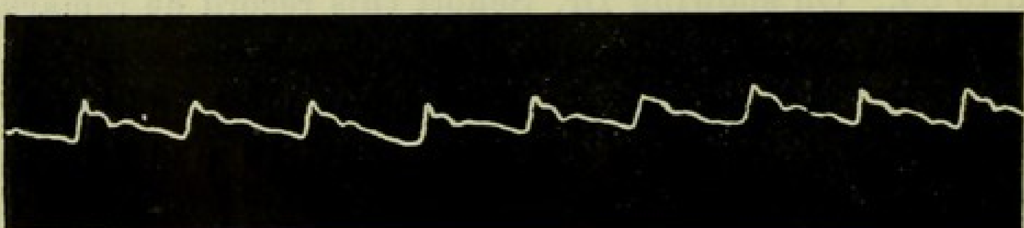


Fig. 70.—Before exercises.

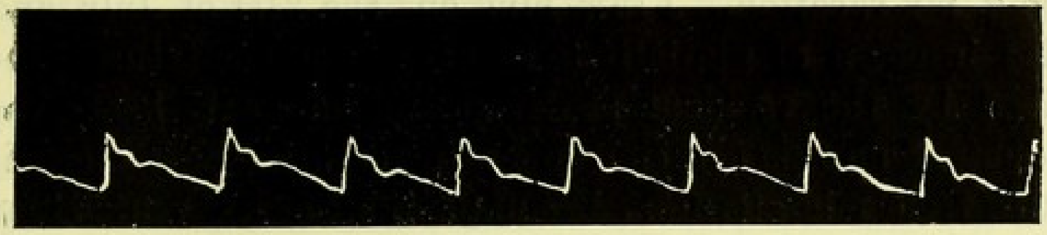


FIG. 71.—After exercises.

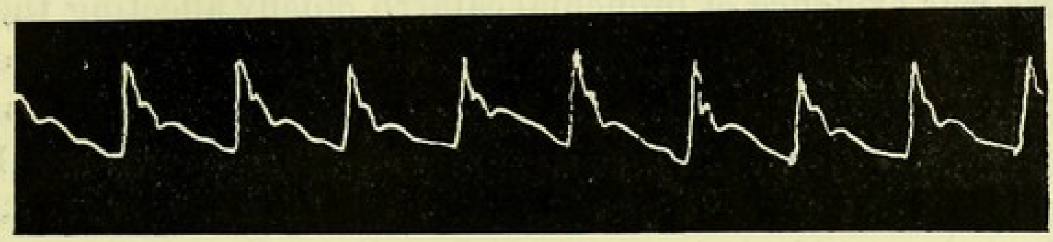


FIG. 72.—After exercises.

After a series of movements on November 14th similar changes to those noted above were observed. The increased force of the apex beat close to the left edge of the sternum in the fifth space was noteworthy. Systolic pulsation in the third left space over the position of the pulmonary artery was also remarked. The patient averred that her dyspnœa had diminished since the commencement of exercises, which have been carried out by her mother, whom I instructed. Dr. Cecil Morgan was present on this occasion.

CASE IX.—T. K., æt. 34, French polisher, is a man of middle height, fair, and of a lithe figure. He has been a champion swimmer, having won many medals and prizes for excellence in that art. He was under my care in 1895 for bronchitis with hæmoptysis, and I then discovered that he had mitral valvular disease with a presystolic bruit. He was unaware till then that his heart was in any way affected. Under treatment by cardiac tonics, with rest from work, he recovered his usual health and resumed his occupation. There was no history of rheumatic fever, but a brother who had had rheumatic fever curiously enough also had mitral constrictive disease. T. K. was under my care at the St. Marylebone General Dispensary. He returned to the dispensary with cough and pains in the chest in July, 1896, during my vacation. I saw him on the 21st of July, and added infusion of digitalis to an expectorant mixture prescribed by the resident physician. The apex beat was determined on this occasion to be in the fifth space 8 centimetres from mid-sternum, the upper limit of left ventricular dulness to be under the third rib, there was a presystolic bruit and slight reduplication of the cardiac second sound. There was evidence of bronchial catarrh chiefly affecting the left lung anteriorly and posteriorly. I did not again see the patient until August 1st. He had in the interval had an attack of diarrhœa, but had recovered from this. When I saw him the apex was noted as being "7·5 centimetres (3 inches) from mid-sternum, area of cardiac dulness 12 centimetres by 12·75" (4¾in. by 5in.), and it is recorded that these points "came in half an inch after some exercises." It is to the phenomena connected with these exercises that I now wish to call attention. Dr. Forbes Ross was present and noted the pulse rate while I administered movements of moderate severity. The following is a transcript of his notes, made at the time:—"Patient about to commence movements. No arythmia. Pulse rate 108 exactly. Movement I.—Pulse rate not slowed, 108-109. Movement II.—Pulse rate quickened to 108, slowed to 80, then rapidly rose to 108 immediately after cessation. Movement III.—Pulse slowed 100, then quickened, then slowed again to 96. Apex beat in half inch. Movement:—Extension of leg: I., 120; II., acme, 96; finish, 108. After ten minutes' rest pulse 90. Apex still in; movements, observations, and measurements were made in the standing position. The changed position of the apex beat was noted by transferred pencil marks.

The percussion note over the upper limit of left ventricular dulness observed before exercises was clear for about a finger's breadth below that point after the exercises. The patient had a well-formed resilient chest with well-developed serratus magnus. On the day after these exercises he expectorated about a dozen small clots of blood, but on August 8th, when he again presented himself at the dispensary, he was in good condition. The apex beat was $6\frac{1}{2}$ centimetres from mid-sternum, the pulse 84, and the area of cardiac dulness 12 × 12 centimetres. In other words *the apex beat had remained at the point where it was noted after exercises, and the area of cardiac dulness was proportionately contracted.* Dr. Forbes-Ross was again present when these measurements were made. The patient paid his final visit to the dispensary on August 15th, but did not require treatment, and was told he might discontinue the infusion of digitalis, of which he had taken one drachm three times a day, since the date of his first exercises. It was found on this occasion that the patient had considerable pulmonary mobility, and could mask on deep inspiration the percussion outline both of cardiac dulness and of cardiac leerness.

It will be observed that while the ultimate position of the apex beat remained at the point assumed after the exercises, the shrinkage of the area of cardiac dulness was somewhat greater immediately after the exercises than ultimately and permanently. To this fact I shall have occasion to refer again, when commenting on the general effect of the exercises.

Case X.—Mrs. W., æt. 36. Seen in consultation with Mr. Birch, of West Kensington, on July 28th, 1896. The patient had complained for about a year of being easily tired. She had borne two children, of whom the youngest was $2\frac{1}{2}$ years old. Her accouchements were normal, and after the first she had had albuminuria for some time, which had, however, quite passed off. A sister under similar circumstances had likewise had albuminuria. Her father is 67, gouty, and has had apoplexy. Her mother is 56 and in good health. The pulse at the wrist was 72 with occasional intermission. The heart rate during examination was 60 to 66 with occasional pauses. There was no bruit. The A.C.D. was about 12 × 12 centimetres. The apex beat was not perceptible to the hand and was localised by the ear. The lungs were normal. Exertion was always found to increase irregularity.

I instructed her husband in the use of the Schott movements, and indicated on his own limbs the degrees of force I considered advisable. The following sphygmogram was taken at the consultation:—

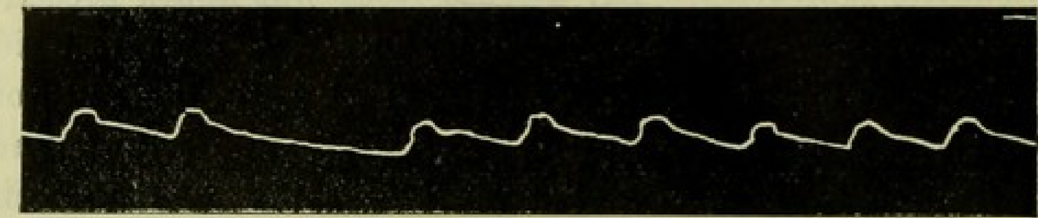


FIG. 73.

For the subjective sensations connected with cardiac intermission she had been under treatment, and these caused some anxiety. On November 10th, 1896, Mr. Birch wrote to me as follows:—"She experiences no discomfort now from her heart, and would if left to herself run up and down stairs as usual. Her pulse tracing is of much the same character, but the heart is much more regular. She continued the exercises until a short time before she returned to town."

CASE XI.—The following case presents many points of etiological and therapeutic interest, and illustrates the use of the Schott movements in cases which are confined to the recumbent position. I shall therefore enter somewhat more fully into its description than I have done in those which have been already summarised. The patient came to my clinic at the Saint Marylebone Dispensary on April 10th, 1896, with cough and a history of previous heart trouble. He attended till the beginning of August, when he married, after which I attended him at his own house. The Saint Marylebone Dispensary consists of a well-appointed out-patient department like that of a general hospital, while the homes of the patients represent wards, in many cases certainly less comfortable than those of a hospital. I shall divide the consideration of this patient's case into four periods :—

(1) From the commencement of his attendance till his marriage.

(2) From his marriage to his first convalescence.

(3) From his relapse to his second convalescence ; and

(4) During his second convalescence.

I. E. F. S., 29 years of age, carpenter. About eight years ago, the patient, on his way home after the day's work, observed the curtains of a house which he was passing to be on fire. He knocked at the door, rushed past the servant who opened it, and extinguished the blazing curtains by beating them with his overcoat. A palpitation which supervened on this operation did not subside, and he, previously a healthy man, was more or less confined to his bed, and out of work for eight months after the above event on account of heart trouble. At the end of that time he was able to resume work, and continued uninterruptedly at it until the autumn of 1895, when he was again laid up with his heart for three months. He again resumed work, but for six or seven weeks before consulting me on the 10th of April, 1896, had suffered from cough and palpitation, night sweats, and loss of flesh. On examination, the patient was seen to be a tall man, (5ft. 11in.), evidently of a neurotic type. The pulse at the wrist was 72 and at the heart 150. The apex beat was noted as being in the 5th space outside the nipple line, the upper limit of the left ventricular dulness (L.V.D.) in the 3rd left interspace, the right auricular dulness (R.A.D.) at the right edge of the sternum, and the upper liver dulness (L.D.) under the right sixth rib. There was a systolic bruit with thrill over the apex, and the murmur was not heard in the back. There was rhonchus at the right pulmonary base and the respiration was over 30 in the minute. There was no albuminuria. The case was diagnosed as one of ruptured chordæ tendineæ with mitral regurgitation and virtual if not actual mitral stenosis. Twenty minims of a recently prepared concentrated infusion of digitalis was prescribed to be taken three times a day. On April 14th he is noted to have rested and taken the medicine, and to be feeling much better. The physical signs were the same, the pulse at the wrist 114, and at the heart 125, and more regular. April 18th, pulse at wrist 84, at heart 114-120. Physical signs as before. On April 25th, I prescribed ½ grain pills of powdered digitalis to be taken three times a day. The pulse at this date sitting is noted as 96 and irregular. The apex beat was four inches from mid-sternum, L.V.D. third rib left, R.A.D. right edge of sternum, and the systolic bruit was not heard in the back. On March 2nd, pulse 78 at wrist, 102 at heart. He continued to take the digitalis pills till the 16th of May, when I prescribed two drachms of the infusion of digitalis to be taken three times a day. On the 23rd the following note was made:—"Pulse at wrist 84, at heart 114. Very emotional. Apex 5th space 4 to 4½ inches from mid-sternum. Thrill and systolic bruit at apex. Epigastric pulsation." ℞. Tr. Digitalis ♏. viii. Liq. Strych. ♏. iv. Pot. Bromide grs. xv., t.i.d.s. May 30th, pulse at wrist 96, at heart 104. Apex 4 inches from mid-sternum. On June 20th the apex beat was found to be 4½ inches from mid-sternum, there was palpable thrill, and the systolic bruit is noted as being faintly audible in the back. The following note was also made: "Very neurotic, engaged to marry, out of work, tachycardia." ℞. Am. Bromid. grs. x. Infusion digitalis ♏. 120, t.i.d.s. He took this mixture till July 7th, when he complained of its "taking away his appetite" and the resident medical officer prescribed an acid cinchona mixture and some linctus Scillæ for cough. On July 18th, I made the following note, "Pulse at wrist 72, at heart 102, irregular; A.C.D. 14½ × 12 centimetres. Apex beat 9 centimetres from mid-sternum, maximum beat in 5th space. Pulsation seen also farther out in 5th space, also in 6th space, and in epigastrium. L.V.D. 3rd rib. R.A.D. right edge of sternum. L.D. 6th right rib. Bruit systolic apex, thrill, bruit not heard in back." The patient's progress so far had been far from satisfactory. He rested from work and came to and fro to the dispensary. Digitalis had been used in moderate doses and with regularity without doing much good, and in the case of an out-patient I did not care to give much larger doses. A mixture containing one drachm of the infusion of digitalis and two grains of quinine was ordered to be taken three times a day. I then instructed a relative of the patient in the use of some of the arm and leg Schott movements, and prescribed their employment for half an hour each day. On July 25th the pulse at the heart was 102 to 108, at the wrist 72 to 78. He stated that he felt his heart to be much steadier, there was less apex thrill, the beat was 8·8 centimetres from mid-sternum, A.C.D. 14 × 13 centimetres. L.V.D. at the top of the 4th left rib. R.A.D. at the right edge of the sternum and L.D. at the 6th right rib. The action of the heart was noted as being less tumultuous, and the bruit as more regular. The lungs were clear. On August 1st the apex was $3\frac{1}{2}$ inches from mid-sternum, A.C.D. $5\frac{1}{2} \times 5\frac{1}{4}$ inches. I administered some of the movements to him, as also did Dr. Forbes Ross. It was observed that during administration the pulse first quickened, then slowed, and on abandoning effort again quickened. The patient stated that he continued to feel better. On August 8th the apex beat was $8\frac{1}{2}$ centimetres from mid-sternum, the A.C.D. was $14\frac{1}{4} \times 14\frac{1}{2}$ centimetres. P. at the heart 114, at the wrist 78. The patient stated that his heart had not been so quiet during the previous week, and that as he was unable to follow his usual occupation, and was exhausting what little means he had accumulated, he had purchased a small newspaper business, and intended to marry next day. He did so.

II. A fortnight later, August 22nd, he returned to the dispensary a cardio-vascular wreck, complaining in addition to his other troubles of sexual impotence and insomnia. The apex beat was 9·5 centimetres from mid-sternum. A.C.D. $16\frac{1}{2} \times 14$ centimetres. L.V.D. 3rd rib. R.A.D. 4·5 centimetres from mid-sternum to the right. Pulse at wrist 120, at heart 150, rhythm irregular, bruit systolic apex. There was also an irritating dry cough with crepitation at the left base posteriorly. I advised him to go home and go to bed, and avoid all excitement. ℞. Sulphonal grs. xx. ℞. Am. Bromide grs. x. Inf. Digit. ♏. 60 t.i.d.s. August 23rd, in bed. Heart pulse 150, wrist 120, very irregular. Apex 10 centimetres from mid-sternum with systolic bruit. Sibilation and crepitation at lung bases posteriorly especially on the left side. Urine very much reduced in quantity, sp. gr. 1025; no albumen, no sugar, much bile colouring matter. Slept rather better. A sphygmogram of his pulse on this occasion will be found on p. 12, Fig. 6. August 24th, cough very troublesome; copious thin, prune-juice expectoration. Lung signs as before and preponderating at the left base posteriorly. Otherwise in statu quo. *Ice to be applied continuously to head and forehead.*

August 25th.—After the application of ice, much less cough. Expectoration less abundant and thicker. Temperature 100 degrees F. Pulse 132. Respiration 20. The following sphygmogram was taken :—

Fig. 74.—Right radial pulse.

August 28th.—Temperature 97·6. Pulse at wrist 90, at heart 120. Resp. 20. Urine sufficient in quantity. Appetite good. Sleep good. Ice on head 4½ hours when seen. Sphygmograms follow :—

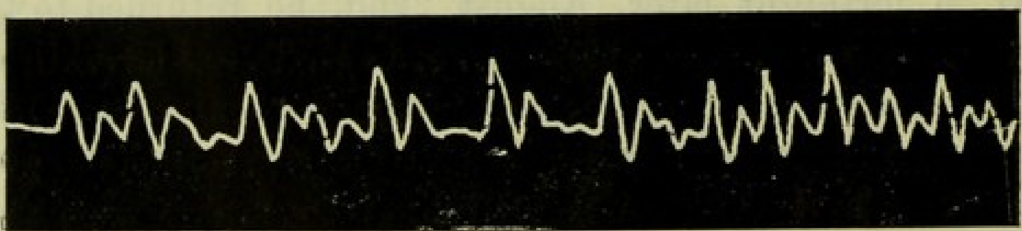


Fig. 75.

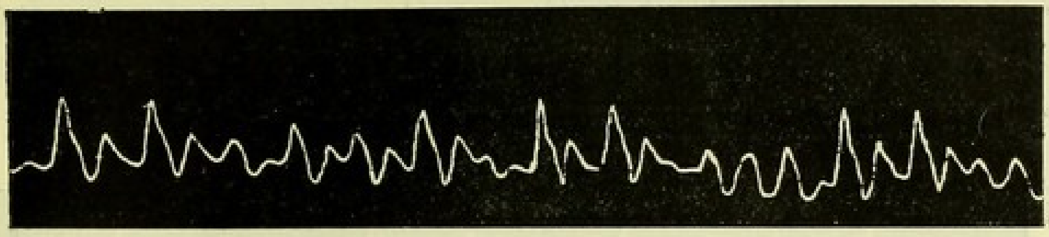


Fig. 76.

August 30th.—Has continuously improved since the use of ice to the head. Chest now clear, very little cough or expectoration, the latter not blood-stained. Pulse and heart still very irregular, but action more powerful. Rate 90 to 120. Resp. 24. Tachybradypnœa when asleep. Urine sufficient in quantity. Appetite good. Still in bed. The first of the following sphygmograms was made after the ice had been removed from the head, and the second after it had been re-applied for fifteen minutes.

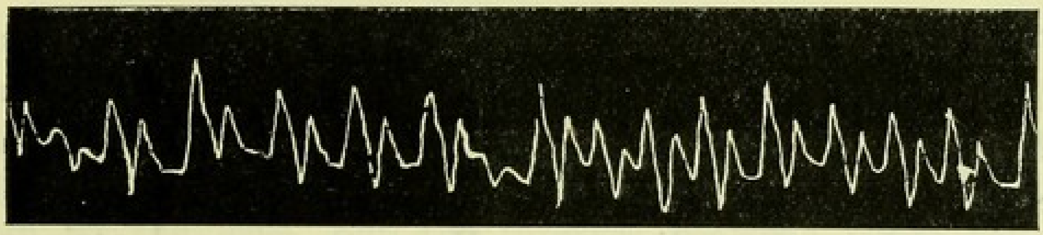


Fig. 77.—Ice removed.

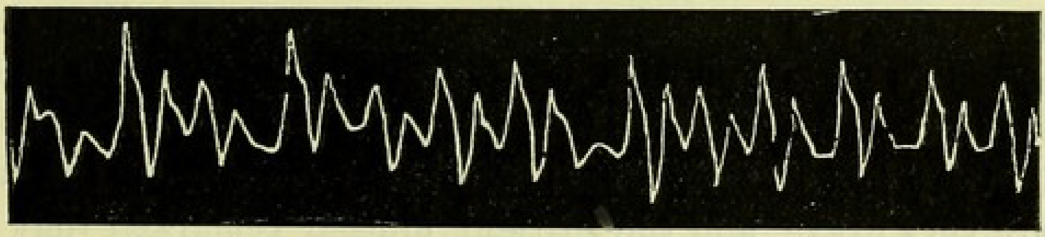


Fig. 78.—Ice applied 15 minutes.

It will be observed that the patient still had a very irregular heart, with extremely low arterial tension. After ice the ventricular systole (up stroke) was always increased in length.

III. During most of September I was out of town, and only occasionally saw the patient. He was under the care of my friend Dr. Forbes Ross. His heart and pulse were still very irregular on September 12th, as is shown by the following sphygmograms :—

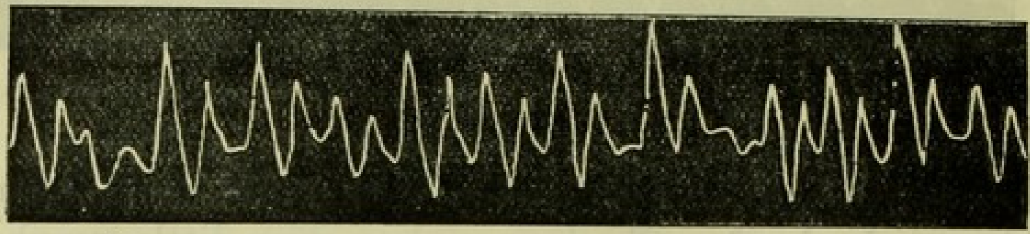


FIG. 79.—Sept. 12th. Right radial pulse (lying).

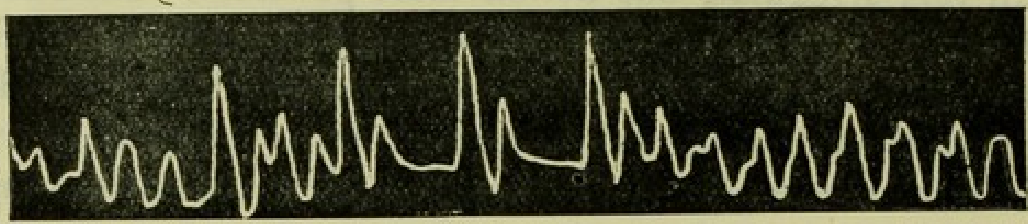


FIG. 80.—Sept. 12th. Right radial pulse (standing).

The last of these was taken while the patient was standing, his hand and forearm resting on a piece of furniture. The general sense of well-being had, however, improved, and he got up and began to move about the house a little. He went out for a short distance. He soon relapsed seriously. The pulse became very irregular and rapid (140). The lungs again became involved and he expectorated much thin mucus of a prune-juice colour. There was well-marked epigastric pulsation with much heaving, and visible pulsation in the precordium. On seeing him with Dr. Ross soon after the last tracing was taken the prospects of the case were very grave, and the patient himself remarked that he felt "three parts dead." Ice was applied to the precordium as well as to the head, and 15 minims of the tincture of digitalis prescribed to be taken regularly every six hours. He again rapidly improved, and on October 2nd, 1896, I made the following note: "Pulse 72 to 78, irregular, but each pulsation felt at the wrist and corresponding with the cardiac systolic sound. Occasionally 84 at the heart and 78 at the wrist. Resp. 24. Sleeps 8 to 9 hours a day with-

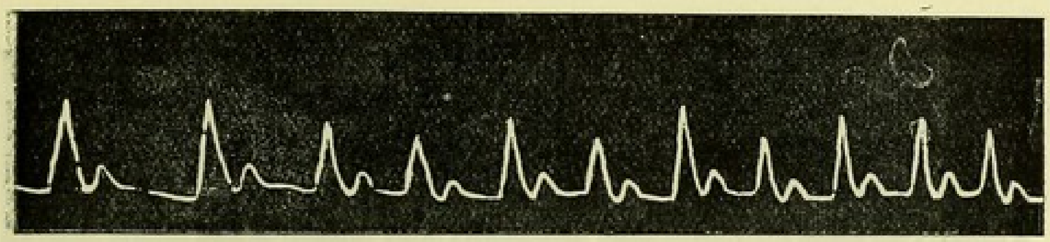


FIG. 81.—Oct. 2nd. Right radial pulse.

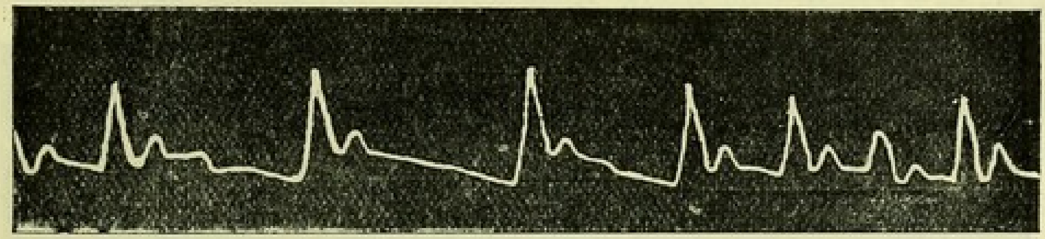


FIG. 82.—Oct. 2nd. Right radial pulse.

out an hypnotic. Apex beat 5th space 9·5 centimetres from mid-sternum. L.V.D. 3rd rib (lying). R.A.D. right edge of sternum 4 centimetres from mid-sternum. L.D. 6th rib. A.C.D. 15 × 12·5 centimetres. Systolic bruit at apex, together with a *bruit de galop*. Over the visible apex beat diastolic impulse to be felt. Reduplication of second sound also at the base, but the interval between these sounds shorter than those felt at the apex between the systolic and diastolic impulses. No epigastric pulsation, less precordial heaving. No tricuspid systolic bruit as on a former occasion. Some rhonchi at left base posteriorly, but lungs and organs generally practically normal. Sphygmograms show improvement. Still confined to bed.

IV.—On October 11th the patient remained very comfortable. The *bruit de galop* at the apex was both audible and palpable while lying, and neither audible nor palpable while standing. The pulse quickened in the erect position, but there was no change in the ascertainable size or position of the heart in the two postures. The following sphygmograms were taken, and also a cardiogram, by placing the sphygmograph over the visible apex beat. All taken in the recumbent posture :—

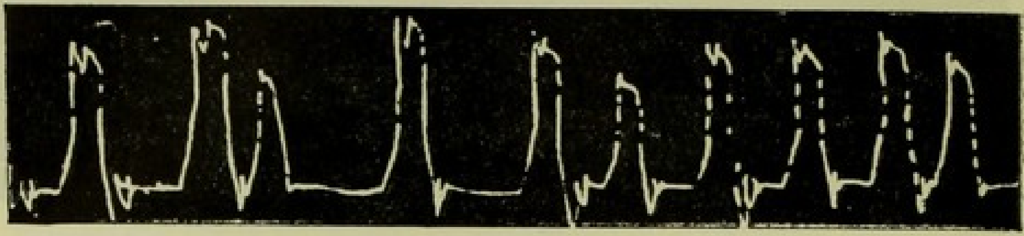


Fig. 83.—Cardiogram (lying). Oct. 11th.

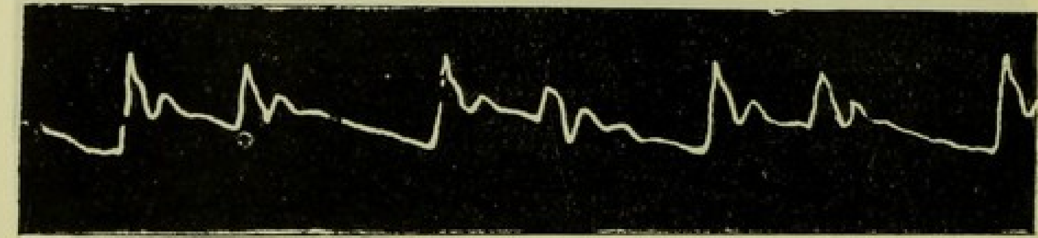


Fig. 84.—Right radial pulse. Oct. 11th.

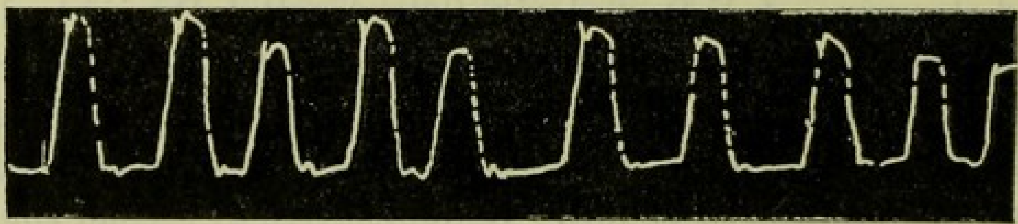


Fig. 85.—Cardiogram. Oct. 12th.

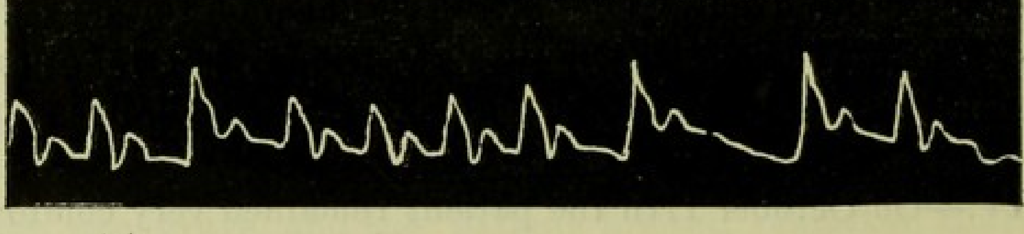


Fig. 86.—Right radial pulse. Oct. 13th.

The patient had taken 15 minims of tincture of digitalis every six hours until October the 6th, when it was reduced to 7 minims. On October 13th, his condition being comparatively satisfactory, as shown by the following tracings, a series of gentle Schott movements were commenced in the recumbent position.

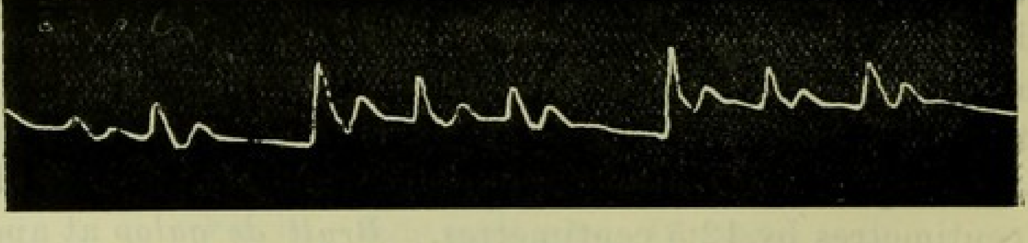
Flexion and extension at the wrist and at the elbow on both arms were alone used and with a power not exceeding 4 to 5 lbs.

On October 18th the patient began the use of self-resisting (Selbsthemmungs) exercises in addition to having Schott movements administered to him by me on the occasions on which I visited him. As regards one of the effects of both these kinds of movements upon the heart's action, the following notes are of interest:—

"October 30th.—During exercises the pitch of the bruit is raised; thus it resembles the syllables loof, loof, loof, expressed in a loud whisper, and immediately falls on the cessation of movement to loaf, loaf, loaf, enunciated in the same tone."

On November 2nd I determined that the same change of note in the bruit followed the self-resisting exercises. I also observed on this occasion that after the larger muscular movements of the legs, the raised pitch of the bruit did not resume its lower tone so rapidly as after the smaller movements of the arms. The patient continued to take at this date ♏x. of Tinct. of Digitalis three times a day. The area of cardiac dulness on some occasions was observed to become slightly less, and the apex beat to move a little inwards, and even to vary during the same visit, but the general position of these points was not importantly altered. As a final note I may transcribe that made at my visit on November 7th. "Found him sitting on an easy chair; had been up since 11 a.m. (it was then 5 p.m.). He felt a little tired, but was in no way distressed. Pulse 60-78. Apex 8·5 centimetres from mid-sternum. A.C.D. 13 centimetres by 12·5 centimetres. *Bruit de galop* at apex barely audible, but just to be heard, not to be felt. Made him lie down; the pulse was then about the same, but *bruit de galop* was immediately both heard and felt. Made him sit up again, and gave him the flexion and extension movements at the elbow twice, and also abduction and adduction of the arms, and flexion and extension at the knee. The triple rhythm was then neither heard nor felt, and the systolic bruit was clear and loud. Apex beat 9 centimetres from mid-sternum, the position occupied when lying as marked on the chart. Still, these variations of the apex would be covered by a shilling. Performs self-resisting exercises for half an hour twice each day. Takes ♏x. of Tr. of Digitalis three times a day. On November 14th I allowed him to leave his room and go downstairs. Ten days later I found him at work in his shop. He had been out for a walk, which in no way distressed him, and he stated that beyond some subjective precordial discomfort at times, he felt very well. His pulse rate was about 84. The A.C.D. standing 10 by 14½ centimetres. Apex 8·5 centimetres from mid-sternum, and sphygmograms still showed the irregular occurrence of hemi- and hypo-systole. He continues to use the self-resisting exercises, and takes small doses of digitalis.

The circumstances which enabled this patient to recover were:—(1) that uncertainty as to his means of livelihood and the realisation of his social desires were in great measure removed; (2) after the relief of his urgent symptoms he slept and ate well; (3) his cardiac condition permitted the bold use of digitalis; and (4) his convalescence was not interrupted by the necessity for resuming labour for which he was physically incapacitated. The following sphygmograms were taken at the dates, and under the circumstances indicated:—



G. 87.—Right radial pulse (standing). Oct. 13th.

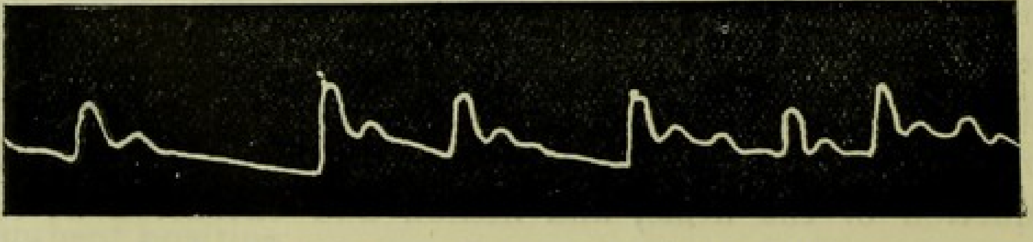


Fig. 88.—After mild exercises. Oct. 13th.

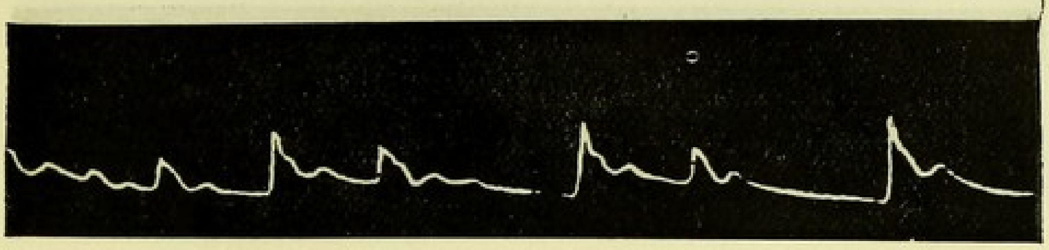


FIG. 89.—Soon after food. Oct. 18th.

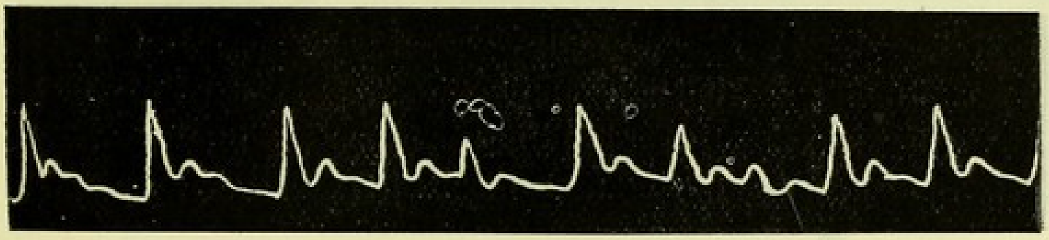


FIG. 90.—During exercises. Oct. 18th.

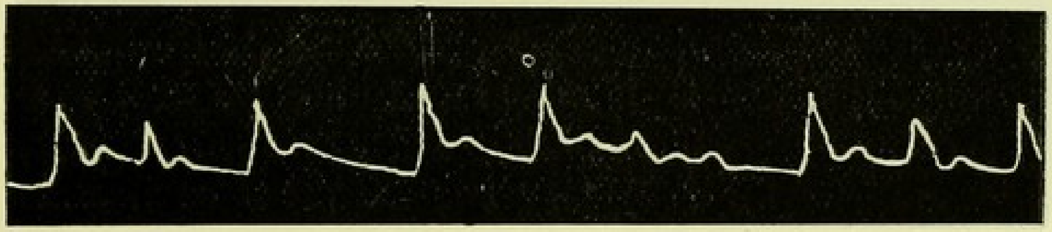


FIG. 91.—After exercises. Oct. 18th.

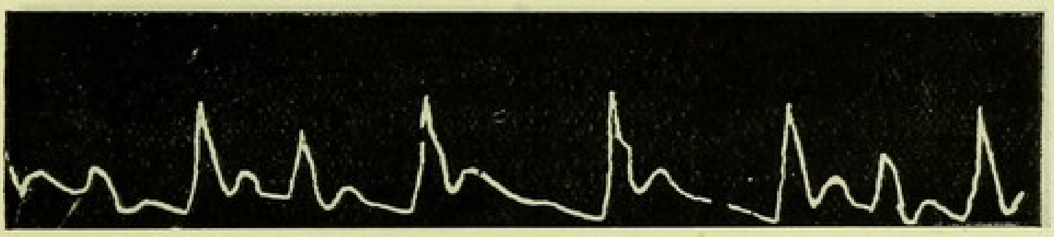


FIG. 92.—Before exercises. Oct. 20th.

FIG. 93.—Immediately after exercises. Oct. 20th.

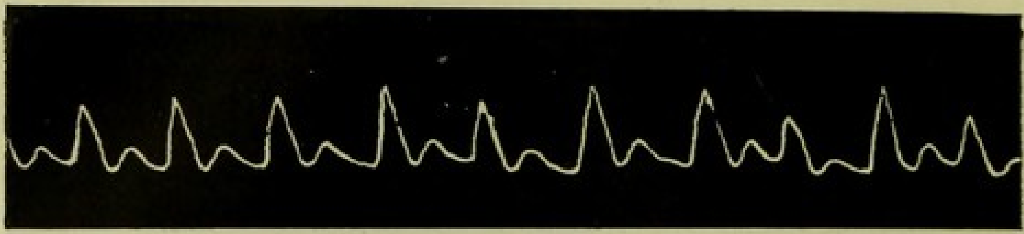


FIG. 94.—Still later. Oct. 20th.

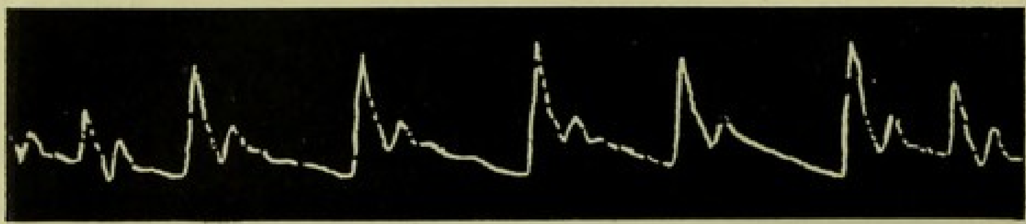


FIG. 95.—Before exercises. Oct. 24th.

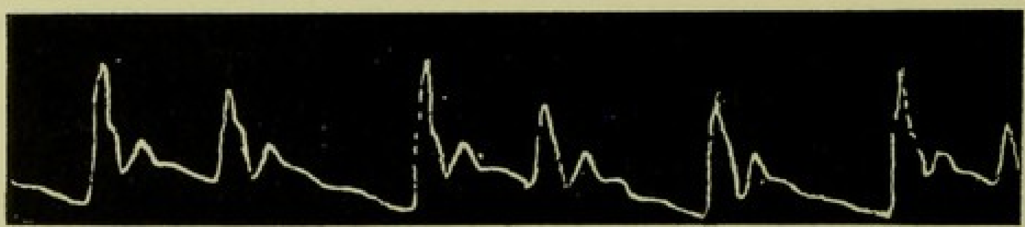


FIG. 96.—After exercises. Oct. 24th.

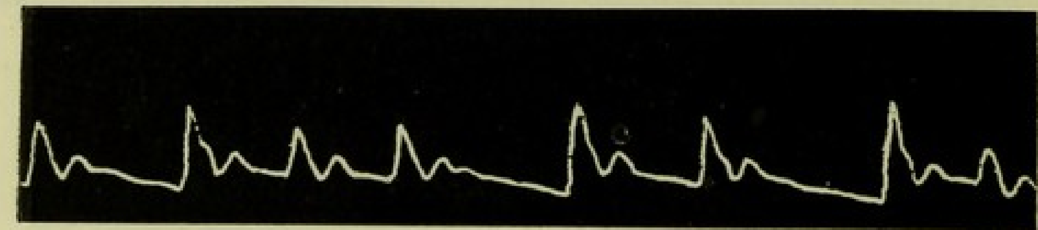


FIG. 97.—Before exercises. Oct. 28th.

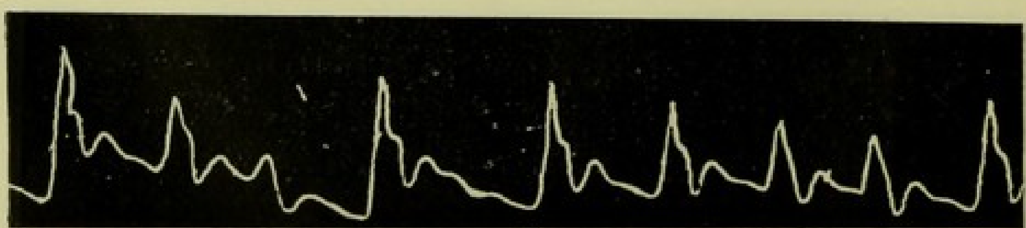


FIG. 98.—After exercises. Oct. 28th.

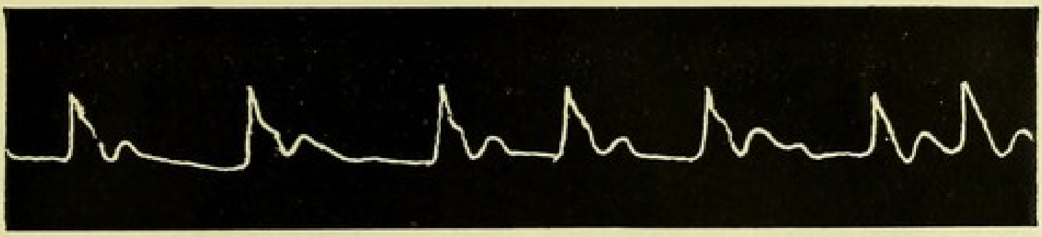


FIG. 99.—Before exercises. Oct. 30th.

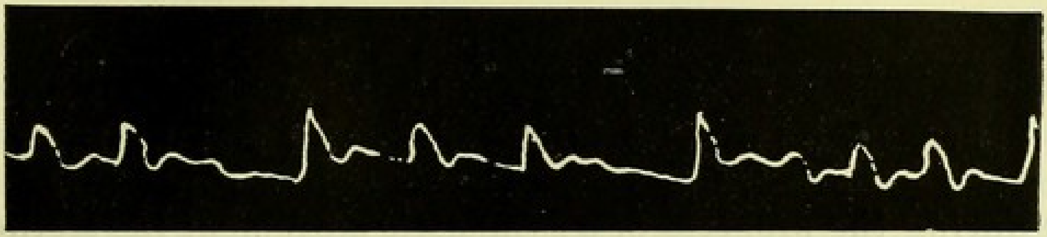


FIG. 100.—After resistance of 10—12 lbs. Oct. 30th.

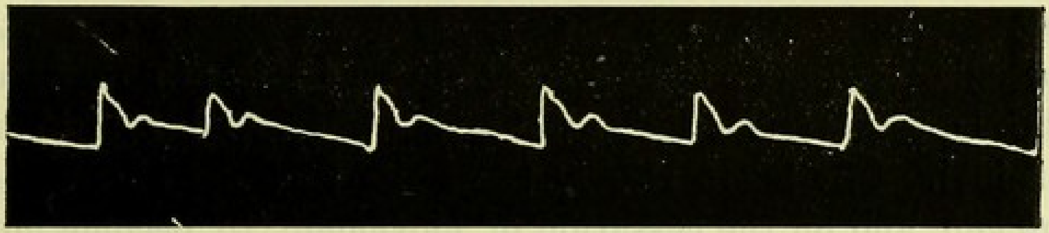


FIG. 101.—Before exercises. Nov. 7th.

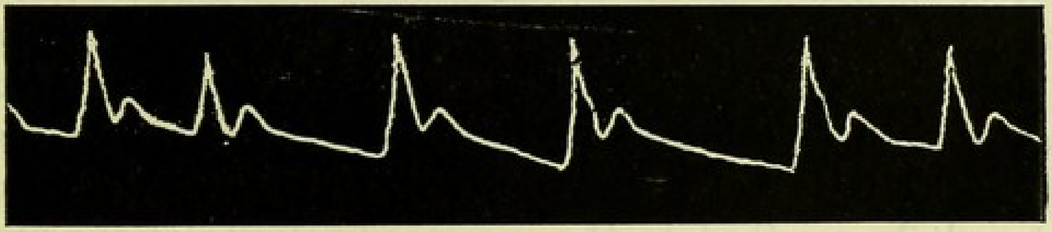


FIG. 102.—After exercises. Nov. 7th.

SECTION VI.

EFFECTS OF GYMNASTIC MOVEMENTS ON THE HEART.

If during the progress of a gymnastic movement the stethoscope be placed over the heart and a bruit be present, the pitch of the bruit will be observed to rise until a certain highest note is reached, and on cessation of movement the pitch will be observed to fall to its original *timbre*. The smaller the muscular effort made the sooner does this fall of note occur. The larger movements entail a more gradual fall to the original. The heart may at the same time be observed to quicken, and on the cessation of movement to become more slow. When the movements made exceed a certain severity and the general force of the subject is good, a fall in the frequency of the heart's action may in some cases be observed when the movement is at its acme, but the rule is acceleration in proportion to exertion. The cause of the raised pitch of the bruit under these circumstances, associated as it is with increased rapidity of heart's action, can only be ascribed to the increased velocity of the blood passing through the orifice at which the bruit is generated, unless we assume a diminution of orifice from muscular contraction, of which there is no evidence. Inasmuch as the force of a moving body is in proportion to its velocity, it follows that its progressive and retrogressive impulse must alike be increased under these circumstances. We can therefore easily understand that dilatations of the heart unassociated with conditions favouring the regurgitation of blood, rapidly rid themselves by increased propulsion, of blood accumulated in their chambers. No doubt the right ventricle empties and fills synchronously with the left, but the veins in the systemic section, and the lungs in the pulmonic, are capable without distress of containing a considerably larger quantity of blood than that usually circulating in them under normal circumstances. All the blood in the body may, as is well known, be contained by the veins, as the empty arteries proclaim after death. When, moreover, the gymnastic movements, as is frequently the case, are carried out in the erect position, gravitation tends to retard the incoming inferior caval blood as was pointed out when discussing orthopnœa, and the accelerated action of the left ventricle then acts to greater advantage in emptying the pulmonic circuit. But while the increased velocity of the escape of blood for a time is all in favour of propulsion, a stage is reached with increasing peripheral pressure when the resistance of the blood column opposed to the propulsion of the heart acts as a check upon the latter, and, as I have stated, at the acme of a movement, cardiac force as measured by velocity tends to fall if the nervous mechanism of the case have a normal response. It may be said of the momentarily retarded action of the heart, "elle se recule pour mieux sauter." This is of importance in all cases, and especially when regurgitant lesions are present. In the latter the primarily increased velocity tells on both the progressive and retrogressive tendencies of the ventricular blood, and the utmost care is necessary to limit so far as possible the retrogressive tendency. This can, of course, only be done by limiting progression, and simply implies the use of a minor degree of force in movement. Obstructive lesions, on the other hand, benefit by the increased force which accompanies increased velocity, and under favourable circumstances, as in the case of T. K. (Case VIII.), a permanent alteration may be effected in the position of the heart, which cannot be satisfactorily explained otherwise than by the removal of some condition which favoured its displacement.

August Schott believed the alteration of position was associated with diminution of bulk, and that the latter was due to the removal of excessive accumulation of blood within the chambers of the heart (*loc. cit.*). I am not prepared to dispute this interpretation, and if it can indubitably be proved that the altered position and diminished cardiac area in such cases are associated with decrease in the size of the organ, argument on the subject is at an end.

Dr. Theodor Schott believes that the Röntgen rays have enabled him to demonstrate this to be a fact, and has so informed me in a private communication. His results are not yet published, but will be awaited with interest by the profession. In the absence of such evidence, the interpretation which appears to me more feasible is, not that the organ is appreciably diminished in size, but that altered position of the heart, with some rotation towards the right instead of the left, offers, *in perspective*, a smaller area for percussion, and greater facility for the reflection into lung substance of percussion blows directed antero-posteriorly upon the cardiac area. To avoid obscurity in this matter, if the heart of a sheep be taken, which has died in systole, and suspended behind a graduated wire-work in a position fixed by transfixing the great vessels as they leave the heart, and then a thread be passed through the apex so that this part of the heart may be altered in position from right to left, or left to right, round the basal vessels as a centre, and the organ be photographed from the same point in the various positions it occupies, the *perspective* area of the heart will be observed to be less in some positions than in others, although the organ itself has of course undergone no change (Figs. 103 and 104). I am aware that this experiment is crude and rough, but it will serve to explain my meaning in the above passage. The heart may therefore, I believe, until there is irrefragable evidence to the contrary, be assumed to contain much the same quantity of blood, be of the same size, act more vigorously in an altered position, and appear on percussion to be smaller without actually being so,

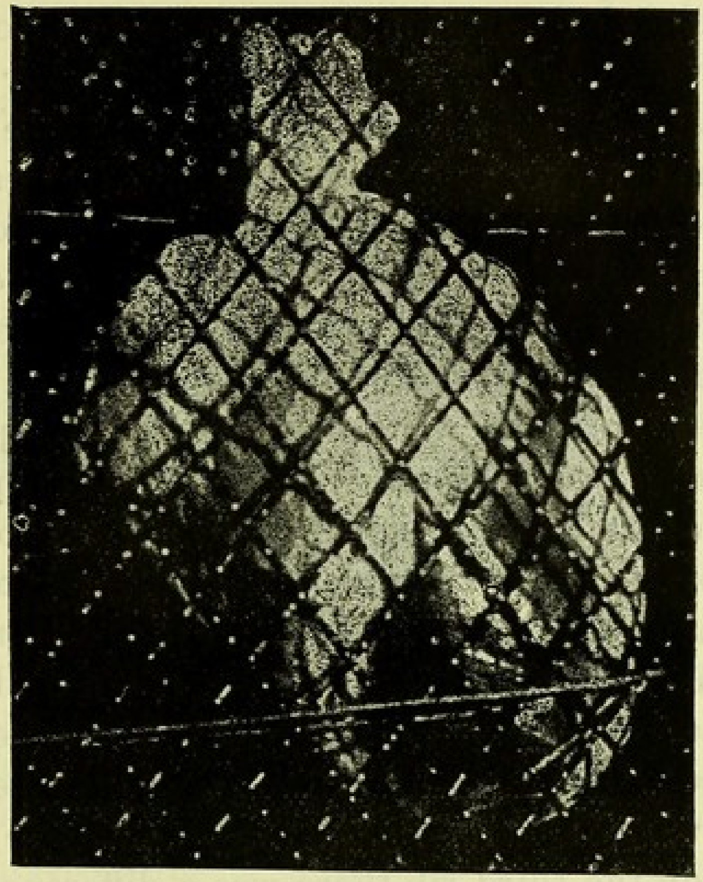


FIG. 103.—Displacement towards the left with increase of the cardiac superficies.

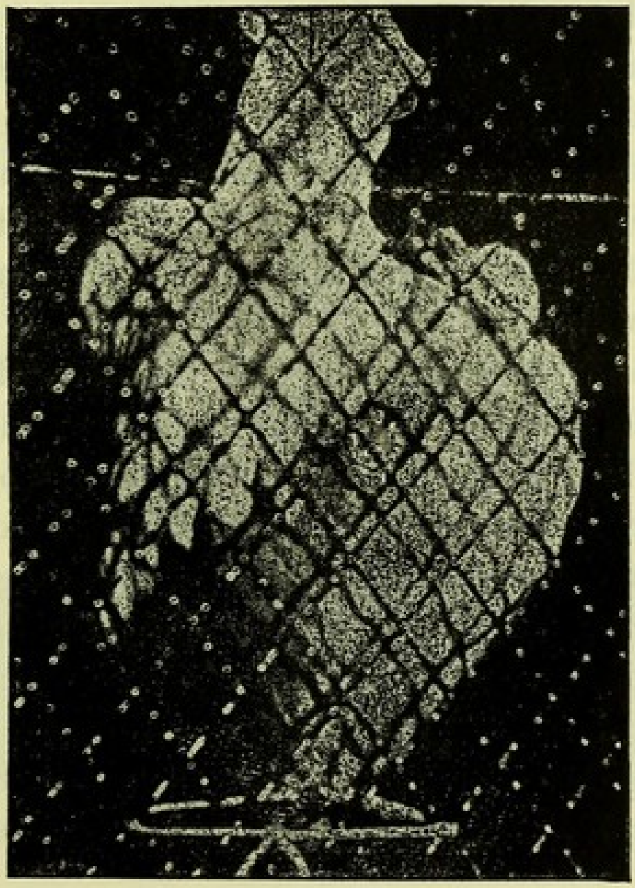


FIG. 104.—The smaller surface of the heart not displaced towards the left.

although Schott's contention that the removal of excess of blood in the chambers of the heart accounts for shrinkage in the cardiac area must be admitted to be quite possible, a view of the same phenomenon taken, as already stated, after venesection. Neither the Schotts nor anyone else, so far as I know, maintain that an hypertrophied heart is actually reduced in size, but that the distension of the heart by surplus blood is removed by its more vigorous action.

Since the above was written, Dr. Schott has published a paper (*Deutsche Med. Wochenschrift*, No. 14, 1897, p. 220) containing an account of investigations undertaken to determine the degree of cardiac shrinkage after baths and exercises, by means of the Röntgen rays. In this investigation Professor Newton Heineman, of New York, was associated with him. The two cases of which skiagrams are published were in young subjects, 8½ years and 14 years of age respectively. The former was submitted to gymnastics with the result that at the level of the third rib there was a difference of rather less than one centimetre, and at the level of the fourth rib rather more than one centimetre. The second case was bathed, and showed an apparent shrinkage of 0·8 centimetre. These results seem to me to support those who have been unable to satisfy themselves of the existence of the very considerable shrinkages at times recorded, and in their explanation change of position in the more energetically acting heart must be regarded as a possible factor as well as any alteration of volume.

Dr. Theodor Schott informs me that the diminution in size is the rule, not the exception, unless the heart be much disorganised, and a crowd of recent adherents to his doctrines in this country appear to agree with him. I do not presume to compare my experience with his, but regret that my experience, such as it is, so far compels me to differ from him on this point—*the point* in his late brother's teaching marked with a sign of interrogation by Oertel (*loc. cit.*) when lauding August Schott's work generally. In this I am supported, as will be seen in the appendix, by Dr.

Gröedel. Shrinkage by disengorgement occurs, but not, I think, as a rule, and there are other factors to which I shall refer presently which must not be overlooked in deciding the question.

The effect of the movements in accelerating the heart's action, and projecting the blood more powerfully while these are in progress, is shown by some of the sphygmograms from the case of E. F. S., and also by the following, which are from the right radial artery, and in a sitting position, of a very severe case of cardiac failure with dilatation, but without valvular lesion. The patient, after having been anasarcous, orthopnœic, and albuminuric (to $\frac{1}{4}$) for three weeks, and whose recovery seemed very doubtful, did recover perfectly under the use of 12-minim doses of Tinct. of Strophanthus with Ammonia and Ether, used persistently for a month.

The readiness with which accelerated action of the heart manifests itself while a movement is in progress, may, in the absence of cardial bradycardia or emotional states, be regarded as a measure of the stability of the cardiac mechanism, and therefore, so far as my observation goes, is greatest when in addition to muscular failure there is valvular lesion.

The sphygmogram representing acceleration during a movement in the last case was taken during a tolerably severe flexion at the elbow, and the general direction, as well as to some extent the size of the waves, is in a measure due to the conjugate tension which is almost unavoidable when a considerable muscular movement is taking place in one arm, and the other is kept at rest with the sphygmograph attached.

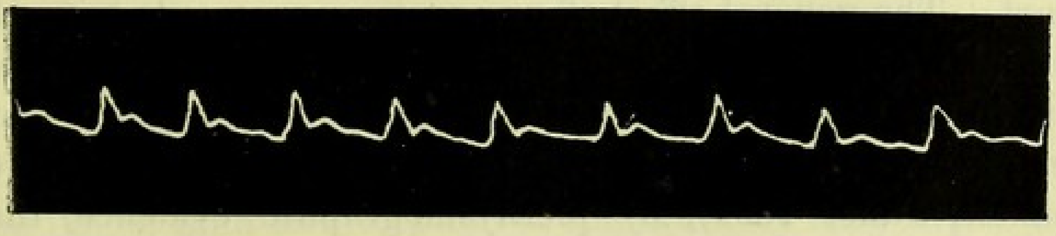


FIG. 105.—Before flexion and extension of elbow. (Right radial pulse).

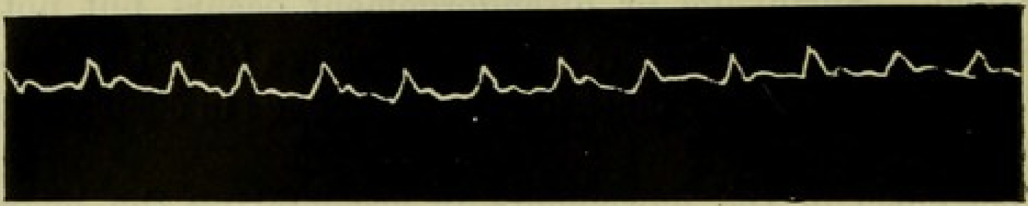


FIG. 106.—During these movements.

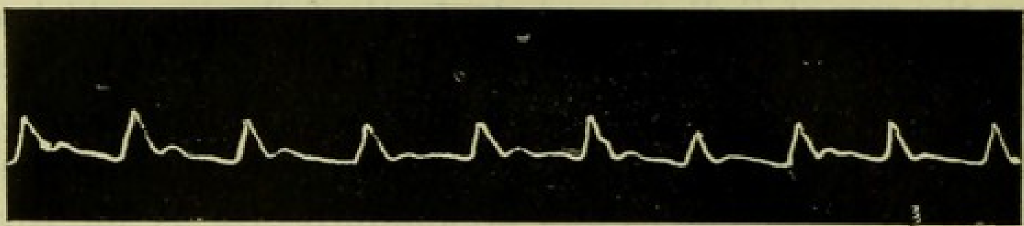


FIG. 107.—After these movements.

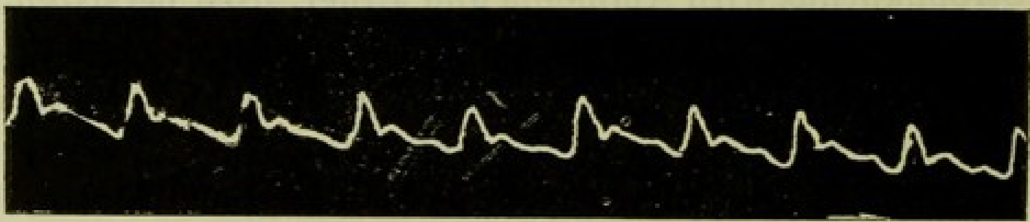


FIG. 108.—After several movements.

To effect repletion of the arterial periphery, frequency of cardiac action must be associated with increased velocity of tolerably equal volumes of blood, which implies increased power in the heart. A quick heart with an irregular or subnormal output may, as we all know, be the harbinger of death. The natural result of the condition stated, is to fill the arterial periphery and to be succeeded by cardiac retardation, just as the quick palpitation of the anginal storm may be observed in many cases to raise peripheral pressure and be succeeded by the quiet pulsation of the unburdened heart. The general effect of gymnastic movements properly administered is like that of the baths, to raise arterial pressure in the sense that more blood is contained in the systemic periphery. Dr. Oliver has shown in his Croonian Lectures (*Lancet*, June, 1896), by plethysmographic evidence, that the bulk of an exercised limb is increased by the movement. Whether this is all due to a retention in it of the watery constituents of the blood, as he suggests, or no, need not be discussed in this place.

The effect of the exercises upon respiration.—Stokes remarks (*op. cit.* p. 357) that the subjects of cardiac failure submitted to treatment by exercise may evince the condition known as "getting the second wind," a term and sensation familiar to those who exert themselves actively. But this acquisition of the "second wind" need not occur in the case of those who undergo therapeutic gymnastic movements, inasmuch as they need never or only in slight degree lose their first wind. Any evidence of the transition stage to the second wind, namely, dyspnœa, is the signal for the abandonment or mitigation of movement, which is followed by the patient re-acquiring his first wind. Respiration may frequently be noted to be fuller and easier, and associated with an increased sense of thoracic comfort, but this is due more to the removal of the intra-cardiac stimulus to exaggerated pulmonary effort, as pointed out in the section on cardiac dyspnœa, than to expansion of the lungs. Although the percussion note over the inferior limit of the lung may at times be somewhat clearer after than before exercises, the diaphragmatic line, as Dr. Schott and others have pointed out, is not much altered. The lung expansion after therapeutic exercises is in other words not a notable phenomenon, and like the respiration itself, is rather regulated by the pulse rate and intra-cardiac pressure than regulative of these.

In the case of therapeutic movements of a more energetic type, deeper respiration may at once be observed, and a continuation of these may induce an active encroachment of lung substance upon the upper boundary of the cardiac area, but my own observation leads me to believe that the extension of pulmonary resonance where the change persists is due rather to an altered position of the heart relatively to the lungs, than to alteration of the latter by lung expansion. This is proved by such a case as that of T. K., in which the change of position of the apex was maintained, while the area of cardiac dulness expanded somewhat after cessation of the movements. In a minor degree, lung expansion may account for some of the immediately observed diminution of the area of cardiac dulness, but I do not think this is, under the circumstances, so important a factor as it might *à priori* be expected to be. In the more active forms of exercise, such as hill climbing, in which the acquisition of the "second wind" is observed, it probably plays a greater *rôle* than in the carefully regulated Schott movements, whereby the circulation is relieved and the first wind practically conserved. This conclusion is supported by the comparatively small increase noted after active exercise by Oertel, who says, "As to the physical investigation, the inspiratory enlargement of the thorax measured across the nipples had increased 1½ to 2 centimetres (½ to ¾ in.), and the vital capacity from 1,050 cubic centimetres to 1,300 or 1,350 cubic centimetres (from 64 cubic inches to 83·2 or 86·4 cubic inches). The degree of alteration that had taken place in the respiratory process is hardly sufficiently expressed in the above small figures in comparison with the normal amounts, but must be deduced rather from the above-mentioned circulatory alterations, the reduction of the blood volume, and the perfect restoration of the previous compensation." ("Therapeutics of Circulatory Derangements," *Ziemssen's Handbook of General Therap.*, Vol. vii., translated by Edward J. Edwardes, M.D. London, 1887, p. 203.)

The most important indication of cardiac alteration is the change in the situation of the apex beat, not the obscuration of the basic outline, and when the former remains little or not at all altered, the latter may, notwithstanding the encroachment of lung, be regarded as stationary also. In a series of very interesting experiments on the cadaver Dr. Leith (*loc. cit.* p. 760) found it possible to displace the apex inwards for an inch and slightly upwards, owing to the curvature of the diaphragm, when the lungs were inflated simultaneously. I have repeated his experiment on a healthy child killed accidentally, but did not note perceptible movement of the heart with the thorax opened. I have observed, moreover, in the living subject, convalescent from serious cardiac dilatation, and in more normal conditions, that a well-marked apex beat, almost obliterated on deep inspiration, still manifests itself in the same situation throughout the respiratory act, although the basic outline is encroached upon by expanding lung. That this should be so is not remarkable, for it has been shown by the careful and lucid experiments of Halford (*op. cit.* p. 13), that the apex is much the most fixed part of the heart in the normal execution of the cardiac cycle. That, however, a resilient chest wall and mobile lungs render these organs a more potent adjuvant to the circulation than in cases of greater thoracic fixity, is probable *à priori*, and supported by the behaviour of such a case as that of T. K. already mentioned. I was inclined to attribute the small influence exercised upon the position of the heart by simultaneous inflation of the lungs, which was observed by me, to the fact that the larger right lung counteracted the displacing influence of the smaller left lung, notwithstanding the greater deviation of the cardiac apex towards the left; but I have no hesitation in accepting the possibility of some displacement of the heart towards the right under these circumstances, on Dr. Leith's authority. In arguing from the dead to the living, however, due weight must be given to the absence of vital motion in the former, that is to the harmonious co-operation of the active case and its mobile contents during life.

The fact upon which so much emphasis has been laid, namely, that the diaphragmatic level is not much if at all altered after baths and exercises, and the assumption that, this being so, there can be little lung expansion, seems to me to require qualification. The lower portion of the chest is comparatively fixed in the erect position by the numerous and far-reaching attachments of the abdominal muscles, the influence of gravitation, and the fusion of the costal cartilages from the 6th to the 9th, and sometimes the 10th, while the costal origin of the diaphragm from the lower six ribs and the upward trend of its muscular fibres to the central tendon, cause the midriff on contracting during inspiration to be less depressed than it would be were its insertion at a lower level. This fixation affects the elevation and rotation of the ribs above the 6th less than it does those lower. The deeper and fuller respiration noticed after exercises, administered properly, continuously, and for a sufficient length of time, is, however, incompatible with unaltered thoracic space. The personal sensations of one who has undergone movements so administered is proof of this. There can, therefore, be no doubt, that the thoracic alterations after such exercises are the same in kind, though much less in degree, as those observed after the severer exercise of hill-climbing or other energetic movement, and the more dyspnœic the patient from any cause, the more readily will this be induced. If this be so, some of the obscuration of the basic outline at times observed must be due to elevation, rotation, and bending of ribs and cartilages in the same manner, though to a much less extent than the changes which are observed on recumbency, and which, as I have stated, caused marked resonance in areas previously dull on percussion. In the lying position no doubt the relief of constriction from the abdominal muscles on their becoming flaccid, and the straightening of the vertebral column,* induces the marked thoracic expansion noticeable, which, together with some recession of the organs as already stated, accounts for the difference in physical signs under these circumstances. The comparative fixation, moreover, of the erect thorax must favour the spread of the inflating lung. The general conclusion, therefore, at which I have arrived after some investigation is, that therapeutic movements induce more powerful action of the heart, causing it to rid itself, in many cases, of distension by surplus blood, but, that other physical factors besides

* Quain's *Anatomy*.

diminution of cardiac capacity account for some of the shrinkage at times observed after the use of baths and exercises, and that the constant detection of these is attained by clinical means of which I confess I am ignorant, but which it would be presumptuous on my part to term fallacious. In thus criticising with Oertel the character, degree, and frequency of the objective evidence of cardiac change after baths and exercises insisted upon by Drs. August and Theodor Schott, I have no desire to minimise the value of their work and method, which I consider to be great.

Other effects of therapeutic gymnastics.—The increased vigour of circulation observed to result from wisely employed gymnastic movements is followed by the disappearance of retrostatic evidences of defective circulation. Organs swollen from passive hyperæmia diminish in size, their secretions assume a normal character, and escape in normal quantities. Effusions into closed cavities, such as the pleura and peritoneum, are absorbed, and anasarcous limbs again exhibit a natural contour. That the balneological and gymnastic treatment of an embarrassed circulation can do all this is attested by many witnesses; but, in ascribing these effects to baths and exercises, we must always be careful to give due weight to the possible potency of pharmaceutical agents and other measures. In many cases of more or less weak heart, in which some degree of irregular secretion, dyspnœa, or œdema of the extremities may be present, it may not be necessary to seek the concurrent aid of cardiac tonics, and the patient relieved of his usual necessity for persistent exertion, placed under favourable circumstances for proper nutrition and for rest, alternating with a carefully graduated amount of exertion, may recover by the aid of baths and exercises alone. But, great as is the additional aid afforded by these means at suitable phases of a case at times in serious peril from heart failure, it would be assuming a grave responsibility not to afford additional help, which we *know* may be rendered by the skilful use of drugs and other methods, when a human life is trembling in the balance. And, if such aid be rendered and the contemporaneous use of several agents results in steady circulation and absorbed effusion, let us not forget that these brilliant results have been attained without the use of baths and exercises. *Fortiores vixerunt.* Case X. in the series I have quoted was plucked from death by ice and digitalis. He benefited very considerably, nevertheless, by the careful use of resisted and self-resisting exercises, and I am certain that his convalescence was materially promoted by them, and that the patient, when he first left his bed, did so a much stronger man than if he had followed too exclusively the old regime of "rest, resignation, and abstinence"—a useful enough prescription at times, but which abused is very properly defined by Dr. Theodor Schott to be "a passive waiting for the sooner or later appearance of disturbance of compensation" (*Herzkrankheiten*, p. 10).

As regards the *durability* of the changes brought about by gymnastic exercises, I have already quoted Dr. Theodor Schott as having stated that although more striking at the moment than those induced by baths, they persist for a shorter time than in the case of the less energetic measure. I have already, however, related a case in my own practice (p. 181) in which the change was permanent. That a systematic repetition of the exercises skilfully administered tends to consolidate the effects in some cases is, however, shown by the results of many cases in the practice of those who have had considerable experience of these methods, although the very remarkable shrinkage related to have taken place immediately after exercises does not appear to persist in the degree noted at the time.

In this connection I wish to record the result of my examination of a case which threatens to become historical, and an account of which I published in the *Practitioner* for September, 1896. I mean that of Mr. L., who was examined by Sir Grainger Stewart and others at Nauheim, in 1895, and was referred to again by him at the meeting of the British Medical Association at Carlisle, in 1896; has been reported as having an area of cardiac dulness of very modest dimensions by Dr. Bowles in his paper;* and whom I was fortunate enough to have an opportunity of examining with Dr. Schott on July 13th, 1896. This patient came to Nauheim with well-marked evidences of cardiac dilatation and retrograde stasis in 1895, and when examined by Sir Grainger Stewart and some others his apex beat before exercises was about 17 centimetres from the mid-sternal line, and after them 15 centimetres from the same point. The general area of cardiac dulness before was 22 centimetres by 12 centimetres, as compared with 17 by 9 after exercises. Or, using Potain's formula already referred to,

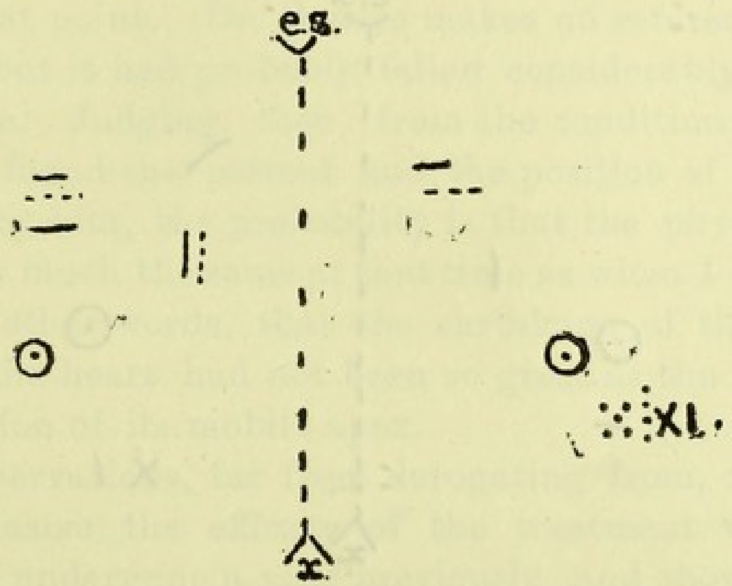


FIG. 109.—Case of Mr. L. The dotted lines denoted shrinkage after exercises.

there was a difference before and after of 92·2 in square centimetres—namely, as 219·1 is to 126·9. So enormous a shrinkage in the area of cardiac dulness, whether explicable by heart-shrinkage or lung-encroachment, or by both these factors in combination, could not, of course, be permanent, and was probably very transient. These measurements were taken from a chart which Dr. Newton Heineman, of New York, at that time resident in Nauheim, was good enough to permit me to copy, and of which Fig. 109 is a reduced drawing. When Dr. Bowles saw this patient, a month later than Sir Grainger Stewart, his condition was, as he

* *Practitioner*, August, 1896.

has stated (*loc. cit.*), one of circulatory ease, and the apex-beat, as noted in the diagram, was in the nipple line. The area of cardiac dulness, however, marked by him, is only the most superficial cardiac leerness, and has little bearing upon the previous diagram, which he prints from the chart made by Sir Grainger Stewart. On July 13th I saw Mr. L., on his return to Nauheim for a second course of treatment, of which he did not appear to stand very much in need. He had passed the winter in good health, and had taken no cardiac remedies whatever. He was free from anasarca or other evidences of circulatory embarrassment, and when I

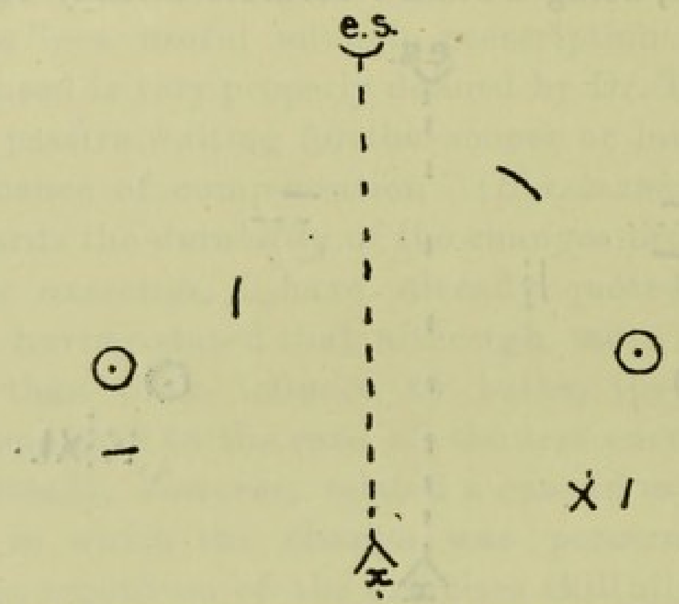


FIG. 110.—Percussion points on Mr. L.'s thorax when seen by me.

examined him had taken neither baths nor exercises. The chart of his chest, of which Fig. 110 is a reduced drawing, I made in the presence of Dr. Schott, who corroborated the results of my examination. There was no cardiac bruit. It will be observed on comparing these charts that the apex-beat when I made the examination was $6\frac{1}{2}$ centimetres nearer the middle line and more than 2 centimetres lower down than the original position of this point before exercises, and about 3 centimetres nearer the middle line and rather more than a centimetre lower down than the position of the apex after exercises as determined by Sir Grainger Stewart and some others. The position of the apex as I found it and that determined by Dr. Bowles was about the same. Nevertheless, the general area of cardiac dulness as I found it, Mr. L. being in good health, was 19 centimetres by 13, which, according to Potain's formula, yields in square centimetres 205·0—an amount only 14 square centimetres less than the dimensions of the original organ in a condition of engorgement and displacement, and 78·1 square centimetres larger than that noted immediately after the exercises referred to. The upper limit of distinct hepatic dulness was, when Sir Grainger Stewart and his confrères examined the case, 5 centimetres above the level of the right nipple, and when I examined it, had fallen to 3½ below that point. Dr. Bowles makes no reference to the liver level, but it had probably fallen considerably when he saw the case. Judging, then, from the condition in which Dr. Bowles found the patient and the position of the apex-beat noted by him, the probability is that the physical conditions were much the same at that time as when I examined Mr. L.; in other words, that the shrinkage of the general volume of the heart had not been so great as the alteration in the position of its mobile apex.

These observations, far from derogating from, appear to me to emphasise the efficacy of the treatment which the patient had undergone a year previously, and show that his improvement was permanent. It is also evident that Mr. L. led a very comfortable existence with a heart of very considerable size, which there could be no special object in reducing much, if at all, and which probably, fortunately for him, neither baths nor exercises could reduce much more. Both, however, might help to ensure a prolongation of the physical comfort of which he was in the enjoyment when I saw him at Nauheim.

If all the effects in this case were brought about solely through the agency of baths and exercises, I think it will be admitted that we have in them a very powerful means of influencing the heart and circulation.

SECTION VII.

THE MODUS OPERANDI OF THERAPEUTIC EXERCISES.

In connection with the graduated gymnastic exercises executed by means of the Zander instruments and the Schott movements it has been hitherto customary to note the pulse rate and cardiac conditions before and after their use. In order, however, to perceive their *modus operandi* it is manifest that observations should also be made while they are in progress. As I have already mentioned, anyone who does so will observe that there is a phase of more or less accelerated cardiac action, with a proportionate alteration of heart tone or bruit, if the latter be present. The power of the heart is augmented, and the velocity of the blood increased. In accordance with the natural law, that the projectile force of a travelling body is proportionate to its velocity, it follows that the systolic output of the heart remaining tolerably equal, its increased velocity must have likewise increased penetrative force into the vascular system. Thus Fick,* assuming that the ventricle ejects 80 grammes of blood during each systole, and estimating the systolic contractions per minute at 70, and the aortic column of blood as 2·5 metres high, calculates that the work done by the heart per minute is 14 kilogrammetres, or in English measure about 28 foot pounds or 448 foot ounces. This would yield a force of about 6½ foot ounces per systole, and if this calculation be correct it is interesting to note that the radial artery at the

* *Med. Physik.*, p. 145.

wrist may, in a healthy man of medium size and average pulse-tension, be obliterated by a pressure of 4 to 5 ozs. The heart force has, however, been very variously computed, and has had a range from Borelli's estimation of 180,000 lbs. to that of 5 ozs. as computed by Kiell. (*The Forces which Carry on the Circulation of the Blood*, Buchanan; Churchill, 1874, p. 1.) The late Dr. Andrew Buchanan, of Glasgow, gave a convenient method of estimating the heart force in the *Lancet* for November 12th, 1870 (*op. cit.* p. 92 *et seq.*), and arrived at the conclusion (p. 97) that the momentum of the blood as emitted from the heart was equal to the weight of the observed hæmastatical column (22 oz. avoird.), multiplied by the volume of the ventricular blood (2 oz. av. = a column 8 in. in height), and was thus represented by 22 oz. moved over a space of 8 in. at each pulsation, or with a velocity of 10 in. per second. Whatever precise conclusion the mathematical physiologist may arrive at, the general principle is incontrovertible, that 2 oz. of blood travelling at the rate of 80 or 90 systoles a minute must have a greater penetrative force than the same volume with a velocity of 70 systoles a minute. This increase of velocity and penetrative force, therefore, must be regarded as an important factor in the *modus operandi* of the measures which provoke it. Controlled as it is by the periodical rest prescribed in the Zander and Schott exercises, the effect of the increased velocity is to stimulate the augmentative and inhibitory properties of the heart without overthrowing the latter by an excess of accelerated action.

It is shown by Oertel, moreover (*op. cit.* p. 132 *et seq.*), that cardiac acceleration, even although associated with the sphygmogram of what is termed a low-tension pulse, need not be accompanied by low blood pressure, for by means of v. Basch's sphygmogrammeter the pressure expressed in millimetres of mercury was usually higher during exercise than when resting. Dr. Schott's objection to hill-climbing as a mode of exercise in cardiac cases appears, however, to be well founded, at least during the period of cardiac instability in such cases, because it is difficult to control and to prescribe in accurate doses. The evidences, moreover, of acceleration last for a long time, as the pulse alterations consequent upon it persist for many hours in some cases (Oertel, *op. cit.*, p. 136). In bradycardial cases, however, such as that of Dr. K. (p. 129), which appeared to be practically uninfluenced by the baths, the leisurely ascent of a hill was found to act as a suitable cardiac accelerant, and the subsequent condition of the patient both as regards his subjective sense of well-being and the character of his pulse, was satisfactory in every way. Active exercise, therefore, within moderate limits, is quite compatible with those more controllable movements which may be abandoned at once on the appearance of any evidence of over-exertion on the part of the patient, and is, indeed, prescribed in some instances at Nauheim, when the cardiac patient is considered sufficiently convalescent to undertake it with safety.

A perusal of the section on the neuro-muscular and hæmic factors in heart disease will suggest some of the means whereby the effects ascribable to exercise are brought about.

If we place a patient possessing an easily visible apex beat in a good light, and administer the movement of abduction and adduction, if the arms be in a horizontal plane, it will be observed at the commencement of the movement, and throughout if cardiac instability be not great and the pressure exerted carefully moderated, that the beat becomes more powerful and somewhat slower. If, however, the resistance be slowly and steadily increased, a point will be reached at which the action of the heart becomes accelerated in a degree proportioned to the resistance. On the cessation of resistance the pulse rate again falls. In his interesting Harveian Oration for 1894, Dr. Lauder Brunton regards the object of massage and exercises to be that, through the dilated vessels of the muscles, the blood may find a channel of relief, and the work of the heart be thus diminished. He admits that the primary effect of muscular exertion is, by compression of the peripheral arterioles, to increase the labour of the left ventricle, but that the subsequent action of dilator fibres in the motor nerves widens the vascular channels and relieves tension. Oertel also (*op. cit.*, p. 159) considers that the increase of blood pressure is accompanied, owing to excitation of the depressor nerves, by vascular dilatation, with lowering of arterial tension and increased volume of blood in the arteries. To dispute these views would argue an ignorance of the present position of this question in the light of modern physiology, but we must ever bear in mind the difference between "blood-pressure" and "pulse-tension." Pulse-tension may induce a high blood-pressure, and a high blood-pressure may, under certain circumstances, be present, and abolish high pulse-tension. It is difficult, however, to understand, even on this hypothesis, why the heart should cease its acceleration when musculo-vascular relief has been procured. The total result of carefully executed movements is cardiac retardation, and this, in accordance with Marey's law, is inversely as peripheral pressure. The practical comparison which has been instituted by August Schott and others between the action of digitalis and the effect of therapeutic movements would rather tend to indicate that the acceleration of cardiac action observed when a movement of relative or actual severity is in progress is due to the endeavour to secure an equipoise of pressure, with the intrinsic ganglionic system of the heart as a mid-point, by the regulative nerves of the heart to which allusion has been made in a previous section. The ultimate flushing of the periphery on this hypothesis would be ascribable to the cumulative propulsive and regulative power of the heart, and its continued retardation with easy peripheral tension, to a continuation of the inhibitory stimulus at the centre, which would imply the absence of such cardiac engorgement as would induce accelerated action; and we know that the slower the action of a tolerably powerful heart the larger the amount of blood projected on each contraction into the arteries. A maintenance of this central control is calculated to result in the compensatory hypertrophy aimed at, directly, by a trophic influence neural in character, and indirectly by imparting greater vigour to the coronary circulation; while the exercise of the skeletal muscles in limb, abdomen, and thorax is promotive of their own tonicity and growth, and renders them more effective aids to the central organ of the circulation. The peripheral vascular pressure, therefore, is on this showing maintained by the cumulative effect of stimuli upon the ganglionic system of the heart, and is happily associated with a proportionate lowering of arterial tension due to the vasomotor conditions induced by the raised peripheral pressure referred to. The sphygmograms from Count A.'s case (p. 175) are good illustrations of these remarks. I recognise, however, the wisdom of the proverb which says that he who tries to prove too much frequently succeeds in proving nothing, and the explanations I have offered as to the *modus operandi* of these measures are but tentative, their chief recommendation, if any, being that the data for them have been gathered in the laboratory of the hospital ward or sick-room, and agree, in the main, with the accepted teaching of modern physiology.

It is thus as true of treatment as Stokes believed it to be of disease, in the words I have placed on the title page, that "many paths conduct to the same end," and it is the duty of the rational physician to determine, first, whether benefit be justly attributable to a certain remedy or measure; and next, to enquire into the causes which contribute to that result. And, in view of the importance ascribed in these pages to the management of the nervous system, the lines from Virgil, which I have placed beside the words of Stokes, may be instructively if freely rendered thus:

> Happy the patient, who, knowing the cause of his ills,
> Can tread underfoot his fears and his cruel fate,
> And listen unmoved to the roar of greedy Acheron.
> * * * * *
> What help his drugs afford, what willing Nature
> Yields, he uses.

It is the neurotic, and he who cannot with stoicism or heroism, as the case may be, meet the future with "a heart (!) for any fate," who frequently sacrifices by exhausting trepidation his chances of recovery, and brings to naught the wisest efforts of the physician. Nauheim and the active treatment of heart disease, as holding out a new hope to the cardiac patient, seem also at times to have exerted a beneficial influence by calming the fears of those who have not learned to tread them under foot.

SECTION VIII.

CASES SUITABLE FOR TREATMENT BY THE VARIOUS MEANS INDICATED.

The remedial means to which must be assigned the place of honour in the contest with disease and death is, naturally, like force employed in any other battle, that to which we mainly trust to secure or hold a position. With respect to the place to be assigned in the treatment of cardiac failure to *baths* and *exercises*, medical opinion is at present divided into that which would assign them no place at all, that which would place them in the first rank, and that which recognises their value under certain more or less defined circumstances. It is certainly an advantage in favour of baths and exercises such as those carried out by means of the Zander instruments and the Schott movements, that their effect when skilfully administered does not persist for an indefinite time. Cardiac tonics, on the other hand, of an efficient character, must continue to influence the organism which has absorbed them until they are eliminated, and in case of their having disagreed with a patient their effects have to be checked by other means of a more or less antidotal character, which likewise must, if not inert, continue their action for a period not absolutely determinable by the physician.

Every practitioner of experience will recognise the large and important class of compensated valvular cases, in which, from some circumstance, the power of the cardiac muscle is not equal to its average efficiency; and that still larger class in which, in association with a general atony of the system, from whatever cause, the force of cardiac action is impaired. Before so much attention was directed to delineation of the cardiac area, many such patients were said to be "run down," and advised to avoid for a time those circumstances which were apparently most active in impairing their health, and did so with benefit.

Baths and exercises, and the leading of a rational life, are, undoubtedly, in this large class (ever increasing with the high pressure under which modern society, in all ranks, lives), a most efficient means of restoring health. But it would be altogether unjust to these measures to limit their efficacy to such cases. The state of the cardiac muscle is, according to those who have had much experience in this matter, the determining factor as to their applicability.

From the observations which have been given, and the conditions discussed, it is evident that baths may be of use when some of the exercises are inapplicable, and that the strength of a patient may be capable of reacting favourably under a certain dosage of resisted movement, while it would be detrimentally affected by being subjected to a more severe strain. And, finally, that a combination of these means may be necessary to hasten a beneficial result, which neither alone is so well adapted to secure. This conclusion is supported by experience, which is the only test of even valid conjecture. When, however, the instability of the cardiac muscle is great, or whenever a case may from any cause be considered to be of an anxious character, I confess that the exaltation of any method of treatment, be it baths, exercises, digitalis, or strophanthus, to the exclusive position of a panacea, savours to me of a biassed judgment based upon limited premises, the conclusions of which must be disregarded. No such exclusive claim, so far as I know, is made for the balneological and gymnastic treatment of cardiac failure by responsible exponents of it, and I have already mentioned cases in which their operation was beneficially combined with cardiac tonics of established reputation.

Sir T. Grainger Stewart, in the comprehensive address with which he opened the discussion on the treatment of cardiac failure at the meeting of the British Medical Association at Carlisle in 1896, came to the conclusion that the baths should be tried in all cases, and when there is grave debility of the heart he advised the employment of passive exercises. When the heart showed somewhat greater vigour, he advised the use of the resistive exercises of Schott, varying them from day to day according to the precise condition of the patient; and when the cardiac tone had sufficiently improved he approved of the method of Oertel (*Brit. Med. Journ.*, Sept. 19th, 1896, p. 706). With the principle here enunciated of an adaptation of the means used to the strength of the patient, all must agree, but massage may be a much more fatiguing operation than the Schott movements gently administered in approximately definite doses. The more vigorous movements, whether Schott's or Zander's, are naturally only permissible under circumstances of considerable cardiac vigour, whether the latter be associated with valvular lesions or with non-valvular myocardial states. *A priori,* it might reasonably be inferred that measures which raised the pressure in the aortic column of blood were not calculated to benefit cases of *aortic valvular inadequacy*, and this opinion has been expressed by noteworthy authorities. But it has been pointed out that, with a rise in the blood pressure during movements, there is usually some acceleration of cardiac action, and when these are carried out carefully the ultimate retardation of the heart's action is associated, not only with a rise of peripheral pressure, but with this modified by a diminution of pulse tension, which renders safe a procedure which might otherwise be regarded as dangerous. As a matter of fact, many such cases have undergone treatment by baths and exercises with benefit. It is none the less true, however, that when the instability of the cardiac muscle is considerable, cases of aortic inadequacy are less suited for this treatment than those in which the sigmoid valves are perfect and the *atrio-ventricular* diseased. The cases which usually give the most brilliant and rapid results are those in which all the *valves* are potentially, if not actually, *perfect*, even when the *heart* is much *dilated*, and the consequences of retrograde stasis well-marked. The experience of most will, I think, cause them to agree that this is true not only of the balneological and gymnastic, but of every other mode of treatment. *Aneurisms*, and an advanced degree of *arterio-sclerosis* are considered by Dr. Theodor Schott contra-indications for the use of this treatment, but more moderate degrees of arterial degeneration even in association with aneurism, appear to benefit in some cases from the *baths without the exercises*. On this point Dr. Gröedel, who formerly believed arterio-sclerosis to be a contra-indication for the balneological treatment, writes as follows :—" I can now state that the baths are also beneficial in these cases, for in the course of years I have treated by no means few patients suffering from advanced arterio-sclerosis, and without in one single instance having found any unpleasant result; on the contrary, the repeated effect was a considerable improvement of the circulation and general state of health (even in some cases combined with aortic aneurism)." (*Bad-Nauheim: Its Springs and their Uses*, p. 51, 1896.)

Notwithstanding this favourable judgment, however, based upon a large experience, it is manifest that every precaution must be taken in the treatment of this class of cases as to temperature and depth of the baths, and the comfort of the patient in bathing, as well as to the general state of the patient about to take the baths, the period of day when they are prescribed, and the conduct of the patient after bathing. This naturally brings us to the consideration of the applicability of baths and exercises to the treatment of cases of *angina pectoris*. The diagnosis of angina pectoris has been sufficiently considered in a previous chapter, and its treatment, regarding it as a symptom of cardiac failure from various causes, has been considered, more or less, in the course of these pages. Reference is now made only to *classical cases of angina pectoris* in which the diagnosis of arterio-sclerosis, probably associated with some change in the coronary arteries, has been positively determined. Knowing as we do that attacks of this "disease" are frequently provoked by exertion even of a mild kind, it is evident that measures which raise the pressure of blood in the systemic arteries must be employed, if at all, with every precaution, to prevent so far as possible injurious effects. It is only rational to conclude that if the baths are productive of any good in arterio-sclerosis they should likewise be of some service in these cases, and baths being, as August Schott stated, but a minor form of gymnastics, that exercises skilfully administered should likewise be of service, provided the blood pressure which is raised by them can also be associated with a lowering of pulse tension. We can easily understand that if these conditions be secured, the increase of aortic pressure may, even in the case of narrowed coronary arteries, such as those depicted elsewhere, be of service in maintaining a more vigorous coronary circulation. I have at Nauheim seen cases diagnosed as angina pectoris in men over middle life, subjected to exercises in the treatment of this disease with apparent benefit. There can, of course, be no question of a cure of true angina pectoris dependent upon coronary lesions, but, as in the case of the uncompensated cardiac muscle from any other cause, it is not irrational to conclude that the ventricular nutrition may be improved by these means, and the chambers thus rendered less prone to that syncopal tendency which, it has been argued (p. 54 *et seq.*), is the essential point in the etiology of the attacks which threaten life.

It may thus be very justly maintained that baths and exercises have a very wide sphere of usefulness, and an experience now not inconsiderable has rendered this conclusion incontestable. But to give one's adhesion to this view is not at the same time to proclaim a belief that these measures are equal to every contingency, or that they may not for a time in many cases have to play a subsidiary *rôle.* I cannot, therefore, agree with Dr. Bezley Thorne (*loc. cit.*, p. 67) when he says "with regard to treatment, although the physical method relegates pharmaceutical remedies to the rank of auxiliaries, their influence is, in some instances, of material value in correcting a special defect of health, or in raising the general tone of the system." I should rather most emphatically state that he who trusts mainly to these measures when a cardiac patient is *in extremis* incurs a grave responsibility, and that to rescue when rescue is, as it often is, possible, such a case from death, the exercise of all the skill in the employment of the potent pharmaceutical remedies, in the use of which the genius and patience of generations has instructed us, is the duty of the physician and the rightful expectation of the patient. These pharmaceutical agents are not, in such cases, relegable to the rank of auxiliaries. They afford the patient his only chance of life, while baths and exercises await his convalescence, and may be powerfully promotive of its secure establishment.

SECTION IX.

THE CARE OF THE CARDIAC CONVALESCENT.

When a sufferer from heart disease is *in extremis,* whatever refinements of diagnosis or theoretical subtilties of treatment suggest themselves to the physician, three great objects must never be lost sight of—the patient must sleep, feed, and rest, in whatever hydraulic position he chooses or in which he can do so. Means to secure these ends must be pushed at *all* hazards. A victorious army may ignore the brooks, hillocks and brushwood of the enemy's country, but its mountains, rivers and forests must ever be borne in mind. So, too, when the patient is convalescent the management of the three essential factors—sleep, food, and rest—is the key to treatment. As action or activity is the aim of life, rest must be abandoned in an increasing degree, sleep shortened in proportion to waking activity, and food increased to supply the increased evolution of energy. But these changes should be brought about gradually. Unfortunately, in the case of the poor, whose subsistence depends upon personal labour, these prudent considerations are in most cases impossible to observe, with the inevitable result that compensation once seriously lost is difficult to regain for any length of time, as is too eloquently testified by the short lives of poverty-stricken sufferers from heart disease. Sir Hugh Beevor has called attention to this point in a paper on diagnosis and prognosis in cases of valvular disease (*King's College Hospital Reports,* Vol. ii.), and has suggested that convalescent homes for the reception of such cases are a much needed want in our charitable system. Unfortunately, it is but one of many wants in our charitable, social, and political system, and although the Christian era has seen many advances in the care of the disabled citizen, *vœ victis* is still writ as large, under many circumstances, over the enfeebled in our own day as in the days of Imperial Rome. Whether it can be altered remains for the future to decide, but for the poor in the battle of life, when seriously wounded, the relieving arm of "Death as a Friend" is at present considerably longer than that of charity. It is possible, however, in some cases even among the poor, to do somewhat towards the abandonment of a laborious for a more easy mode of life, as in the case related at some length in another place (p. 184), and, when possible, this seems at present the only means of affording time for the more permanent establishment of convalescence from serious cardiac failure among the labouring classes.*

Among the wealthier the principle remains the same, and the means are forthcoming for giving effect to measures likely to consolidate improvement. Under these more favourable circumstances the gradual resumption of activity may bring about compensation which may last for a lengthened period, and which, once fully established, may permit the patient, practically no longer a patient, to participate even in arduous undertakings. It is this gradual resumption of activity, with alternating rest, good food, and warm clothing, which is the every day analogue of the treatment of heart disease by graduated movements, and is naturally a continuation of this treatment in cases submitted to it. It may undoubtedly in many cases be overdone, like hill-climbing, and have injurious effects, but, prudently regulated, may likewise result in a confirmation of the benefits received from therapeutic gymnastics. These are

* The patient referred to called upon me in January of this year, in very fair health, and able to attend to his new occupation. Although I have not seen him since that date, I have reason to believe that he continues in a satisfactory condition.

the principles of an enlightened "nachkur," and it only remains to mention that, in the selection of a situation for residence during convalescence from serious cardiac trouble, the altitude of a health resort is of importance. The *gradus ad Parnassum* should be very gradual, and Parnassus itself should not be more than 3,000 feet or so above sea level, to avoid the dilative influence of higher altitudes to which the recently diseased heart might not readily accommodate itself. Having maintained, in agreement with some others, that the *rationale* of the action of the digitalis group of cardiac tonics is the same as that of the more obviously mechanical modes of treatment, it follows that it is judicious after the subsidence of the ordinary evidences of cardiac failure to maintain the tone of the heart by the administration for some time afterwards of digitalis or strophanthus alone or in combination with other measures. As regards digitalis, for reasons given in the context, its administration during convalescence, in cases of aortic reflux, should be more frequently supervised than in those cases in which all the valves in a recently dilated heart are perfect, or in which the mitral valves alone are diseased.

APPENDIX.

BY MEDECINALRAT DR. GROEDEL OF BAD-NAUHEIM.

IF in what follows I add somewhat, in amplification of Dr. Morison's treatise on baths and gymnastics in diseases of the heart, I must beg to be excused, if I reiterate in a measure what has already been stated; and on the other hand, pass over material which may seem necessary for completeness, as it would carry me too far.

Baths are chiefly suitable for two purposes, namely—

(1) *To unload the heart, to lighten its work, and thus to afford it an opportunity of recovery with increase of power.*

(2) *To stimulate the heart, and with the aid of its reserve force to urge it to more powerful action.*

In my opinion, the first object is the most important. It must always at the commencement of a course (Kur) take precedence, especially in the more severe cases of cardiac insufficiency, in which the absence of any reserve force whatever is indicated by the fact that the heart refuses the least call upon its capacity for responding (dyspnœa). A bath may in several ways act in relieving the heart; thus, for example, by increasing peripheral circulation and diminishing peripheral resistance, by facilitating the return of venous blood from capillary areas and the entrance of arterial blood into them, by relieving the tension of particular sections of the circulation, especially of the visceral arteries, and further by increasing the pulmonary circulation from improvement of respiratory power.

As a *stimulant*, a bath may operate by raising peripheral resistance in the circulation and by direct irritation of the nervous mechanism of the heart. The increased flow of blood to the left heart on more powerful expiration is also an incentive to greater cardiac activity.

It will now be my task to examine bathing in its special effective factors, to go through them *seriatim* and to relate what has been established experimentally concerning their influence upon the human organism, what is to be regarded as lessening, and what as increasing the work of the heart. A comparison of these results must then yield certain conclusions concerning the *modus operandi* of baths in disorders of the circulation, and indications for their modification according to the different conditions with which we have to deal. But my earnest endeavours to reach a definite conclusion by this route have shown me, that so many explanations advanced still rest upon hypotheses, that it appears impossible to me at present to explain satisfactorily, by the aid of securely established physiological facts, the operation of baths upon the sound and diseased heart and the significance of baths in regulating abnormal conditions of the circulation. The matter is extraordinarily complicated; so many factors partly incalculable enter into it, that I doubt upon the whole whether we shall ever reach a definite conclusion. Much has indeed been thoroughly investigated; for example, the thermic influence of a bath upon the heat economy (wärme Haushalt) of the human body. The influence also of stimulation by heat upon the respiration and cardiac action is tolerably clear, so that even now, acting from the physiological point of view, we can choose the temperature of a bath so that, according to need, either a preponderant lightening of cardiac work or a rousing of the heart to increased action may thus be brought about. As regards the operation of the mineral constituents of baths, however, we are not yet in a position to build our indications for their use upon a strictly scientific foundation. We only know concerning the salts that they produce a certain stimulation of the skin in the bath, but their peculiarities and significance for the organism are still so little understood, that some maintain that the saline contents of a bath are quite unnecessary to its effective operation. To me, also, the results of the researches in question, including my own,* are not convincing. But, notwithstanding, I am quite convinced of the importance of the salts in the bath as specific skin stimulants, from my lengthened therapeutic experience and from certain observations which I have frequently made. Of the latter I shall only mention the feeling of greater weariness after a powerfully saline bath as compared with the sensation experienced after a warm sweet (or fresh) water bath of like warmth and duration.

That the carbonic acid in the bath exercises a peculiar stimulation upon the end organs of the cutaneous nerves is admitted by all. It is only upon the mode of this stimulation and its effects that opinions vary much. I cannot enter more into detail in this matter, but feel compelled to make a remark in opposition to a view expressed by Leith in his clear and careful work, *Physiology of the Action of Thermal Saline Baths, etc.* He there states that the sense of warmth produced in the bath may partly be due to the fact that the bubbles of carbonic acid keep the water away from the skin. In opposition to this I wish to remark that a similar sense of warmth may be felt in dry carbonic acid gas baths. There were formerly such baths in Nauheim. The patients sat with the head in the open air, in boxes, into which the gas streamed from below, from Spring No. 11, which disappeared in 1886. I have often convinced myself of the sense of warmth caused by these gas baths, and found while in the

* "Pneumatometrische Beobachtungen über den Einfluss verschiedener Bäder auf die Respiration," *Berl. Klin. Wochenschrift.* 1880. "Zur Behandlung Herzkranker," *Berl. Klin. Wochenschrift,* 1883. "Ueber den Einfluss von Bädern auf die Electrische Erregbarkeit der Muskeln und Nerven," *Deutsch. Med. Zeitung*, 1889.

bath a slight increase of pulse frequency and soon after the bath a decrease. Unfortunately, at that time, for want of appropriate instruments and arrangements, I did not prosecute my experiments with such baths farther, and published nothing on the subject, as I had only made the observations on pulse frequency on my own person.

From all we know of the phenomena which carbonic acid baths induce, I believe that the carbonic acid acts chiefly upon the heart in such a manner that it influences the peripheral circulation appreciably, and thereby indirectly the circulation as a whole, as well as the respiration. But I believe also in a direct action by way of the end organs of the cutaneous nerves upon the respiratory, cardiac, and vasomotor centres. This, I believe, applies also to the salt in the bath water. If we grant that the carbonic acid and salts exercise a stimulation of the skin, the same in kind, we must also concede the probability of a centripetal influence of both upon the central nervous system. That the inhalation of carbonic acid during the bath is to be regarded as an incentive to increased respiratory and cardiac action, I shall not positively deny. On the other hand, to regard this circumstance as the most important, as Zuntz has recently done, (*Sitzung der Berliner Gesellschaft fur inner. Medicin*, Jan. 18, 1897), I consider erroneous. In Nauheim we rather believe the influence of the inhalation of carbonic acid to be injurious and endeavour as far as possible to avoid it. Some other points which might also be mentioned I must abstain from discussing, as it would lead me too far.

Experience (die Empirie) is of more value than all researches into the particular effects of the different constituents of the bath and than all physiological views with regard to them. I quite agree with Leichtenstern of Cologne, who remarks (v. Ziemssen's *Handb. d Allgemeinen Therapie*, Vol. ii., p. 223), "After a careful investigation of what we know theoretically of the *modus operandi* of bath treatment, of the physiological effects of cold and warm baths, and of saline and gaseous baths, we come to the conclusion that, in spite of numerous important works on the subject, our present knowledge is not sufficient to erect thereon a satisfactory theory or explanation of the manner in which mineral waters act in different pathological conditions. The present standpoint of balneotherapy is the empirical, and rests upon the observation and experience of physicians. The fact that various bath treatments prove beneficial in different diseased processes of a chronic nature, that the curative power of balneotherapy is to be numbered amongst the most important and indispensable remedies, all critics firmly maintain." The opinion thus generally expressed applies also to the bath treatment of heart disease. I do not, however, absolutely affirm—nor does Leichtenstern do so—that all scientific researches in this field have been unnecessary and purposeless, or that they will in the future be so. On the contrary they afford us in some respects important conclusions, and also some guides in treatment. Especially have I pointed this out as regards the best known effect of baths —the thermic. But some other points touched upon by me also give us a certain guidance in our prescriptions for bathing, especially in that direction which I have indicated as the most important at the beginning of my remarks, namely, that we are in a position *so to use the baths that they may, in a preponderant degree, relieve the work of the heart or provoke increased cardiac effort.*

With this knowledge as a foundation, and supported by our experience, we can in general terms state the following concerning the different modifications of baths: If we desire to relieve the heart the bath must not be cooler than 92 degrees nor warmer than 95 degrees. The carbonic acid and saline contents also must not be too great. If we reduce the temperature we must, in order not to increase too much the labour of the heart by the stimulation of cold, and not to give too great an impulse to increased cardiac activity, add greater quantities of carbonic acid to the bath, which, also, indeed acts as a cardiac stimulant, but not to the same extent that it moderates the active heart-burdening influence of cold without weakening the generally tonic influence of the latter, and its favourable action upon the respiration. The lower the temperature is the more intensely incitive to cardiac action is the influence of baths. But too great a lowering of temperature is not advisable, as otherwise, by over stimulation, a vascular relaxation (bluish-red colour of skin) supervenes, which has, as a consequence, a rapid sinking of the internal body-heat, and may thus cause too great a weakening of the heart in essentially abnormal organs, in a converse manner to the heat-retention of baths which are too warm. If we add carbonic acid to the cool bath we may reduce the temperature more than without this. Yet from my experience I believe it to be advisable to state that, even in the case of the carbonic acid baths, we must not reduce the temperature, as a rule, below 85 degrees, and at most, and only exceptionally, to 82 degrees. Cardiac patients also bear a higher degree of salinity better with a simultaneously strong carbonic acidulation of a bath, as the general relaxing and tiring effect of the salt is overcome and nullified by the tonic stimulation of carbonic acid. A very high degree of salinity is, speaking generally, seldom borne by cardiac patients. While in some other diseases, for example, gout, I often add 5 or even 10 litres of mutterlauge to a bath, I seldom use more than 3 litres in the case of those suffering from heart disease.

The *duration* of the bath also comes under consideration. Short baths do not act so powerfully as those of longer duration. Heart-relieving may be longer than heart-exciting baths. In the dosage, pauses, etc., we must be guided by the degree of insufficiency of the cardiac muscle and the reserve force at command, of the greater or less availability of which one may easily convince himself. In the effervescent current baths (strom-sprudel bäder) the greater amount of free carbonic acid has a more stimulating effect than in still baths; and here, perhaps, also in a measure from inhalation, on which account I only prescribe these when we can rely a good deal upon the heart. The running may also act as a more powerful thermal stimulant than the standing water.

The *act of bathing as such,* the alternating exertion and rest connected with it, is not without influence in any bath—the rest is always beneficial, the exertion or effort often injurious, on which account I seek to avoid the latter as much as possible. Drying and rubbing also after the bath, if carried out without effort on the part of the patient, operates by relieving the heart, and is favourable. Cooling after the bath, as burdening the heart, must be avoided when there is great insufficiency of the organ, and also prolonged or, as a rule, any walking after the bath. Rest after the bath acts by sparing the heart. If one dare excite the heart more powerfully, not too long a walk may be useful. But, as a rule, we must remember the following: The more or less normal dynamic relation between the venous and arterial circulation established by the bath continues after it, and acts, moreover, favourably upon the cardiac activity and upon the strengthening of the weakened cardiac muscle. On this account all things must be avoided after the bath which are calculated again to disturb this relation.

I am well aware that my remarks are imperfect, and exhibit many deficiencies. Concerning some matters I have said nothing, that I may not exceed farther the bounds set to my task. I must, however, still mention two points.

It is usually said that the Nauheim baths increase the *blood pressure.* I have, however, already repeatedly remarked that we may so prescribe the baths that they do not have this effect, but may rather *diminish the blood pressure.* This is necessary when a blood pressure above normal already exists, as is usually the case in arteriosclerosis. In these cases a warm salt bath of about 92 degrees, rich in carbonic acid, and not of long duration, usually operates by reducing the blood pressure. Further particulars on this point may be found in a work by Gräubner ("Beitrag zur kenntniss und Behandlung der Angina pectoris," *Zeitschrift fur practische Aerzte,* 1896), as well as in my publication "Ueber Bäder bei Arteriosclerose" (*Deutsche Med. Zeitung*, 1895, and *Weiner Med. Wochenschrift*, 1896), where also I have given rules for reducing the initial rise of blood pressure unavoidable even in the baths described.

A much contested question is that *whether a single bath can cause a dilatation to recede.* I admit the possibility in theory, but consider that the influence of a single bath is not in most cases strong enough to bring about a marked and indubitably demonstrable shrinkage of the heart. In spite of frequent investigation I have only exceptionally succeeded in proving a shrinkage of cardiac dulness after one bath, and even then I could not altogether rid myself of doubt concerning the correctness of my observation, especially as to whether I had not to deal with normal physiological variations. *Such great differences as Bezley Thorne and others have found I have never been able to determine.* Perhaps Röntgen-radiography may afford more certain evidence. Till now, the tracings obtained, at least those which I have seen, are still too indistinct (Verschwommen) to prove anything thereby statistically. If, thus, in regard to the demonstrable effect of single baths, I differ from many observers, I must on the other hand state that I have often been able to prove by percussion during the treatment, and especially at the end of this, a distinct shrinkage of the cardiac dulness as compared with that found at the commencement of the course. But, in relation to the whole number of my cardiac patients, even these cases were not very numerous.

That the decrease in cardiac dulness is to be explained by better expansion of the lungs, as is generally maintained, I consider incorrect. On the contrary, there is often present in the case of incompetent hearts a lung increased in size from congestion (pulmonary rigidity—Lungen Starrheit of Basch)—which with improved heart's action and more powerful breathing recedes, and then must rather allow a greater cardiac dulness to appear.

Morison's somewhat too pessimistic position on this point may perhaps be explained by my intentionally not having sought out so-called show-cases (Parade-Fälle), but he saw patients exactly as chance brought them.

The *mechanical treatment* of circulatory disturbances, especially of chronic diseases of the heart, I am accustomed to regard, like the balneological, from these two points of view: *that which operates by relieving the heart, and that which is more stimulating to the heart.* The answer to these questions is important for the proper prescription and choice of the different methods, namely, *Massage* and *Passive Gymnastics,* manual (Schott's) resistance gymnastics, mechanical (Zander's), and the Terrain cure (Oertel's).

The possibility of improving circulatory disorders by mechanical means, as these are referable to mechanical causes, several Swedish physicians besides Ling have shown in practice for more than 30 or 40 years, and have related their experience. When we examine the works of Zander, of Stockholm, of the year 1872, and the later ones of August Schott and Oertel, we already find in these some processes mentioned which relieve the work of the heart, and others which urge it to increased, more energetic, and more frequent contraction.

The more rapid escape of venous blood from the capillary areas and peripheral veins, relieves the work of the heart, and must, in my opinion, be regarded as the most important point in rational mechanical treatment. This is attained during massage by external pressure and centripetal stroking. In certain passive movements the veins, because alternately compressed and enlarged (diminution and increase of capacity), become alternately empty and filled by suction (vollsaugen), that is the blood flow is promoted from the periphery to the heart by their valvular arrangements as in a pressure and suction pump. In Zander Institutes there are several apparatus which, constructed after careful anatomical and physiological study, take this circumstance into consideration. In resistance gymnastics, manual and mechanical, this fact is also borne in mind, as also in walking, especially up hill. Further, in active, especially resistance gymnastics, as also in the Terrain cure, a pressing out of the venous blood is brought about by the powerful muscular contractions. Finally, by deep inspiration, the blood-flow from the veins is hastened. This may be effected by so-called lung-gymnastics, voluntary deep inspirations, which are based upon definite movements calculated to widen or restrict the thoracic capacity. They are of especial importance in Zander gymnastics and in the Terrain cure. More powerful expiration aids the action of the heart by hastening the evacuation of the thoracic arteries. A reduction of peripheral resistance in the smaller arteries acts, moreover, as a relief by moderating (mässigend) the demand made upon the capacity of the heart for work. "Ubi irritatio, ibi affluxus" is a well-known axiom. An increased blood-flow to one part of the body is, however, only conceivable if the supply vessels widen. This is notably the case on muscular movement. The intramuscular arterioles also widen. The dilatation of vessels in a limited area would, however, only act by relieving the heart to a slight extent. But in the Terrain cure, as also in mechanical and manual gymnastics, there are researches which show that the peripheral arteries are dilated generally from reflex causes by muscular action, that is, not merely in the parts moved. This circumstance enters as a heart-relieving factor into all active movements. According to Sommerbrodt, forced respiration also produces relaxation of the arteries. More powerful heart's action is induced by massage and passive, as also by active movements, from the fact that increased flow of blood to the heart is associated with increased work by the heart. Yet is this increased effort by the heart transient on account of the simultaneous relief. On the other hand every active movement, especially if made with a certain force, places increased demands for effort upon the heart. This is the case both in manual and mechanical resistance gymnastics and in the Terrain cure. One can very well in these three different modes of treatment graduate the demands made. The modification of manual resistance gymnastics recommended by A. Schott may be regarded in any case as the least trying to the heart. Carried out gently it acts preferentially by relieving the heart. Hill-climbing acts more energetically. Between these lie the resistance movements of Zander's gymnastics, which, however, if we regard them as a whole, that is including the apparatus for passive gymnastics, massage, etc., offer the greatest amount of gradation with most exact dosage and control. One great advantage of mechanical and manual gymnastics over walking cures lies in the fact that the former allow the heart time to rest for recovery between the movements, which does not quite occur in the Terrain cure, even when we interrupt the walking by frequent and long periods of rest. In the former, therefore, is attained much more completely that which we must always bear in mind in gymnastic treatment, *a regular alternation between heart-work and heart-rest.*

The view expressed by Oertel that in walking, that is, in muscular work, a relaxation of the arteries occurs at the same time as an increase of blood-pressure, has also been found to be the case in resistance-gymnastics by Hasebroek, Physician to the Hamburg Zander Institute (*ueber die Gymnastische Widerstandsbewegung in der Therapie der Herzkrankheiten*, Leipzig, 1895). He regards this as increased cardiac action due to emphasised work energy (Arbeits energie) of the heart muscle, which is caused in a reflex manner by the incentive to muscular effort. This increased labour, however, the heart can only completely carry out without being rapidly fatigued, provided it finds the channels for a richer blood supply open. After single gymnastic movements he found the relaxation of the peripheral arteries continue for a certain time, but with reduction of blood pressure. There, therefore, succeeds to increased cardiac effort, under favourable conditions of the circulation, a diminution of effort that is a notable degree of heart-rest (Herz-schonung).

In the case of manual gymnastics (according to A. Schott), also, sphygmograms, etc., taken, allow such an interpretation. We must in the meantime be satisfied with this explanation, although some objections, as Dr. Morison has rightly remarked, may be urged. The interpretation, moreover, of sphygmographic tracings upon which we rely in this matter, is not quite free from objection.

The Decrease of Cardiac Dilatation, that is, the diminution of the cardiac dulness immediately on the termination of gymnastics, manual and mechanical, I have observed more frequently than after a bath. Yet in this case, as in that, I must confess that, as regards the frequency and extent of the diminution, I cannot agree with some others, in spite of the fact that, since A. Schott's first publication on the subject, I have worked at it, and although since that time I have combined bath treatment with gymnastics in numerous cases, and indeed, by exactly the same method as that described by A. Schott, and carried out in some instances by the same persons as those employed by him. Professor Zuntz (*Verhandl. d. Vereins fur in. Med. zu Berlin*, 11th Jan., 1897) has not succeeded by the aid of Röntgen rays in determining a recession of the boundaries of the heart after muscular exertion. Professor von Leyden (*ibid.*) was unable to convince himself of a demonstrable diminution of the left ventricle in the experiments carried out in his clinic by Professor Heineman. I quite agree with von Leyden when he states at the same time that the evidence of a diminution of the left heart is generally very difficult to adduce and very deceptive.*

As regards the *employment of*, that is, the *indications* for *the different mechanical methods of treatment*, it is clear that, in the case of a heart muscle incompetent to a high degree or degenerated and essentially weak, gentler proceedings are indicated than in cases essentially altogether or nearly intact, which are only unequal to demands for increased work in face of abnormal resistance or impediment. Least fatiguing is a gentle, not too protracted massage, ultimately

* Since this was written Dr. Theodor Schott has published results of radiography, to which reference will be found elsewhere—A. M.

combined with passive movements and sometimes also with a few mild resistance exercises. That in the most severe cases of cardiac insufficiency to be considered in this connection, use is not to be made of mechanical instruments is self-evident from the discomfort connected therewith in the case of those seriously ill. Herein consists one great advantage of manual over mechanical gymnastics, which, also, are not procurable in every town.

The next grade—patients with a very slight degree of cardiac reserve force and very mild supervening dyspnœa—is that in which the manual gymnastics, according to A. Schott, play a preponderant *rôle*, and, indeed, the less trying exercises with slight resistance. These are the cases in which the increase (Steigerung) of cardiac work may only be of short duration and intensity, and in which, after each exercise, a period of rest of not too short duration must follow. For these patients the Zander apparatus for passive movements, shampooing (walkung) and vibrations are also recommended. But I prefer gentle manual gymnastics.

As the third grade, I designate patients who already possess a high degree of reserve force, so that, for example, they can walk for a length of time on level ground without difficulty of breathing, and only become breathless on exertion, such as clothing themselves. Here manual gymnastics of a more severe type are indicated (naturally with careful observation of the effect). In this case, however, the Zander Institute with its appliances may accomplish the same object. There, it is best to prescribe, in the first instance, some passive movements, shampooings, etc., to increase the peripheral circulation and relieve the heart, and then active movements of not too severe a type. The resistance must at first be very slight, and gradually increased. Little by little we proceed to more severe exercises. Yet are there a large number of instruments which in heart disease I only very rarely use as they are too exacting (austrengend). We must always be very careful that the pauses which Zander prescribed are properly observed, in order always to allow the heart time for recovery. Independently of these pauses, I always give instructions that exercise must be interrupted if palpitation or quickened breathing occur, and only to proceed to a fresh exercise when these have completely passed off. Strict supervision is necessary eventually to exclude some exercises and add others, to change the sequence and increase or diminish the resistance. As, however, in the Zander Institute my patients are arranged in groups, at stated times I find it easier to control operations myself or through my assistant than in the case of manual gymnastics, which are carried out at the most different times and in the most varied quarters.

The Zander are distinguished from the manual gymnastics chiefly by this: that in the former all the movements are performed several times in succession, in the latter each movement only once. To the former, therefore, pertains a certain duration of cardiac strain (Leistung), and on this account the movements, according to A. Schott, are to be preferred in both the first grades. On the other hand, one advantage of Zander gymnastics is the greater attention paid to properly forced respiration. While the following out of the directions, as Zander has given them for each of the exercises, usually causes patients not the least fatigue, I have in vain sought the same result in the case of manual gymnastics, and am contented when patients practising the latter breathe freely, regularly, and without effort. I frequently allow the patient as an addition, at the conclusion of manual gymnastics or repeatedly after single exercises, as also during treatment with massage and passive movements, to make deep inspirations, sometimes with expansion of the chest with the help of the gymnast, corresponding to the special Zander apparatus E6 serving this purpose. By many patients these deep inspirations are found to be extraordinarily beneficial; some, however, cannot bear them, and become, for example, giddy during the process. The exercises should not be too frequently repeated in succession —three to five times (according to Zander, five to ten times).

I now come to yet a fourth group of patients. These are they who already exhibit a considerable degree of reserve force, and only on more severe exertion, for example, on walking upstairs rather quickly, experience breathlessness or palpitation of the heart. In valvular incompetency let us say, patients with compensation sufficient for ordinary purposes. In these cases the Zander Institute effects decidedly more than gymnastics according to Schott, to methodically habituate the heart to greater and unusual effort, and to steady it permanently. In the case of these patients a prudent terrain cure is usually suitable. I now proceed to mention a few details.

We see the most frequent and best results of gymnastics in circulatory disorders and affections of the heart *without* valvular lesion. Of valvular diseases insufficiency of the mitral valve offers the best prognosis in treatment by gymnastics. But I cannot say that a particular kind of valvular failure quite excludes it from mechanical treatment. But in insufficiency of the aortic valve, as well as in stenoses with disturbance of compensation, the resistance must in general be less than in the affection first mentioned, and in these more frequently than in it I have found it better to limit myself to baths alone, or to prescribe massage and passive movements in addition to these. In arteriosclerosis, also, I usually restrict myself to this, although I have repeatedly seen a favourable effect from careful resistance gymnastics in this condition. The same applies to those cases which exhibit symptoms of angina pectoris. These patients in some cases especially praise the beneficial influence of vibratory concussion of the back and even of the front of the chest with Zander's apparatus F1. (Dorsal concussion usually acts by retarding the pulse.) A patient of mine had a small vibratory apparatus with which he promptly removed post sternal pressure with radiating pains. On the other hand, I on one occasion found that a patient with aortic insufficiency who suffered from severe anginal pains, and whom I only allowed to try the Zander Institute on his urgent request, had an attack at once during a gentle exercise, which, however, as was usual with him, was removed by nitro-glycerine. This was, however, the only unpleasant case of which I had experience at the Zander Institute. Zander himself says (Nebel, *Beiträge zur mechanischen Behandlung*, Wiesbaden, 1888), "During many years, having daily to deal with a great number of seriously affected cardiac patients, I have never had experience of an unfortunate case in my Institute." Nor have I from other sources heard of such. Heiligenthal gives information concerning 702 cases of diseases of the circulatory organs treated in the years 1884 to 1893 in the Zander Institute at Baden-Baden by physicians there, and states: "Unfortunate cases have never occurred during the treatment of cardiac patients by therapeutic gymnastics." Among 96 of my patients who exercised in the Zander Institute during the past year there were 76 in whom notable benefit could be determined after single sittings. In 14 no decided benefit was observable, and six patients had to abandon Zander gymnastics, as they did not feel well after them, which was also objectively shown in four of them, as is usually the case, by a somewhat longer maintenance of increased pulse-frequency. The same sometimes occurs with the use of manual gymnastics; but with other modes of treatment, including the medicinal, we have often to abandon or change the procedure employed.

The following additional statistics from the year 1896 may be of interest to some. During this year 1,162 patients with affections of the circulatory organs, disturbance of cardiac innervation (nervous palpitation, etc.) included, underwent treatment in Nauheim under my care. Of these only 268 were treated with massage or gymnastics in addition to the baths. In the remainder I considered such partly unnecessary and in part contraindicated. Only in the case of a small number of patients did I prescribe a Terrain cure, that is, hill-climbing. In not a few I was obliged, or considered it advisable, to seek the aid of medicines. In the latter connection I shall only repeat what I was in a position to maintain with certainty, several years ago, after an experience of nearly twenty years ("Bad-Nauheim und die Behandlung der chronischen Herzkrankheiten," *Petersburger Med. Wochenschr.*, 1893): "That sometimes medicines, such as digitalis, etc., which do not operate aright in the home of the patient, again act effectively in combination with bath-treatment." On the other hand I must also here repeat a statement made in the same place, namely, "That the family physician should first form an opinion on the point whether, on the whole, a certain power of reaction by the heart is still present before he determines to send a patient to a watering-place."

Much as I am convinced of the importance of health resorts, with all their circumstances favourable for patients —and for cardiac patients this applies especially to Nauheim —yet I must affirm that one may frequently effect a cure at home, and not rarely obtain satisfactory results in the treatment of chronic disturbances of the circulation without baths and also without gymnastics.

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