A RECENT METHOD OF STUDYING THE ACTION

OF THE HUMAN HEART, WITH SPECIAL REFERENCE

TO AURICULAR FIBRILLATION

—BY—

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During my term of Office as House Physician to Addenbrooke's Hospital, Cambridge, I have had an opportunity of studying and have paid special attention to many interesting diseases of the heart.

A large number of these cases have been assoc- iated with some irregularity of Rhythm.

Their study has been rendered more valuable by the fact that I have had access to tracings of each heart as shown by the Einthoven String Galvanometer, and in the majority of cases to tracings taken with Mackenzie's Polygraph.

During the last few months, I have examined several cases exhibiting the features of Auricular Fibrillation.   The features of this disease have recently been clearly defined by several observers, notably Dr James Mackenzie and Dr Thomas Lewis, the former working with the Polygraph, the latter with the String Galvanometer.

The researches of these men have demonstrated that auricular fibrillation is quite a common occurrence in the human heart, constituting as it does about 50 per cent of the arrhythmias of the heart.

I propose in this paper to describe the usual characteristics of these cases with special reference to the String Galvanometer and the characteristic tracings obtained by its use.

The study of the irregularities of the heart has interested clinicians for many years, but it is only

since the introduction of methods of graphically
recording the cardiac mechanism that any progress has
been made in this direction.   For many years the
Sphygmograph was the only instrument in use, but as
it recorded only the movements of the Radial pulse
and therefore indirectly the action of the left ven-
tricle, little advance was made.

Mackenzie, recognising the shortcomings of
this instrument, devised the Polygraph, by which he
was able to record the movements of the jugular pulse,
Carotid or radial artery, and apex beat simultaneously.
In this way, he could study the action of the other
Cardiac chambers.

From a careful and systematic study of the arr-
hythmic cases under his care, he was able to classify
them into certain well defined groups.

In one class of case, namely, that usually
associated with an extreme disorder of rhythm,
occurring particularly in old standing cases of Mitral
Stenosis, he noticed that all signs of the normal
auricular activity were absent.

In attempting to explain this absence he was
guided by the conditions found at autopsy.   He
explains (1)   That in several cases where these
features had been observed during life, the auricle
was found at post mortem examination distended and
thin walled.   He therefore concluded that the
absence of all signs of auricular systole was due to

the auricle having become atrophied and paralysed. This view was shortly afterwards withdrawn owing to the fact that similar cases showed that instead of the auricle being thin walled it was hypertrophied. In addition it was difficult to see how paralysis of the auricle accounted for the marked irregularity. He then suggested that the stimulus for contraction arose at a site lower down than usual and that the stimulus passing up to the auricle and down to the ventricle caused a simultaneous contraction of these chambers.   Fixing on the auriculo-ventricular node as the possible site, he named the condition "Nodal Rhythm".

It is now known that neither of these explanations is the true one. The true solution of the problem only became apparent with the introduction of the StringGalvanometer.

The study of the Electrocardiogram is not new to physiologists as A.D. Waller in 1887 studied the changes of electric potential that occurred in the heart during its contraction. He even constructed a diagram showing the lines of diffusion of these changes of potential on the surface of the body. (Fig. 1)
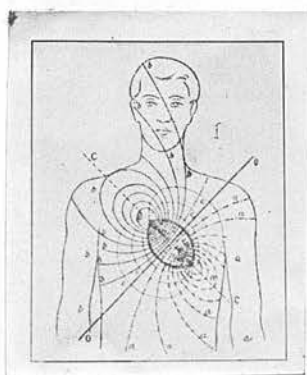
These changes of potential are, however, very small measuring only anything up to $\cdot 5$ millivolt. Hirschfelder (2) gives them as $\frac{1}{10,000}$ to $\frac{1}{3000}$ of a volt. The capillary electrometer used by Waller at this time though sensitive was not quick enough in response to record these changes satisfactorily. In 1906, Einthoven succeeded in making a galvanometer sufficiently sensitive to record accurately the changes of potential of the heart. The records obtained by this new instrument are very accurate, but it is somewhat complicated and requires no little skill for its manipulation. The records used to illustrate this paper have been taken by Dr Shillington Scales, Physician in Charge of the Electrical Department at Addenbrooke's Hospital, who has kindly allowed me to use them for this purpose.

The principle of the String Galvanometer is simple.   It depends upon the fact that a magnetic needle is deflected when an electric current is passed through a wire in its vicinity (Howell [3]) The needle will be deflected to the right or to the left according as the current passes in one direction or the other.   The effect of the current upon the needle increases with the number of turns of wire and with the current.   A similar result is obtained if a wire be suspended between the poles of an electro-magnet on the principle of the D'Arsonval Galvanometer, the moving coil in this case being represented by the suspended wire.

In order to make the instrument as sensitive as possible, Einthoven suspended a very fine quartz fibre, silvered to make it a conductor, between the poles of a powerful electromagnet.   The quartz fibre is so fine as scarcely to be visible to the naked eye and measures about 2.5 microns   (James and Williams [4]) The fibre moves at right angles to the "field" and will vary in direction according to the direction of the current.(Fig. 2)

Fig. 2. Diagrammatic View of Einthoven Galvanometer.
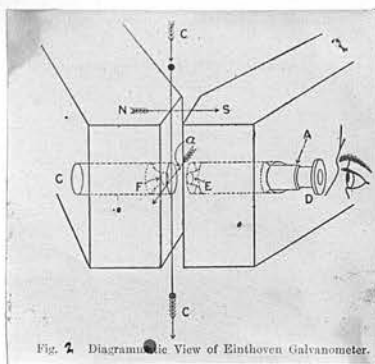
(N,S, = the poles of the magnet)
(cc = the string or fibre   )

The poles of the magnet are perforated, the one con-
taining a condensing system, the other a projection
system.   A powerful arc light acting in conjunction
with these and through a cylindrical lens causes the
shadow of the string to be magnified and focussed upon
a sensitive photographic plate which moves in a
vertical direction and so photographs the movements of
the string. (Fig. 3)
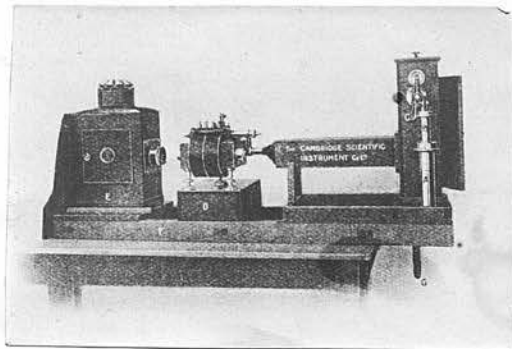
By means of a micrometer screw, the tension of the
string may be altered so as to vary the sensitiveness
of the galvanometer.   The string is in connection
with two terminals to which the wires are attached
which convey the current generated in the patient to
the galvanometer.   Figure 4 represents a photograph of
the galvanometer.

THE EINTHOVEN STRING GALVANOMETER.
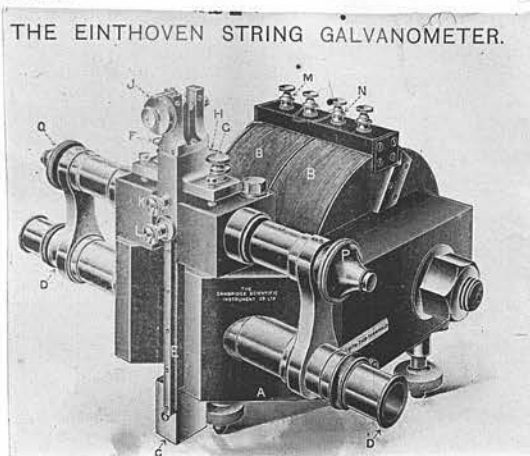
These wires are connected to the Patient by means of
Electrodes.   The latter may consist of vessels

containing solution into which the limbs are immersed
and which act as non polarisable electrodes.

The electrodes which we have used at Adden-
brooke's Hospital consist of thin, flexible sheets
of Aluminimum covered with thin felt.   These are
thoroughly soaked in normal saline solution and tied
about the extremities with tapes.   In this way
dangerous cases need not be disturbed at all. (Fig.5)

FIG. 5.—The electrodes in use.
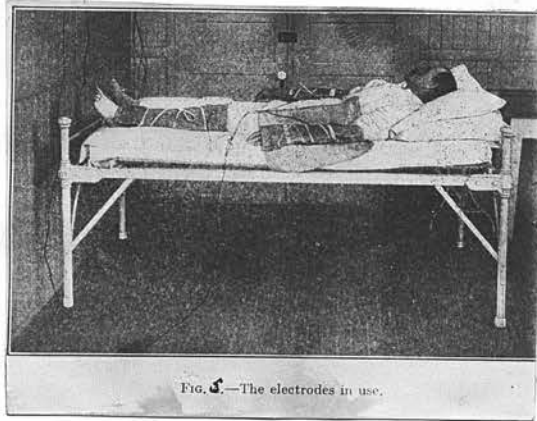
We use this method because the Wards of Addenbrooke's
Hospital are some considerable distance from the
laboratories, and the electrodes are connected to the
galvanometer by overhead wires.   Certain other
appliances are necessary to complete the apparatus.

The resistance of the body of the Patient
and of the electrodes has to be equalized.   This is
accomplished by means of resistances and adjusted by
a telephone in connection with a small faradic
battery, or by means of a Wheatstone's Bridge.

In addition, we require some "Null" apparatus
to compensate for the deflection of the string which
occurs as the result of the skin current, Generally

assumed to be produced by the activities of the various skin glands etc.

Lastly, in order that records taken in this way may be easily compared, we require to have the string at a known degree of sensitivity. That originally proposed by Einthoven and still followed is, that the string should move one centimetre when a difference of potential of one millivolt is applied to the terminals. To attain this standard, some appliance for regulating the voltage or amperage is necessary.

When all these points have been attended to the Patient is ready for the photograph. The Patient must be warned to keep still as sudden muscular movements by producing great changes of potential might break the delicate fibre as well as prejudically affect the tracing.

The whole process of actually recording usually takes from three to five minutes in expert hands.

In every case it is advisable to take photographs or electro cardiograms from three different "leads" or "derivations".

Those commonly used and known as Leads I. II. III. are respectively:-

    1. Right arm and left arm.

    II. Right arm and left leg.

    III. Left arm and left leg.

The electro cardiograms from these leads differ
slightly from each other in certain important characters
and are useful in forming a diagnosis.   The records
from Leads I. and II. usually give the best tracings.

In interpreting the electro cardiograms,
certain facts must be borne in mind.

The surface of that portion of a muscle which
is active becomes "negative" to the parts at rest.   As
the contraction spreads along the muscle, each part
as it enters into contraction becomes electro negative
to the parts at rest.

This wave of "negativity" or as it is better
expressed, this change of electric potential is known
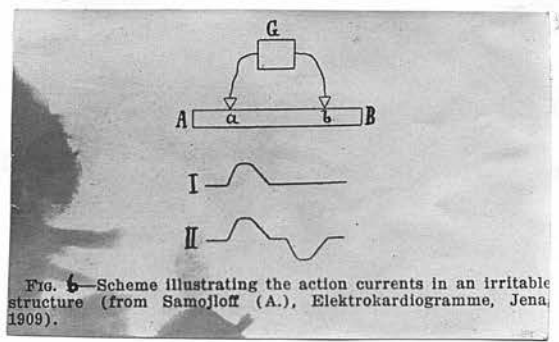as the Action current.

Fig. 6.

FIG. 6—Scheme illustrating the action currents in an irritable structure (from Samojloff (A.), Elektrokardiogramme, Jena, 1909).

If we take a strip of muscle A.B. apply electrodes at
(a) and (b) and connect with a galvanometer, the
contraction starting at A. will cause a deflection of
the needle in a definite direction.   As the contrac-
tion passes along the strip, the needle will return
to its original position and when the contraction
reaches B. the needle will deviate in the opposite

direction.   The effect is therefore a diphasic one
and may be represented diagramatically thus. (Fig.7)

-Scheme of a diphasic variation accompanying a simple muscle con
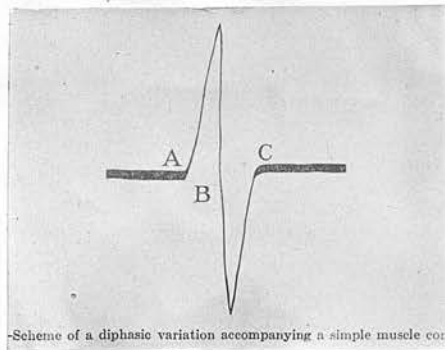
By photographing this deflection we can state where
the contraction began.

The heart, however, is not a simple muscle
strip like the example just chosen and in order to
trace the path of the contraction wave through the
heart, it is necessary to look at its development.

In an early stage of development, the heart
appears as a simple tube.   The posterior end of
this tube receives the veins from the body into a
pouch called the Sinus Venosus.   This end of the tube
appears to be the most excitable as the contraction
commences here and passes along the whole length of
the tube.   As development proceeds this tube
becomes bent upon itself and pouches appear upon it
which ultimately become the auricles and ventricles.
Still later the sinus venosus and the parts of the
original tube which connect the auricles and
ventricles become incorporated with the latter
structures and lose their power of contraction.
These portions which cease to exist as a tube are

believed to form a connecting band between the auricles and ventricles and in addition to play an important part in initiating the stimulus of contraction.

Recent observations have shown that remnants of these rudimentary structures still exist in the human heart.

Several definite nodes and bands have been discovered, some of which have very important functions and require mention. The most important of these are:-

1. The Sino-Auricular Node.

This node of tissue is found at the mouth of the Superior vena cava. It was first described by Keith and Flack and is often known by their names. This node consists of fine, delicate fibres faintly striated and is supposed to represent the remains of the original Sinus venosus.

2. The Auriculo-Ventricular Node.

This node is found near the mouth of the Coronary Sinus in the right auricle and was first described by Tawara. It is similar in structure to the Sino-Auricular node. From this node arises the third important structure namely;

3. The Auriculo-Ventricular Bundle.

Arising from the auriculo-ventricular node this band passed to the upper end of the interventricular septum and here divides into two main branches, one branch passes to each ventricle

and eventually breaks up into an extensive and
complex subendo cardial network of swollen, faintly
striated cells known as the Fibres of Purkinje
(5)
(Lewis).

This bundle in the upper part of its course
consists of cells of undifferentiated protoplasm
with a large nucleus and slightly striated at the
circumference.   This bundle was first demonstrated
by Stanley Kent and experiments by Kent, His and
others tend to show that it conveys the stimulus
from auricle to ventricle.

The actual starting point of the heart's
contraction is still uncertain, but the Sino-
auricular Node probably initiates the contraction.
Other remnants of the Sinus venosus may be found,
but the Sino Auricular Node is the only definite
one known at present.   From this node, the contract-
ion is supposed to spread to the auricle and then
passes by the auriculo ventricular node and bundle
to the ventricle.
(6) and (7)
Experiments by Gotch tend to show that
the contraction through the ventricles follows the
direction of the original tube.   He has demon-
strated that an area at the root of the aorta is the
last part of the heart to contract and represents
the homologue of the Bulbus Arteriosus in the lower
animals.   These facts are of importance as they
form perhaps the most satisfactory way of explaining
the characters of the electro cardiogram, as will
be seen later.

With these facts made clear, I shall now
proceed to discuss the changes in and clinical
features of Auricular Fibrillation.

The condition of fibrillation refers
to that condition where the muscle fibres instead of
contracting co-ordinately contract inco-ordinately
and independently of one another.

These conditions may be produced experimen-
tally by sending a rapid series of electric stimuli
through the heart.　　The changes which occur are
　　　　　　　　　　　　(8)
reported by　Cushny　　and by　Cushny　　and
　　　　(9).
Edmunds.　　　They found that if the ventricle was
sent into fibrillation, death rapidly ensued from
failure of the circulation.　　On the other hand,
when the auricle was experimented upon the circulation
continued.　　They found that when Auricular fib-
rillation was produced in the dog, it was invariably
associated with a rapid and very irregular aterial
pulse, similar to that which had long been a recog-
nised feature in the human being of old standing
cases of Mitral Stenosis.　It was therefore suggested
by them that this was the cause of the irregularity
in these cases.　Several people were incredulous,
the main objection being that auricular fibrillation
could not go on for a long period of years as these
cases of Mitral irregularity were known to do.

The String Galvanometer was then utilised
and it was discovered that in each case, there was
no trace of the normal auricular complex, but that
there were numerous fine oscillations which were
undoubtedly produced by the fibrillating muscle.

(10-11)
Lewis also proved that these oscillations were
maximal when one electrode was placed over the right
auricle.

Such a condition has never of course been
actually seen in the human being, but a similar con-
dition occurs in the horse. (12) Lewis has had the
opportunity of seeing an auricle in fibrillation in a
horse which had just been killed. The auricle was
found distended and ballooned and no complete systole
was accomplished, yet the wall of the chamber appeared
to be in a constant state of movement. "Rapid, minute
and constant twitchings or undulatory movements are
observed in a multitude of small areas upon its sur-
face" (Lewis).

There is no reason why this condition should
not occur and persist for some time in the human
heart. The auricles are really reservoirs which
supply the ventricles and are not really essential to
the circulation.

In addition, this condition fully explains
the extreme disorder of rhythm which ensues.

Each of these vibrating areas would appear to
be capable of originating a stimulus and exciting the
ventricle to contract. Haphazard and irregular
impulses pass to the ventricle as rapidly as they
can be conducted along the auriculo ventricular
bundle. The rate will depend upon the power of
the bundle to contract and individual cases vary
from 30 to 200 per minute.

This condition is now known to be a very common affection. It is the usual cause of the irregularity in Mitral Stenosis and in Senile cases with Cardio Sclerosis. As regards the etiology it occurs most frequently after an old standing rheumatic affection of the heart. Lea[13] found that a history of Rheumatism or Chorea could be obtained in 56.6% of cases of Auricular Fibrillation. This fact will be emphasised in the special cases.

Although most common with Mitral Stenosis, it often occurs without valvular disease. The actual valvular disease is not the serious factor. It is the changes that are set up in the muscular wall that lead to fibrillation. The actual nature of these changes is not yet determined. In the majority of cases examined, changes of a chronic inflammatory nature were found with an increase of fibrous tissue and of nucleated cells. It is apparent, however, that Fibrosis itself is not the only cause as cases showing obvious fibrosis have frequently occurred without the occurrence of fibrillation.

Whatever be the real cause, it is a progressive one and leads sooner or later to heart failure. The heart is usually dilated, due no doubt to exhaustion, the result of the rapid and irregular stimulation.

Before discussing the clinical features which
include the characteristic phlebograms and electro-
cardiogram, I shall review the normal records.

The Venous Pulse is sufficiently well known not
to require a detailed explanation.   On it are found
several distinct waves of which the first one called
(a) is due to the auricular systole.   About $\frac{1}{5}$
second after (a) comes another wave due to transmitted
pulsation from the carotid artery (c).   This is
followed by a depression (x) occurring during ven-
tricular systole and then another wave (v) often
marked off into two distinct waves (v^1) and (v^2).
The notch between (v^1) and (v^2) marks the end of ven-
tricular systole (see diagram)
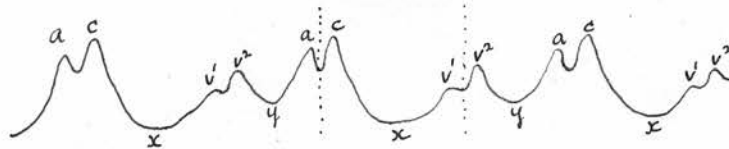
In cases of auricular fibrillation, as we have seen
the notable feature is the total absence of the (a)
wave due to auricular systole.   This type of pulse
has been designated by Mackenzie "ventricular" in
contradistinction to the normal or "auricular" type.
The extreme irregularity will also be apparent and if
the heart is acting slowly, a series of fine
oscillations is sometimes seen in the diastolic period.
These are produced by the fibrillating auricle.

Examples of this type of venous pulse will be shown later.

The normal and abnormal electro cardiograms require more attention.

The normal electro cardiogram consists of three waves in an upward direction and two smaller waves in a downward direction these latter sometimes barely evident. Those directed upwards seem to indicate a relative negativity of the base to the apex; those with a downward direction have the opposite significance.

Figure 9 shows diagramatically the characters of the normal electro cardiogram:-


Fig. 9—Scheme of the normal electrocardiogram.
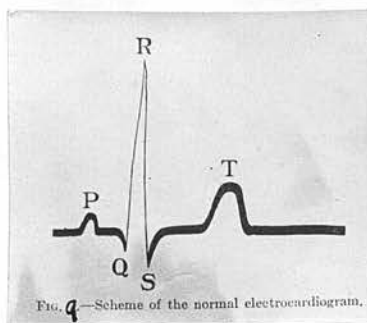
The waves are labelled for convenience P.Q.R.S.T. of which P.R.T. are directed upwards while Q.and S.are directed downwards. Of these waves P. is due to the contraction of the auricle. This has been proved both by actual observation and by its dissociation from the rest in cases of Heart Block. The other waves Q.R.S.T. are produced by the ventricle. Of these R. and T. are the most constant and most

important.   Q. and S. are not always present and their
significance is not quite understood.

P. is a small, rounded elevation.   Between P.
and Q. the string remains at zero and during this
period, the stimulus is passing from auricle to
ventricle through the auriculo ventricular bundle.
R. is the tallest of the series and is clean cut and
well defined.   It corresponds to the initial con-
traction of the base of the heart and continues to
rise till the contraction reaches the apex.   Between
S. and T. the string again remains at zero.   This
has been explained as being due to the fact that
during this period the whole ventricle is contracting
and all parts of the muscle are of equal potential.
T. is a broad and somewhat prolonged wave and represents
the contraction of that part of the ventricle at the
base of the aorta which the experiments of Gotch
have suggesed is the last part to contract.
Figure 10 shows the record in all these leads from
a normal individual.

LEAD I

LEAD II

LEAD III
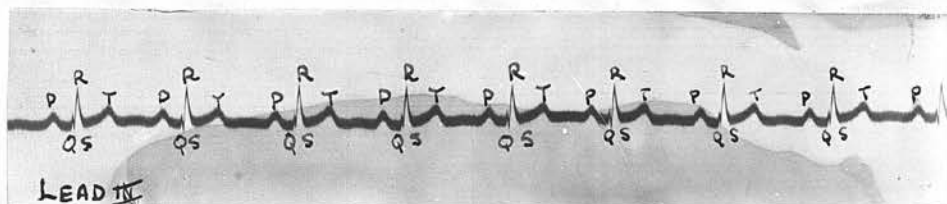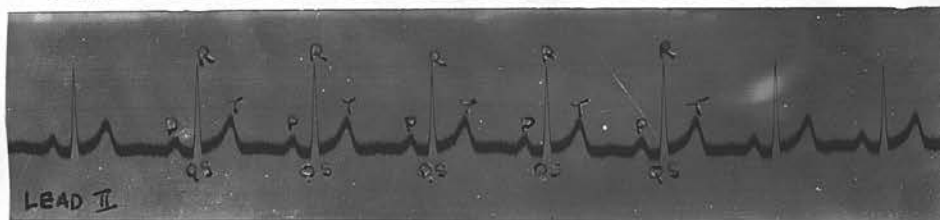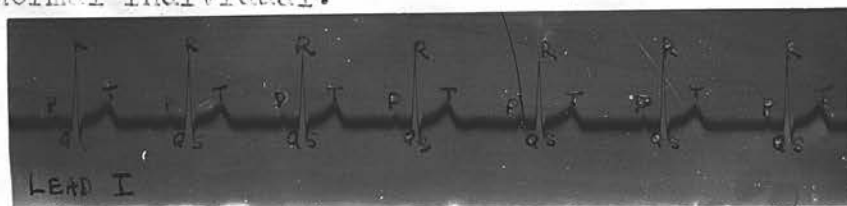
The characters of the electro cardiogram in auricular
fibrillation show marked differences which are
illustrated by the next figure.
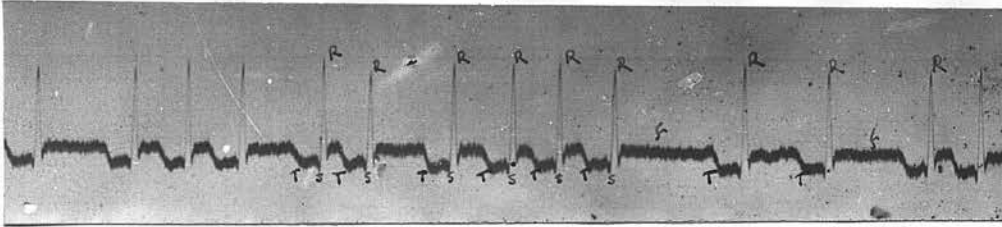
(To be read from right to left)

Scattered throughout the tracing we see the clearly
defined R. waves of the ventricular complexes.   They
occur at irregular intervals and bear no definite
relation in height to the length of the preceding
pause.   The T. waves are also easily recognised but
are somewhat obscured by the presence of fine oscill-
ations upon them.   The reversal of T. in this case
is held to indicate some myocardial changes.

The most striking feature as in the phle-
bogram is the absence of the P. variation. Replacing
P. is found a number of fine oscillations occurring
throughout the whole cycle.   These are the character-
istic and pathognomonic oscillations referred to
earlier in the paper.   They occur in no other patho-
logical condition and are only produced by the changes
of potential occurring in a fibrillating auricle.

The characters of the oscillations vary in
different tracings.   In some they are very prominent
and may be as large as a normal P. variation, in
others they are less marked.   They deform the T.
wave but never affect the R. wave owing to the
rapidity of the latter movement.

Also they bear no relationship to the extent of the myocarditis, for patients may have gross and obvious myocardial disease and yet not give these oscillations.

The presence of the oscillations throughout the whole cycle indicates the continuous activity of the auricle.

The following examples more fully illustrate the clinical features. of cases of Auricular Fibrillation.

Case I.   R.B. aged 38, labourer.

Was admitted to Addenbrooke's Hospital on July 20th 1911 with double Mitral Disease and Double Aortic disease, the result of Rheumatic Fever several years before.

He complained of fluttering of the heart, was very short of breath and unfit for work.   He had a troublesome dry cough, was somewhat cyanosed and lay propped up with pillows.

His urine was scanty and free from albumen. The veins of the neck were greatly distended.   His pulse was very rapid, very irregular and impossible to count.   His heart was slightly enlarged and also very irregular.

At the apex systolic and early diastolic bruits were heard, and over the aortic cartilage was a systolic and diastolic murmur.

The venous pulse was of the ventricular form

and showed all the typical features.

apex.

Robert Beales 4.8.11.

Jugular.
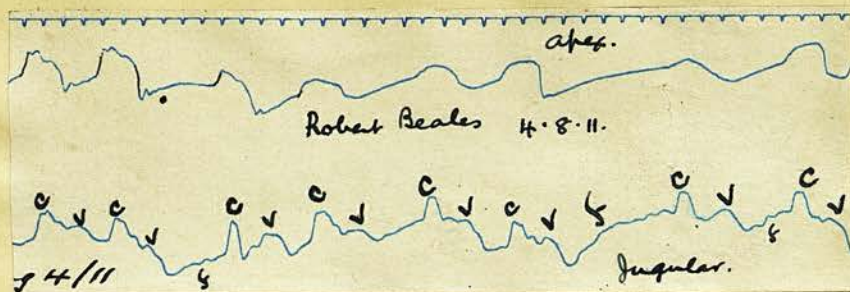
Note the complete irregularity, absence of the (a) waves and the waves in diastole due to the fibrillating auricle marked (f).

The electro cardiograms show the characters already described in the three leads.

Note the reversal of T. in lead III. which is supposed to indicate some change in the distribution of the conducting apparatus.   It often occurs with myocarditis.   There is also a slight tendency to Right Ventricular Hypertrophy as indicated by the height of R. in lead III.

LEAD I

LEAD II

LEAD III
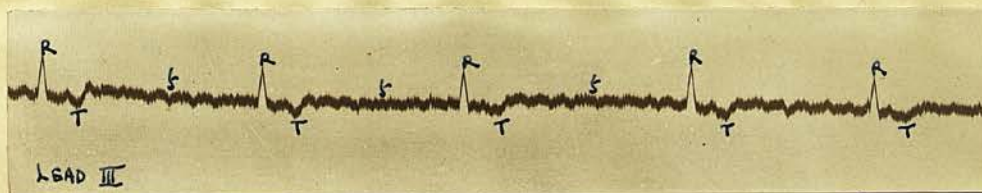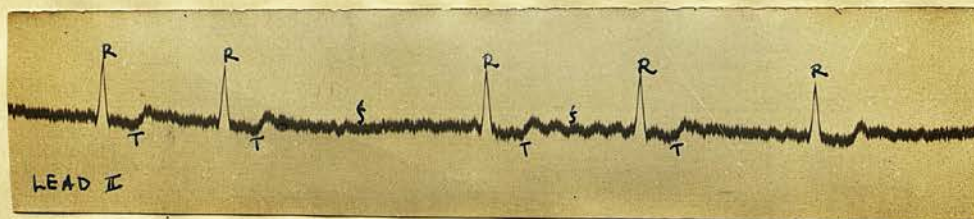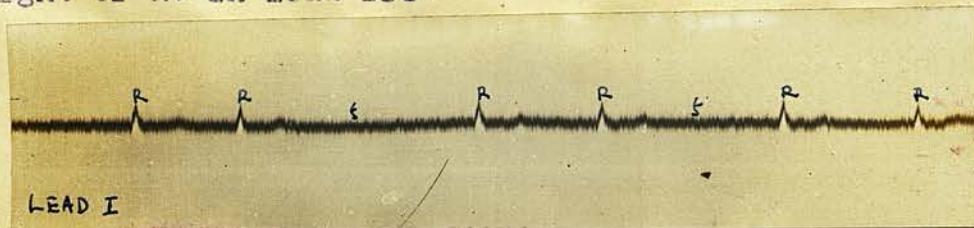
Treatment.   On admission, the patient was given
Tincture of Digitalis 15 minims every 4 hours for three
days.   Marked improvement took place, the pulse
became slower, more regular and stronger.   The urine
was increased and the patient became more comfortable.
The Tincture of Digitalis was then reduced and the
effect continued under 10 minims three times a day.

Patient was discharged in comparatively
good health on August 15th. but was re-admitted on
October 17th. with symptoms of heart failure brought
on by hard labouring work.

On this occasion he received 10 minims of
the Tincture every 4 hours at first but was later
ordered Digitalin Granules (Nativelle) twice a day with
similar good results.

He was discharged again on December 23rd.
free from symptoms.   Since then the patient has
had another attack of Heart failure which proved
fatal.

Case II. J.F. aged 48, Railway labourer.

Was admitted to Addenbrooke's Hospital on
August 4th 1911 with Mitral Incompetence. He had had
three attacks of what he called Influenza but which
were probably attacks of Subacute Rheumatism. He was
admitted with all the signs of heart failure, namely,
shortness of breath, cyanosis, cough, oedema of the legs,
enlarged liver and scanty urine containing albumen and
casts.   There was some emphysema of the lungs and

oedema of the lung bases.

The pulse was rapid and continuously irregular, being difficult to count.

The Heart was enlarged and very irregular in action.   There was a harsh systolic bruit at the apex.

The electro cardiograms show the typical characters namely, complete irregularity, absence of P. wave and the typical oscillations.   The heart's action is feeble.

LEAD I
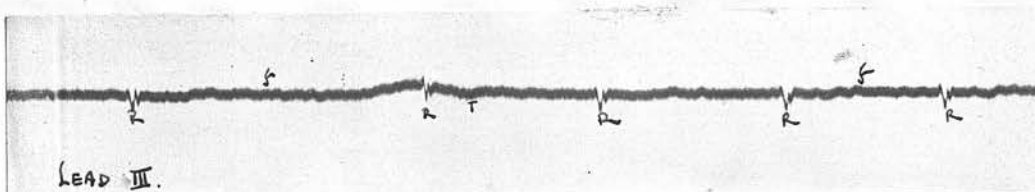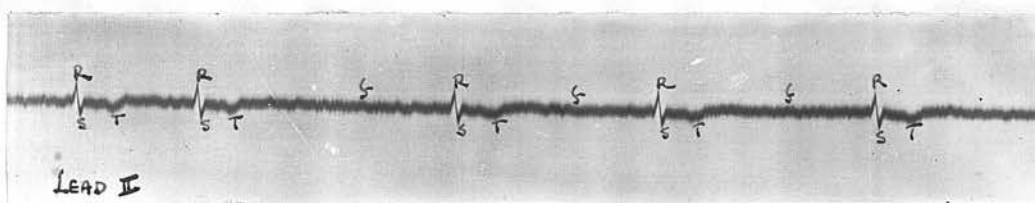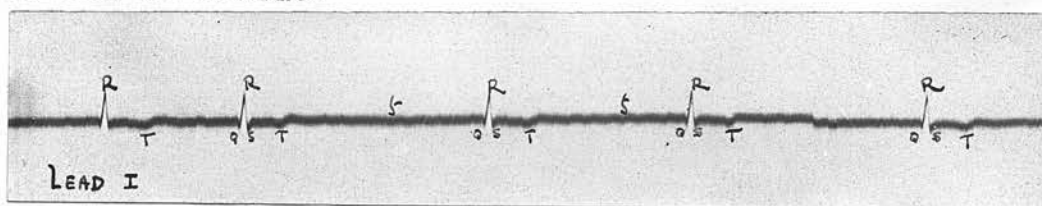
LEAD II

LEAD III.

Note the reversal of the R. wave in lead III. which signifies a tendency to left ventricular hypertrophy.

Treatment.   Patient was put under the influence of Tincture of Digitalis immediately.   I began with 15 minims every four hours until the effect was pro-duced and then reduced it gradually until I found that

the patient could be kept free from symptoms by taking
5 minims of the Tincture three times a day.

Marked slowing of the pulse occurred, the urine
was increased and the patient was better in every way.

He was discharged on September 23rd. but con-
tinued to treat himself by taking Digitalin Granules.
Case III. exhibits another feature which is of some
importance.

In the early stages of Mitral Stenosis the
presence of a presystolic bruit at the apex is usually
detected.   As the stenosis proceeds, another bruit
becomes apparent occurring early in diastole immediately
after the second sound.   When auricular fibrillation
sets in, a change is noticed.   The presystolic bruit
disappears while the diastolic remains.

The explanation of this is obvious. The pre-
systolic bruit is produced by the systole of the
auricle driving the blood through the contracted
orifice.   During fibrillation normal systole does not
occur.   The diastolic bruit persists as it is produced
by the suction power of the ventricle during the
diastole.

A diastolic bruit occurring in Mitral Stenosis
usually indicates some considerable degree of contract-
ion.

Case III. J.S. age 42.

Was admitted to Addenbrooke's Hospital on
February 27th 1912 with Mitral Stenosis and Incompetence,
following Rheumatic Fever 14 years ago.

She had been an Outpatient for some years and
her notes record in addition to the irregularity the
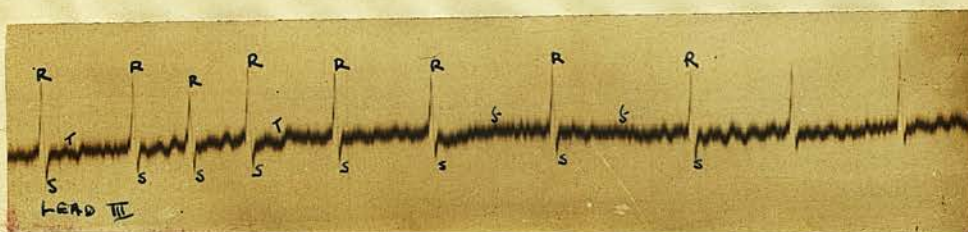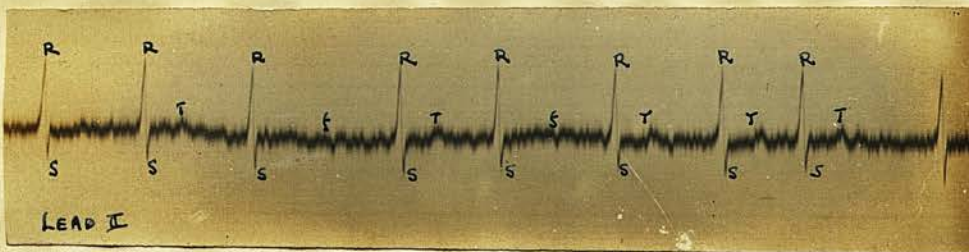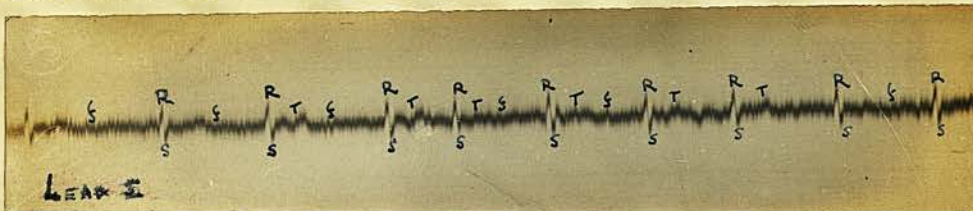
frequent presence of a presystolic murmur.

She was admitted with symptoms of heart failure. The pulse rate was 100 and the rhythm was irregular and disorderly.

The Heart was greatly enlarged, the apex beat being in the Anterior Axillary line.   At the apex there was heard a systolic and an early diastolic bruit.   No presystolic murmur was present.   There was also a systolic bruit over the aortic cartilage.

The venous pulse is of the ventricular form.

Jugular.

c v c v c v c v c v c v c v c v

absence of (a) wave.

Julia Stephoe 29. 2. 12.   Radial.
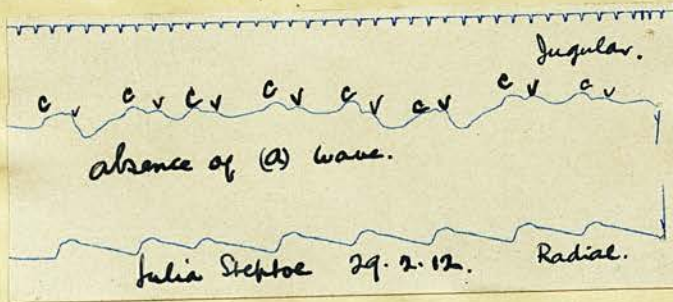
The electro cardiograms show the usual features of auricular fibrillation.

Lead I

Lead II

Lead III

<u>Treatment.</u>   Marked improvement with digitalin granules.

These three cases serve to show the usual features of Auricular Fibrillation.

The chief points are the marked alteration in rate and rhythm, the increased size of the heart, and the reaction to digitalis.

The pulse itself is usually sufficient to diagnose the condition.   The irregularity is of very disorderly kind, no two beats being of the same strength.

There is a constant intermingling of strong and weak beats and many beats do not reach the wrist.. Hering gave the name of Pulsus Irregularis Perpetuus to this form of pulse but this term has fallen into disuse.

Dilation of the heart occurs sooner or later due no doubt to exhaustion from the rapid and irregular stimulation of the ventricle and leads to symptoms of heart failure.

Although Auricular Fibrillation usually gives rise to this extreme irregularity of rhtyhm, it is occasionally the cause of attacks of Paroxysonal Tachycardia, a feature well illustrated by Case IV..

<u>Case IV.</u> A.W. age 18.

Was first admitted to Addenbrooke's Hospital in December 1905 with Mitral Stenosis and Incompetence following Chorea.   She was treated with small doses of Tincture of Digitalis and was

discharged in good health in March 1906.

She was again an In-patient during July and August 1907. She gave a history of subacute rheumatism and frequent sore throat.

Her condition then showed signs of heart failure, shortness of breath, cyanosis, cough, and oedema of the legs being noted.

Presystolic and systolic murmurs were evident at the apex and the heart was considerably dilated.

The pulse was regular. The treatment again consisted of small doses of Tincture of Digitalis which gave relief.

Since then she has been a frequent In-patient, symptoms of heart failure coming on as soon as the Digitalis was stopped.

Her last Notes record:- The Patient is a thin pale, delicate looking girl with a slight malar flush. She suffers from considerable orthopnoea and is liable to severe attacks of palpitation and fainting. The pulse appears regular to the finger but sphymographic tracings detect slight irregularity. The rate varies between 72 and 112 and the pulse is of the Water Hammer type.

There is marked bulging and pulsation over the praecordia. The heart is greatly dilated.

At the apex can be heard a systolic and an early diastolic bruit. At the aortic cartilage well marked systolic and diastolic bruits are apparent.

There is great pulsation in the neck and capillary pulsation can be obtained.

The Jugular veins are prominent and pulsate.

The Patient is liable to attacks of Tachy-
cardia.   These attacks come on suddenly, last a
minute or two and pass off as quickly as they came
on.   During the attack the pulse develops a
regular rate of about 200 per minute.

During the attack the Patient complains of
a thumping sensation in the chest and gasps for
breath.

The electro cardiograms show some variation
in the strength of the ventricular complexes (lead
III.).

There is some Hypertrophy of the Right
Ventricle as shown by the increased height of R. in
lead III.   Reversal of T. indicates some Myocardial
change.

The R. wave in lead I. is bifid, probably
indicating some myocardial change.
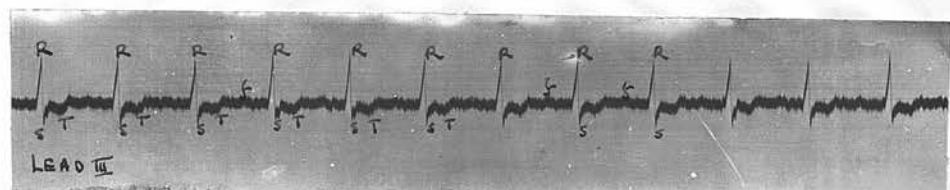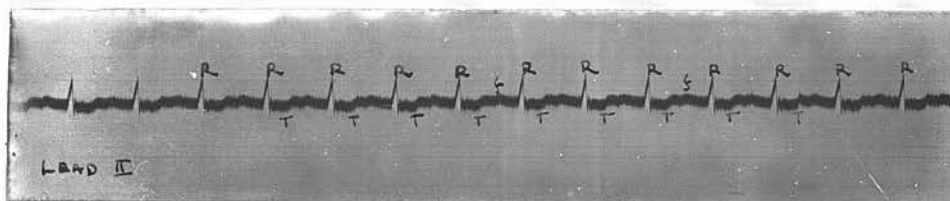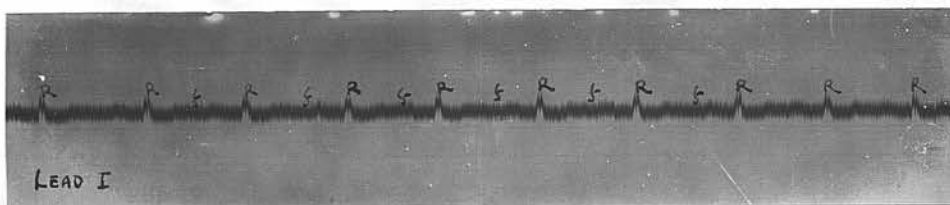
Treatment by Digitalis in this patient acted miracu-
lously.

I found that the Digitalin Granules of
Nativelle gave the best results.

The pulse was slowed, the symptoms were relieved
and absolute freedom from the distressing attacks
of Tachycardia was attained.

After her discharge, she successfully treated
herself with the granules, but succumbed eventually
to a sharp attack of Lobar Pneumonia.

These cases have this in common, they all
react well to Digitalis.

It is in cases of Auricular Fibrillation,
especially those occurring after Rheumatism or Chorea
in comparatively young persons, that digitalis
produces the best results.   In those cases occurring
in elderly patients with Cardio Sclerosis, the results
are more uncertain.

Its action is twofold, partly on the auriculo
ventricular bundle and partly on the vagus.

The result is that a certain degree of Heart
Block is produced which blocks the passage of many
of the irregular stimuli to the ventricle and allows
the latter to regulate its pace.

I have follwed the lines of treatment laid
down by Mackenzie and found them highly satisfactory.

He advises that the administration should in

the first instance be pushed until we get evidence
of the physiological action of the drug.   In adults
it is advisable to begin treatment with 15 minims of
the Tincture every 4 hours.   If this should produce
nausea and sickness, the granules of Digitalin may be
used instead.   Each granule is equal to about 15
minims of the tincture (Mackenzie) [14]

These large doses are continued until the pulse
rate is about 70 per minute.   The drug should then
be stopped for a few days and as the rate begins to
increase again, smaller doses will be found to answer.
Price [15] recommends that the dose be reduced until
we find the "optimum" dose.   This is one that usually
keeps the heart rate about 70 per minute, but the best
guide to this is the sensations of the patient.

Patients are readily taught to treat themselves
with the drug and keep themselves in a comparatively
fit condition.

The next case is one occurring in an elderly
woman where digitalis failed to produce relief.

Case V.   J.N. age 69.

Was admitted to Addenbrooke's Hospital on
December 13th. 1911 suffering from Chronic Bronchitis,
Emphysema and Mitral Incompetence.   Her previous
illnesses include Influenza 20 years ago and slight
Rheumatic attacks.

When admitted she had great dyspnoea, cyanosis

frequent cough and had extensive oedema of the legs, back and Ascites.

The urine was scanty and contained albumen.

Her liver was enlarged.   The veins of the neck were engorged and prominent.

The pulse was of slow rate and frequently irregular.

The Heart was dilated with a long systolic murmur at the apex.

The electro cardiograms show only a slight tendency to auricular fibrillation, the oscillations being most marked in lead III.

In all the records, the beats are very small owing to the feeble action of the ventricle, and there is complete absence of P.

Note the long diastolic pause which probably means a certain degree of Heart Block.

There is a tendency to left ventricular hypertrophy as shewn by the downward direction of R.III. The "splintering"of R. in lead III. is believed by some to indicate a myocardial lesion (Barker)[16]

LEAD I

LEAD II

LEAD III
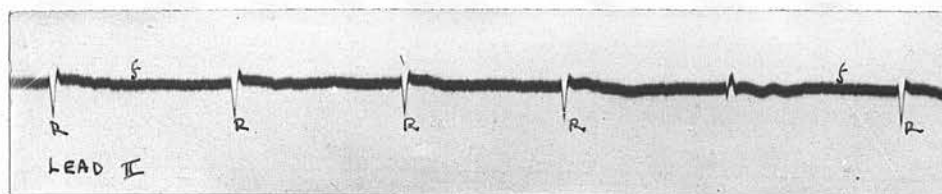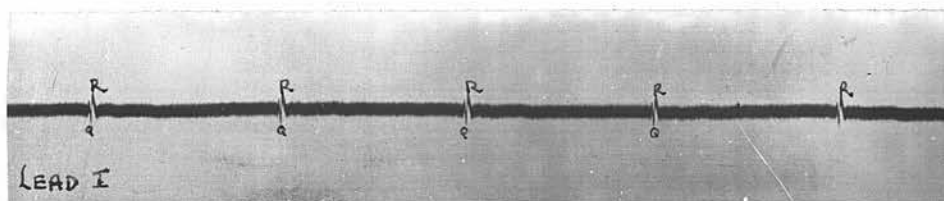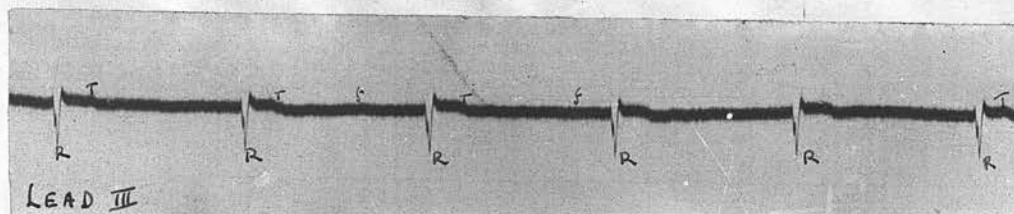
Treatment.   This Patient was treated on the usual
lines with expectorants and digitalis but without
effect.   She pursued a downward course and died
about 6 weeks later.

              Some cases of Auricular Fibrillation are
not always so easy of recognition.

Case VI. is that of an elderly man suffering from
Chronic Bronchitis and Emphysema with Arterio Sclerosis
and a dilated Heart.   There was no valvular disease
apparent.   During the two months he was an In-patient,
the rhythm on the whole was regular.   On one or two
occasions some arrhythmia was noticed.

Case VI.   M.H.   age 71, a labourer.

              Was admitted to Addenbrooke's Hospital
on October 26th. 1911 with Chronic Bronchitis and
Emphysema and Chronic Nephritis.   He was suffering
from extensive oedema of the legs, back, scrotum etc.
There was general anasarca of the body and free fluid
in the peritoneal cavity.

         He gave a history of several slight attacks of
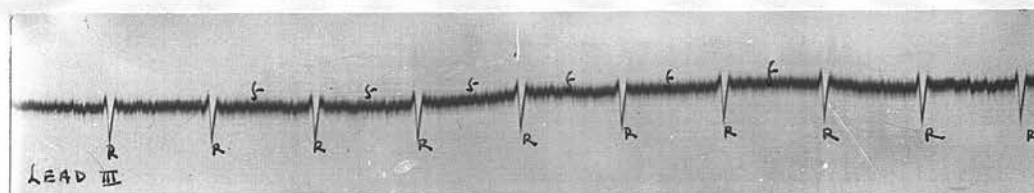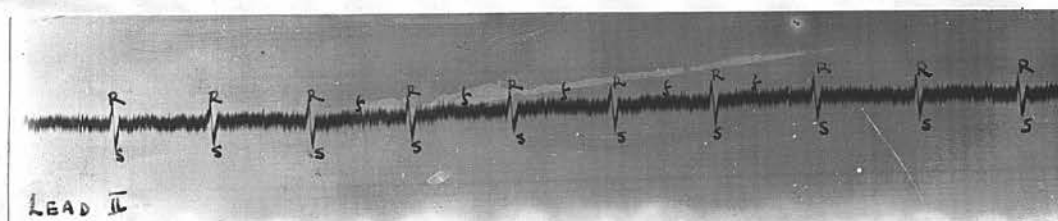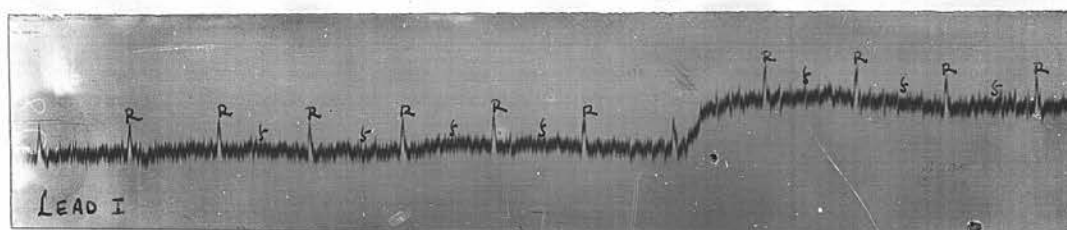Rheumatism.

         His pulse rate averaged 80 and except on one or
two occasions was regular.   The coats were thickened.
The Heart was slightly enlarged and very feeble.

No bruits were audible.

The veins of the neck were distended.   The
urine contained albumen and casts.

I show the electro cardiograms from this case.
They exhibit the usual features and show typical
oscillations but there is no marked irregularity.
T. is not well marked.

Reversal of R. in lead III. indicates Left
Ventricular Hypertrophy.


LEAD I

LEAD II

LEAD III

The following tracings are from a private patient
who exhibited all the features of Auricular fibrilla-
tion.

The Patient was a rheumatic subject with Mitral
Disease and suffered from symptoms of heart failure
with an extremely irregular pulse.

The venous pulse was of the ventricular type and

the electro cardiograms show the usual characteristics.

.This Patient was treated with Tincture of
Digitalis in 15 minim doses twice or three times
daily, but later on he was given Nativelle's Granules
which were more pleasant to him.
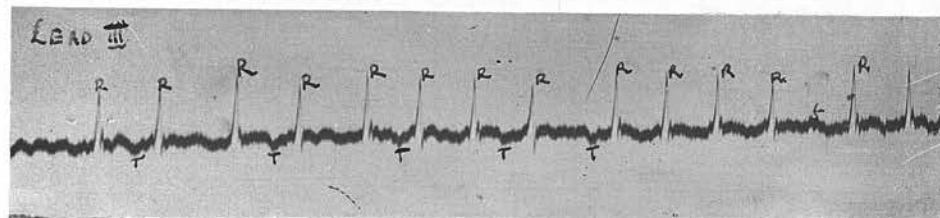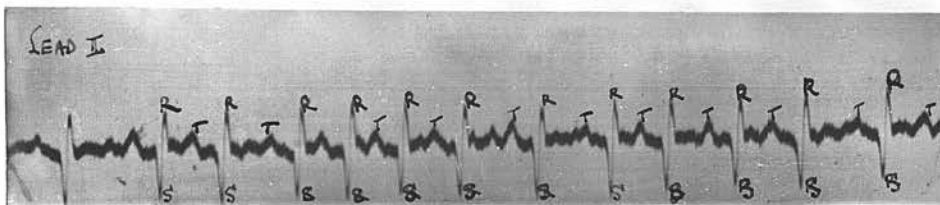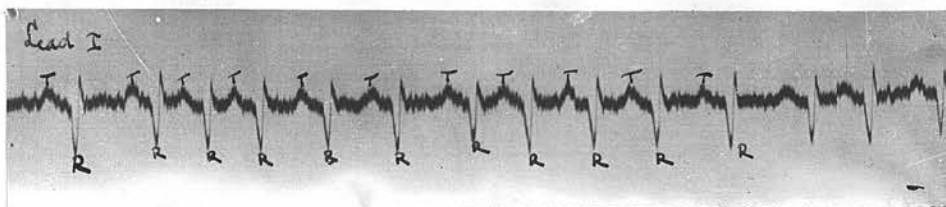
(To be read from right to left)

In forming a prognosis in Auricular Fibrillation,
it must be remembered that the degenerative conditions
producing it are progressive and that the best we can
do is to relieve symptoms.

The prognosis will vary in each case according
to the manner in which the heart reacts to the altered
rhythm.   Some cases show auricular fibrillation
without troublesome symptoms, and have been known to
go on for years.

If the heart dilates greatly and the rate is
rapid, then the prognosis is grave.   If, however,
there is not much dilation and the rate not above 90,
or if over 90 but can be reduced by treatment, then
the prognosis is favourable.

The Patient may go on for an indefinite number of years, sometimes in good health, often chequered by more or less severe attacks of temporary heart failure.

The length of time between the Rheumatic infection and the onset of fibrillation with the intervening history of the patient are important points in forming an opinion.   The manner in which the patients are affected by work and exertion gives an important idea of the reserve power of the heart.

Senile cases are less favourable than cases occurring in younger persons.

Lastly, the reaction to treatment by Digitalis gives valuable information.   Patients by keeping themselves under the influence of the drug can maintain a fair standard of health and can even undertake some light work.

I have attempted to show that the prognosis cannot be definitely stated on one point alone.   It depends on many factors, including the duration of the condition, the extent of the changes, the age of the Patient, the reserve power of the heart and the reaction to treatment.

I have not attempted to give a complete account of the features of Auricular Fibrillation in this paper.   I have endeavoured to demonstrate the commoner features of the disease and especially the steps that lead to its discovery.   I have especially mentioned the characters of the string Galvanometer

and the tracings obtained by it as on account of the
accuracy of the electro cardiograms, this method of
analysing the Cardiac Mechanism is tending rapidly
to supersede all other graphic methods.

S U M M A R Y.

1.   A description of the String Galvanometer.
Invented by Einthoven in 1906, it records the changes
of electric potential which occur in the heart during
its contraction and has been the means of proving the
frequent occurrence of Auricular Fibrillation in the
human heart.

2.   Auricular Fibrillation refers to that condition
of the auricle where the muscle fibres contract inco-
ordinately and normal systole is never accomplished.
It occurs particularly in two groups of cases,

    (a) Associated with old standing
           Rheumatic disease.

    (b) The senile cases with Cardio Sclerosis.
It occurs most commonly with Mitral Stenosis and is
characterised in this disease with the disappearance
of a presystolic bruit.

    The clinical features are those described
previously by Mackenzie under the term "Nodal Rhythm".

    Of all cases examined after death, the only
feature common to all was a fibrosis of the muscle.

3.   The main clinical features are,

    (a) A continuous irregularity of the heart.

    (b) Absence of all signs of normal auricular
           activity.

In some cases it gives rise to attacks of Paroxysonal
Tachycardia.

Sphygmographic Records.

1. Rate usually increased.

2. Complete irregularity with beats of all shapes and sizes.

3. No fixed relation between the strength of a beat and the preceding pause.

Polygraph Records.

1. Absence of the (a) wave due to auricular systole – the ventricular type.

2. Presence during diastole when the heart is slow of rapid undulations of venous pressure.

Electrocardiograph Records.

1. Absence of auricular systolic variation P.

2. Ventricular peaks R. and T. occur but T. is often deformed by the presence of fine oscillations.

3. Occurrence of continuous oscillations generated in the auricle and occurring throughout the tracing.

4. Absence of fixed relationship between the height of peak R. and the length of the preceding heart pause.

Similar records are obtained from animals in which fibrillation of the auricle has been produced experimentally,

4. The prognosis in Auricular Fibrillation depends on a study of several factors in each case.

5. The reaction of these cases to digitalis is sometimes very remarkable. In certain forms, especially those of Rheumatic origin, one can regulate the rate at will by increasing or diminishing the amount of digitalis.

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