The Development of Electrical Diagnosis and Treatment of Reaction of Degeneration.

By M. F. H. HINZ

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WITH the development of modern electronic methods of motor-unit stimulation a much greater range of treatment diagnosis and prognosis is possible.

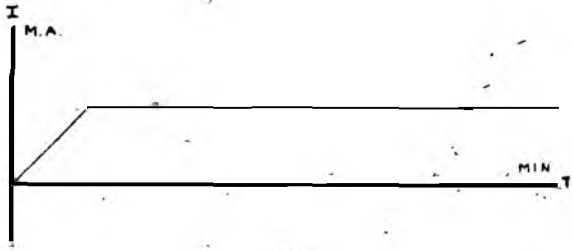
In order to understand these modern methods the physiological factors must be considered. These will be dealt with in greater detail in a further article.

To enable one to appreciate the importance of the newest methods I will first revise and point out the disadvantages of the older methods.

I. OBSOLETE WAVE FORMS FOR ELECTRICAL DIAGNOSIS AND TREATMENT

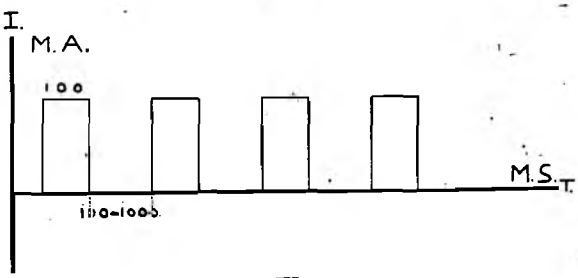
I.

Constant galvanic current for treatment and ionisation. Not for diagnostic or stimulation purposes.



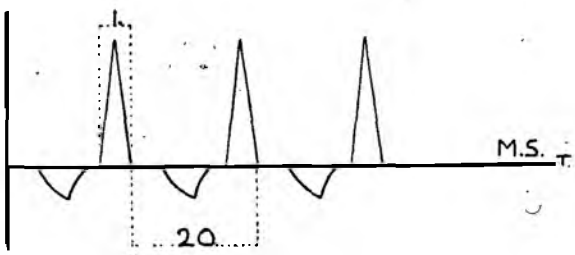
II.

Interrupted galvanic current—manually or mechanically—for stimulation of degenerated motor-units.



III.

Faradic current—irregular alternating and interrupted current—Pulse duration 1 ms. at 50 cycles per sec. For stimulation of normal motor-units.



An interrupted galvanic current causes a contraction of a motor-unit if the intensity of the current is high enough. This current intensity causing a minimal contraction is called the Rheobase or threshold intensity. The Rheobase is the minimal current intensity needed to cause a minimal contraction with a square wave stimulus. The rheobase is lower in normal motor-units showing signs of degeneration. Therefore the current intensity has to be increased in tests or treatment of degenerated motor-units. This is the principle on which the galvanic-faradic test and treatment is based. This method considers only one factor of electrophysiology of nerves and muscles—the rheobase.

The galvanic-faradic test has a purely qualitative diagnostic value not a quantitative or prognostic one.

1. A degenerated motor-unit does not respond to faradism, i.e. it is a qualitative diagnosis and provides no connection to the degree of paralysis.
2. The test has no prognostic value. Frequently voluntary movement has returned before the faradic response.
3. The intensity of the faradic current cannot be measured. The intensity of the galvanic current can be read in milliamps; but the findings are inaccurate and vary from test to test due to:—
   (a) Varying sizes of active and inactive electroes.d The greater the difference in size between these two, the greater will be the density of the current under the active electrode, and the less current will be needed to cause a contraction.
   (b) Varying resistance of the patients' tissues between the two electrodes will give rise to different readings.
   (c) Firmer as opposed to slight contact will give different readings.
   (d) The electrode not covering the motor point accurately—the greater the distance between the motor point and the electrode, the higher the readings.

Before we enlarge on the more modern forms of electrical diagnosis and treatment let us consider the effect of current stimuli of varying pulse duration and interval compared with the effect of the old current forms.

The old current forms are produced mechanically. The direct or galvanic current may be interrupted manually or mechanically. No mechanical interruption can give a duration of a stimulus short enough and a repetition rate *rapid enough to cause a tetanic contraction of a normal* motor-unit suitable for treatment, i.e. 1 ms. or less at a repetition rate of 50 per second . Therefore for treatment of normal motor-units the faradic current was selected. (*See Diagram* 3.).

In modern electrically operated apparatus practically every wave form, impulse duration and rate of repetition may be produced.

Diagram 4. illustrates the current impulses produced by the Ritchie-Sneath Stimulator. The duration of the long stimuli, 10 — 100 ms., would correspond to the interrupted galvanic current. The shorter durations of ·01 — 1 mms. correspond to the faradic range. These short pulse durations set at a repetition rate of 50 per second, i.e. 20 ms. interval will cause a tetanic contraction of a normal motor-unit. Applied to a degenerated motor-unit, the response will cease with the shorter stimuli of ·01, 0·1, or even 1 ms. depending on the degree of degeneration.

It must be realised by now that it is not the nature of the current, alternating current or interrupted direct current, that gives the physiological effect, but it is the duration, form and repetition rate of the impulses. There is no physiological, therapeutic or diagnostic difference between a faradic current of 1 ms. pulse duration at 50 per sec. and unidirectional impulses of 1 ms. pulse duration at 50 per sec. Naturally there will be caustic effects when using unidirectional impulses which are not present with alternating currents. This caustic effect is overcome in many modern apparati by passing a current of opposite polarity through the circuit during the interval between the impulses. The result is the so called de-polarized current. A de-polarized current has little or no caustic effect.

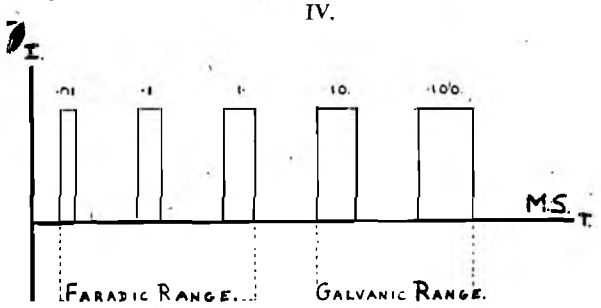
The stimuli or current impulses are normally negative. The reason for it will be discussed in the next article.

II. THE INTRODUCTION OF SQUARE WAVE IMPULSES OF PRESET DURATION

Ritchie-Sneath Stimulator.

The Ritchie-Sneath Stimulator gives square wave impulses from ·01 — 100 ms. duration.

IV.



The duration of the interval or the repetition rate can also be varied.

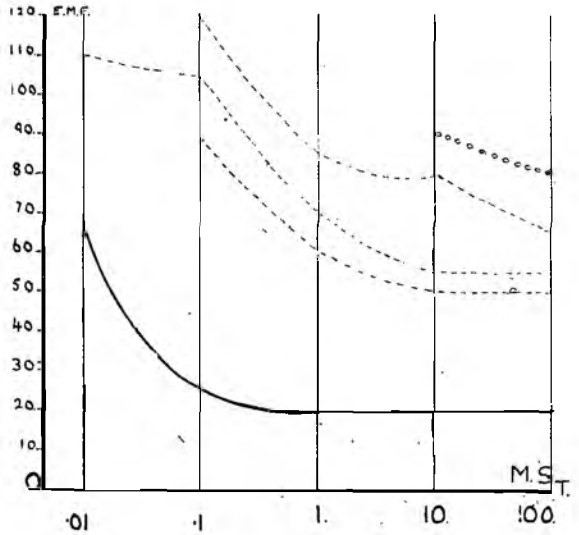
Stimuli in the galvanic range from 1 or 5 per second.

Stimuli in the faradic range from 1, 5 or 50 per second.

This apparatus is suitable for diagnosis—strength—duration method, which considers also one quantitative factor in diagnosis. In diagnosis, voltage is plotted against pulse duration.

Graphs obtained:

V.



——— Normal motor-unit.
– – – – – – – P.R.D. or recovering nerve.
° ° ° ° ° ° ° C.R.D.

A normal motor-unit will respond to stimuli of ·01 ms. pulse duration. The voltage needed will be the same for stimuli of 100 — 1 ms. or even to 0·1 ms. pulse duration. From then on the voltage has to be increased rapidly as seen in the graph.

Irregularities in the curve indicate a P.R.D., or when starting from the C.R.D., a recovery of the motor-unit. Increased E.M.F. will be needed to cause a contraction, and possibly the muscle will not respond to the very short stimuli. See Diagram 5, the curve will lie higher and will end at 0·1 or even 1 ms. pulse duration.

The curve of a muscle with C.R.D. will lie very much higher, i.e. much more voltage is needed to cause a contraction. The denervated muscle will respond only to stimuli in the galvanic range, i.e. from 10 — 100 ms. or only to 100 ms.

Conclusion:

1. In this method we have a positive distinction between normal and degenerated motor-units.
2. It is a reasonably certain method of detecting a P.R.D. which is indicated by irregularities in the curve.
3. *It is also a method of detecting recovery of a* motor-unit before a voluntary movement returns. The re-innervation is indicated—as said in 2—by irregularities in the curve. If the tests are carried out carefully the electrical recovery should be visible approximately 4 weeks before the first signs of recovery of voluntary movement.

This method of electrical diagnosis is definitely a step forward compared with the galvanic-faradic method.

The advantages are:

Avoidance of errors, as previously mentioned, which occur often with the galvanic-faradic technique. In the galvanic-faradic method these factors give different readings. In the strength—duration technique they do not matter because the time factor is considered.

It is stated above what the rheobase is, namely the minimal current intensity needed to cause a minimal contraction with a square wave stimulius.

If a square wave stimulus of a current intensity corresponding to the rheobase is applied to a motor-unit it will cause a threshold or minimal contraction. If now the duration of the stimulus is gradually decreased there will finally be a point at which no contraction will occur. The minimal time of current flow which is needed to cause a minimal contraction with a certain stimulus is the "effective time." The effective time is very short—milliseconds—in normal voluntary muscles. It is longer in involuntary muscles. It is stated above that the rheobase becomes higher in degenerated motor-units, correspondingly the effective time is longer in degeneration. The effective time is no absolute factor but depends on the intensity of the stimulus applied. Therefore at first the effective time of a fixed current intensity equal to double the rheobase was selected. The time of current flow needed to cause a minimal contraction with double the rheobase is the Chronaxie of the nerve or muscle. The effective time or the chronaxie is the above mentioned time factor in this method of electrical diagnosis.

In the galvanic-faradic test only the rheobase is considered. In the strength-duration method the current intensity necessary to cause a minimal contraction with a given impulse duration is found. The results are plotted as mentioned above.

There are two different techniques:

(a) Voltage can be plotted against duration of stimulus (Ritchie-Sneath Stimulator).

(b) Current intensity can be plotted against duration of stimulus (Pantostat 523—square-wave stimuli).

It makes no difference whether voltage or current intensity is used.

The curve is nearly a hyperbola in a normal motor-unit.

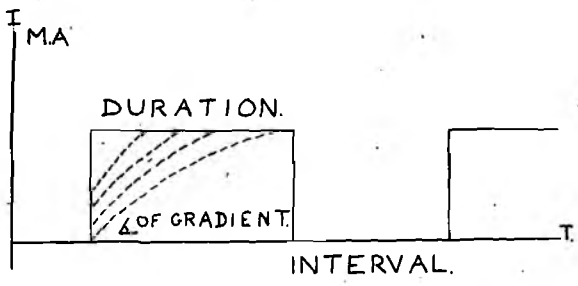
It is not quite a hyperbola because its ends are parallel to the co-ordinates (See Diagram 5). It means that stimuli shorter than a certain pulse duration will not cause a contraction however high the current intensity, and stimuli of lower current intensity than the rheobase do not cause a contraction however long the duration.

Treatment with the Ritchie-Sneath Stimulator is carried out according to the findings of the test. It can be given either by single impulses of set duration or by a series of impulses of set duration and interval.

There is one disadvantage in this method of diagnosis and treatment. This apparatus gives only square wave impulses. A normal motor-unit will respond readily to such a stimulus. A degenerated motor-unit will not respond so easily. The reasons for this fact will be discussed later on. Very high current intensities are needed to cause a contraction of a completely degenerated muscle—up to 60—80 mA. Therefore neighbouring or antagonistic normal muscles will often contract before the degenerated muscle.

III. THE INTRODUCTION OF VARIABLE TRIANGULAR CURRENT IMPULSES

The next progression in electrical diagnosis and treatment is the introduction of triangular current impulses of variable current intensity, pulse duration, angle or velocity of rise of current and interval duration.



The Siemens Pantostat 523 produces :

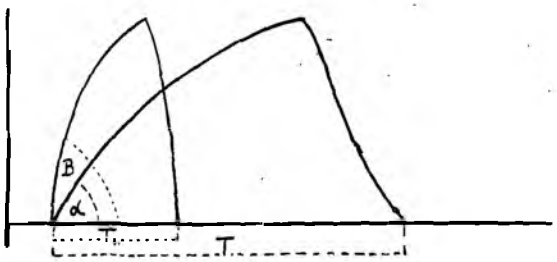
(a) Square wave impulses from 0·1—1,000 ms. duration in a continuous range.

(b) Triangular impulses from 0·1—1,000 ms. duration in a continuous range.

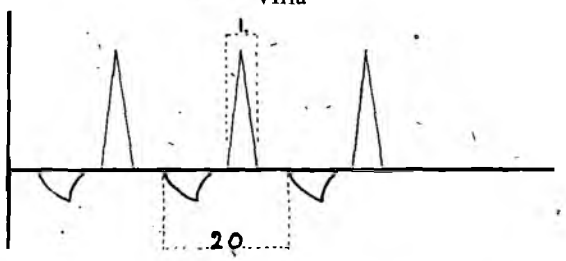
With a longer duration of a triangular impulse naturally there will be a slower rise of current, i.e. the angle of the rise of current is smaller, since the wave form of these impulses is set as follows:

VII

In the longer duration T α is smaller or the current rise is slower than in the shorter duration $T_1\beta$ being greater or the current rise quicker.



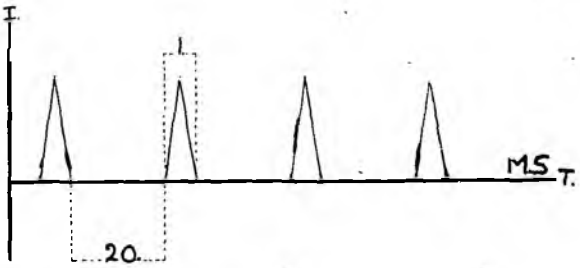
VIIIa



VIIIb

Control R/T on 1./20.
Control T on 0.
Switch d on △ (Triangular).

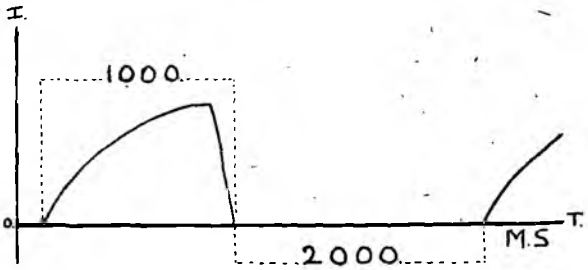
shows a triangular impulse of 1 ms. pulse duration and 20 ms. interval, i.e. ± 50 impulses per second. It is the current form nearest to the old faradic current and will cause a tetanic contraction in a normal motor-unit.



IX

Control R/T on 50/2,000.
Control t on 20.

shows a slowly rising triangular impulse of 1 second, interval set at intervals of 2 seconds.



The Advantages of this New Triangular Wave Form.

The main factor of this new impulse form is the variable rise in time of the current. We have so far considered only two factors, the rheobase and the effective time. An impulse of high enough current intensity and long enough duration applied suddenly, i.e. the curent rises to maximum without time delay, will cause a contraction of a normal motor-unit. An impulse of the same intensity and duration but rising slowly to maximum will not cause a contraction of a normal motor-unit. It is a well known fact used when increasing intensity in constant current treatments, to avoid the so-called electric shock, i.e. an unpleasant sensory and even motor nerve stimulation. A current of given intensity and duration (a) rising to maximum without time delay will cause a greater contraction of a normal motor-unit than the same current (b) rising slowly, or in other words: in (a) the angle of rise of current is greater than in (b).

The conclusion is that a normal motor-unit stimulated via the nerve has the property to accommodate itself to a unidirectional current. The underlying physiological basis will be discussed in the next article. This process

is called "Accommodation." The ability of accommodation is called "Accommodability," its sign being alpha α. Only a normal motor-unit can accommodate because this process takes place in the nerve. A partially degenerated motor-unit tends to lose this ability of accommodation. A completely degenerated motor-unit has lost this ability completely.

It means that a muscle with C.R.D. can still contract when stimulated with a slowly rising current impulse, providing its intensity is high enough, whereas the neighbouring or antagonistic normal muscles will not respond so easily because of their ability of accommodation to a slowly rising current. It can be seen that this new impulse form offers a more accurate method of localising stimulation than has been possible previously.

Naturally the effective time when testing or treating a completely degenerated muscle has also to be considered. The duration of the stimulus must be long, from a minimum of 50 ms. up to 500 ms. or more.

There are 5 factors that can be set and reproduced exactly at any time in diagnosis or treatment with the Pantostat 523:

1. **Current Intensity:** The milliamperage can be preset exactly, with the patient's circuit excluded. The resistance of the apparatus is kept so high that when the patient is included in the circuit the resistance offered to the current does not give rise to different readings.
2. **The Form of the Stimulus:**
   (a) square wave impulse;
   (b) triangular impulse.
3. **Pulse Duration:** In a range from 0·1 to 1,000 ms.
4. **Interval Duration:** In 3 fixed steps: 20, 500 and 2,000 ms.
5. **Rising Time of the Impulse:** From 0—1,000 ms.

Diagnosis with the Pantostat 523:

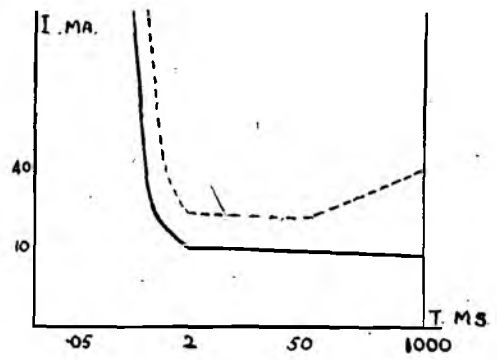
Two curves are taken from every motor-unit to be be tested:

(a) Strength-duration curve, i.e. square wave impulses are used. Intensity is plotted against impulse duration.

(b) Triangular impulse curve. Intensity plotted against impulse duration.

Curves in a normal motor-unit.

X



——— Strength-duration curve.
– – – – – – – Triangular impulse curve.

The strength-duration curve is found as usual and discussed in detail in II.

The triangular impulse curve lies higher, especially in the range of the longer impulse durations. The reason for it is the above mentioned ability of a normal motor-unit to accommodate itself to a unidirectional current, i.e. higher current intensities have to be used when applying a slowly rising impulse as opposed to square wave impulses.

The accommodability α is found by dividing the milliamperage of a triangular impulse by the rheobase of the same pulse duration. It is best to select the values found in the longest pulse duration i.e. 1,000 ms. In Diagram 10 the quotient α is $25/5=5$.

The accommodability α is an important diagnostic and prognostic aid as t changes definitely in degeneration and regeneration.

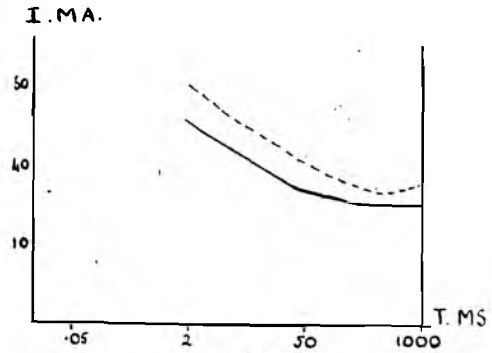
In a normal motor unit α is between 3 and 6.

In C.R.D. α is 1, i.e. accommodability is completely lost.

In P.R.D. α s between 1 and 3, depending on the degree of degeneration.

In regeneration α will rise 2 to 3 months before voluntary movement returns.

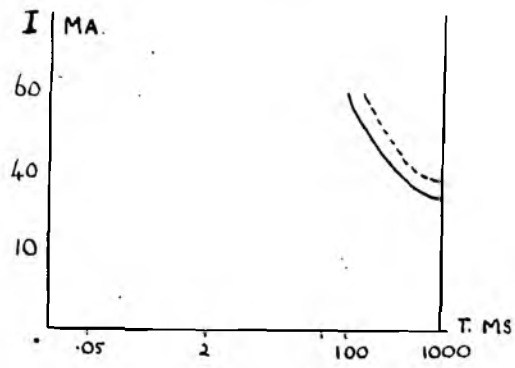
XI.



——— Square wave.
– – – – Triangular impulse.

1. In P.R.D. the strength-duration curve and the triangular impulse curve lie higher, i.e. the rheobase (square wave) and the threshold intensity (triangular impulse) are higher than normal.
2. Both curves are placed slightly towards the right side. It means that the effective time of this motor-unit is longer.
3. Accommodability α is 1·5, i.e. between 1 and 3 which indicates P.R.D.

XII.



——— Square wave.
– – – – Triangular impulse.

1. In C.R.D. both curves lie very much higher, i.e. rheobase and threshold intensity are considerably raised.
2. Both curves are much more at the right side, i.e. the effective time is long, or in other words, the muscle responds only to the long stimuli from 150 ms. onwards.

3... The accommodability is lost, α is 1.

The result of the electrical test shows a C.R.D.

Treatment is carried out according to the findings of the test.

A normal motor-unit is treated with short impulses—0·1—1 ms. at 20 ms. interval. The result will be a tetanic contraction. The form of the impulse—square wave or triangular impulse—does not matter much in the short ranges. The current is either interrupted by means of a key electrode or surged. The patient should be told to contract with the current.

A partially degenerated motor-unit is treated according to the degree of its degeneration. Diagram 11 shows a partially degenerated motor-unit which has little accommodability α is 1·5. Therefore a triangular impulse must be chosen for treatment. The duration of the impulse must be somewhere between 50 and 500 ms. because the effective time of this motor-unit will be longer than normal. The interval duration of 2,000 ms. should be long enough for a partially degenerated motor-unit.

The advantages of this slowly rising impulse of long duration is that:

1. The stimulus can be localised to a great extent.
2. The patient can try to contract the muscle voluntarily with this slowly rising long impulse.

A muscle showing C.R.D.—Diagram 12—must be treated with triangular impulses of long duration, 150—600 ms. or more. The reasons are: the accommodability is lost, i.e. α is 1, therefore the triangular impulse is chosen. The effective time is very long—curve very much towards the right side. For the muscle shown in Diagram 12, a triangular impulse of $\pm$ 500 ms. should be employed.

If it proves that the duration of the interval of 2,000 ms. is too short, i.e. the muscle shows signs of fatigue after a few contractions, a slowly rising galvanic current of preset rise and preset intensity should be applied. The current is manually interrupted. The duration of the interval can now be chosen, it can be any time. The best interval for a muscle showing C.R.D. would probably be 5 to 10 seconds.

BOOK REVIEW

Preliminary Electricity for the Physiotherapist by BRENDA SAVAGE, M.SC., M.C.S.P. (Teachers' Certificates), 325 pp. 191 Figs. Published by Faber & Faber Ltd., 24, Russell Square, London. Price 21*s.* net.

Miss Brenda Savage has succeeded in writing a book which will be invaluable to the physiotherapy student. What few textbooks there are available on Medical Electricity are now badly in need of revision, and in any case do not seem to have their texts planned as specifically for the physiotherapist as is the text of this book.

There are three excellent preliminary chapters on the Nature of Electricity, Static Electricity and Current Electricity. These form the basis for the division of the book into three sections viz. low frequency currents, high frequency currents and radiations. The elementary physics is described clearly and simply, so as to provide an understanding for the chapters on electromechanics and machine construction. Most obsolete material has been eliminated, though there are one or two inclusions, such as the diathermy couch and diathermy massage, which seem a little out of place in a modern text book. The progressive or triangular wave form is not described, though it seems that this will be a valuable asset in the diagnosis, prognosis and treatment of nerve lesions. The physiological effects and uses of the apparatus are comparatively brief, but comprehensive, bearing in mind that this is a book for the preliminary physiotherapy examination.

Throughout there are ample and clear diagrams, invariably on the same page as the text to which they refer a situation which is greatly appreciated after reading textbooks in which this is not always the case. The whole text is set out clearly and is easy to read, and we must look forward to an equally excellent book by Miss Savage on treatments by electrotherapy.

L.E.D.

GENERAL

The next Postgraduate course will be held at the University of the Witwatersrand Medical School on April 30th, in the evening, and on May 1st. The subject will be "Physiotherapy in Pre- and Post-Natal Care." We hope to include a film on childbirth, a lecture by a gynaecologist, a demonstration of classwork and one of the Neumann-Neurode method of infant exercises.

The timetable has not yet been finalised, but all interested postgraduates are asked to contact Miss Blair at the Medical School, or at the Johannesburg General Hospital.

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The C.E.C. is still trying to obtain a final ruling from The Transvaal Provincial Administration regarding physiotherapists in the operating theatre.

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A memorandum has been sent to the Minister of Health setting out the Society's difficulties, together with a request for an interview with the Minister.

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An apology has been received and accepted from the Board of the S.A. Nursing Association for the publication of an advertisement in the S.A. Nursing Journal in November for the Lindstrom College of Swedish Massage.

CHANGE OF ADDRESS

Mrs. S. Patz has moved to 33a, Viljoen Street, Middelburg, Transvaal.

Miss A. I. Burr has changed her address to 182, 10th Avenue, Highlands North, Johannesburg.

Miss S. Oosthuizen's address is now P.O. Box 6468, Johannesburg.

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BRANCH NEWS

Southern Transvaal

On Monday, January 11th, Dr. Henry Yellowlees gave a most amusing and fascinating lecture entitled "Word and Action." We were delighted to have this opportunity of hearing him before he returned to England. There were approximately seventy people present.

On February 22nd a Symposium on Paraplegia was held at the Johannesburg General Hospital. About eighty people were present at this very interesting and informative meeting, at which the speakers were Dr. H. Haden, Mr. A. Rothberg and Miss J. Maurice.

Dr. Haden gave an introductory talk on the pathology, different types of paraplegia and aims of treatment; Mr. Rothberg gave an excellent practical demonstration of the treatment, devoting the short time available to him chiefly to the methods of rehabilitation of walking for paraplegics. Miss Maurice talked to us about treatment of the paraplegic by occupational therapy while the patient is in hospital, and the vital question of his resettlement and vocational training after discharge.

It is hoped that in the future a meeting may be held in the W.N.L.A. centre in Johannesburg, where Mr. Rothberg has promised to provide some of his non-European patients, with whom he can give a fuller demonstration and explanation of treatment.