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THE INFLUENCE OF TEMPO ON RHYTHMIC AND TONAL PATTERNS IN THREE SWEDISH DIALECTS*

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Introduction

In The Scandinavian Word Accents (1973a) I proposed a typology for dialectal manifestations of accents. The Swedish part was based on Meyer's data (1937, 1954) and on more recently collected speech materials (1973b). Since the location of the fundamental frequency peaks plays a major role in the typology it is important to explore how it is affected by speech variables such as sentence stress (Bruce 1975) and tempo. Tempo was one of the variables in an EMG investigation dealing with accents (Gårding et al. 1975) and is the main concern of this paper.

My material consists of a number of noun phrases with two accented words. They have been uttered as statements in three kinds of tempo which I have labelled Slow, Normal and Fast. Let me give you one example.

Figure 1a shows average segment durations and fundamental frequency curves for the phrase en manli(g) nunna. The phrase contains two grave accents and means a masculine nun. It has been uttered by a Central Swedish speaker. My other speakers are from the South and from Finland (Figs 1b and 1c). It should be remembered that the Swedish spoken in Sweden is characterized by two accents with different tonal manifestations according to dialect. The Swedish spoken in Finland on the other hand has no accent contrast.

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In this report I shall study changes with a shift of tempo in segment durations (1), fundamental frequency (2) and in the coordination between fundamental frequency and segments (3). On the basis of my results I shall answer the following question: What change is needed in a generative program for rhythm and intonation to go from Normal to Fast and from Normal to Slow (4).

1. Segment durations

A first step in my analysis is to look at the relative changes in the duration of the segments. In Figure 2 the average utterances have been scaled to a common duration of one second. If the speaker had used a uniform stretching and shrinking of the utterance - or part of it - the diagram would have had parallel lines between the corresponding segments. As can be seen in the diagram there are some lines which are not parallel. They indicate deviations from uniformity and I shall now comment on some of them.

One such feature, which is common to all three speakers, is that the rhythm changes somewhat with tempo. In fast speech the last word occupies a larger part of the whole utterance than in slow and normal speech. This effect is strongest for the Central Swedish speaker. It is brought about by a relative shortening of the consonantal segments and the unstressed vowels of the early part of the utterance.

The larger effect of this rhythmical change may be caused by the more complex tonal pattern in the final grave accent of this dialect - two peaks versus one for South Swedish and East Swedish. This complex pattern may demand more time and hence longer segments.

There is a noticeable deviation from uniformity in the last segment for the Central and South Swedish speakers. In their speech the relative duration of the terminal vowel increases with tempo. This means in absolute terms that the duration of

the final vowel is almost constant all through the tempi and therefore has a larger part of the fast-speech utterance. For the East Swedish speaker on the other hand there is a uniform tempo variation in this segment. One possible explanation is that the East Swedish speaker marks statement intonation by giving a gradual fall to the whole contour (Fig. 1c). The Swedish speakers also mark statement intonation by a fall but it is concentrated to the last syllable (Figs. 1a and 1b). It could be argued then that this syllable needs a certain duration to carry the fall.

2. Fundamental frequency

The second step in my analysis is to bring the fundamental frequency curves to a common time scale. There is no need for any change in the fundamental frequency since the pitch range seems to vary very little with tempo (cf. Gårding et al. 1975).

Figure 3 presents the normalized slow and fast-speech utterances superimposed on each other. There is one striking difference between the speakers. The East Swedish curves are almost the same. the others are not.

A reasonable guess is that this difference has to do with the accents which as I have said earlier are lacking in East Swedish. I shall come back to this later.

3. Coordination of segments and fundamental frequency

So far I have regarded segments and fundamental frequency separately. I shall now take the third step in my analysis and talk about their coordination.

For this discussion I shall introduce the term fix point meaning a point on the fundamental frequency curve which retains its relative time position in a segment regardless of tempo (Fig. 4).

It is clear that with a uniform change of segment durations and fundamental frequency curves there will be fix points all the way. This is in fact what happened in my East Swedish material. Here (Fig. 3) you can see that from the stressed syllable (which is marked by an arrow) onwards there is roughly speaking nothing but fix points. The location of the peaks over the stressed syllables in slow speech matches with the corresponding peaks in fast speech, etcetera. But what about the Central and South Swedish curves? They are not uniform but there are fix points in some crucial places. Figures 1a and 1b show that

(1) the peaks of the accented syllables are fix points and that
(2) the peak of the final syllable marking sentence intonation is also relatively fixed.

4. What change is needed in a generative program for rhythm and fundamental frequency when tempo varies?

I shall now try to answer my introductory question.

Let us first briefly consider a basic program that would generate the normal-rate tonal and rhythmic patterns for the East Swedish utterances. Here the fundamental frequency curve can be derived if we have certain information: phrase boundaries, type of sentence - in this case statement - location of stresses and duration of segments. To get fast and slow speech from this we just have to make a uniform change of the segment durations and of the fundamental frequency curves.

For the basic normal-rate patterns of the speakers of Central and South Swedish we need more information. We must know the accents, their shapes and fix points. The tempo as before determines the duration of the segments rather uniformly for South Swedish and the spacing of the accent shapes.

Figure 5 illustrates this situation for the South Swedish

speaker. The accent shapes are here triangles. They represent the fundamental frequency manifestation of a laryngeal manoeuvre, the response to the accent command. The bases of the triangles in the schematic curves are constant which reflects the fact that the corresponding parts of the observed curves are fairly constant. This indicates that the same laryngeal manoeuvre is retained regardless of tempo. The main difference between the three tempi is that the triangles are spaced differently. The points of the triangles however, are fixed to the segments according to certain rules which are different for the two accents. In slow speech the triangles are separated and the spacing appears as a flat uneventful portion in the curve. In fast speech the triangles come closer to each other. The segments that in slow speech are stretched out in the flat portion of the curve have now been pushed up into the sides of the triangles.

This interpretation shows that the change of program for South Swedish when we go from one tempo to another is not much more complicated than for East Swedish. We make an almost uniform change of the segment durations but we keep the accent shapes with the peaks as fix points. Possible blanks and overlaps will then be filled out by interpolation rules. For Central Swedish we can use the same procedure. But here we must also have a rule that accounts for the deviation from uniformity in the rhythmic pattern.

I shall finally add some physiological comments to my analysis which so far has been rather descriptive. Prosody and articulation are performed by different sets of muscles innervated via different pathways of the nervous system. Hence it seems very improbable that centrally governed articulatory and phonatory events can follow each other in detail. Another factor of importance is that the laryngeal mechanism including the cricothyroid muscle is slower than at least some of the articulators.

In the light of these observations we can interpret our fix points as points of nervous coordination between articulation and intonation. It is then very natural that they should remain fairly independent of tempo. The behaviour of the accents in Central and South Swedish can therefore be regarded as a consequence of the greater inertia of the laryngeal mechanism as compared to the articulatory mechanism. The almost tempo independent covariation between fundamental frequency and articulation that we have observed in East Swedish may be due to the rather flat intonation where the peaks over the stressed syllables have no clear bases.

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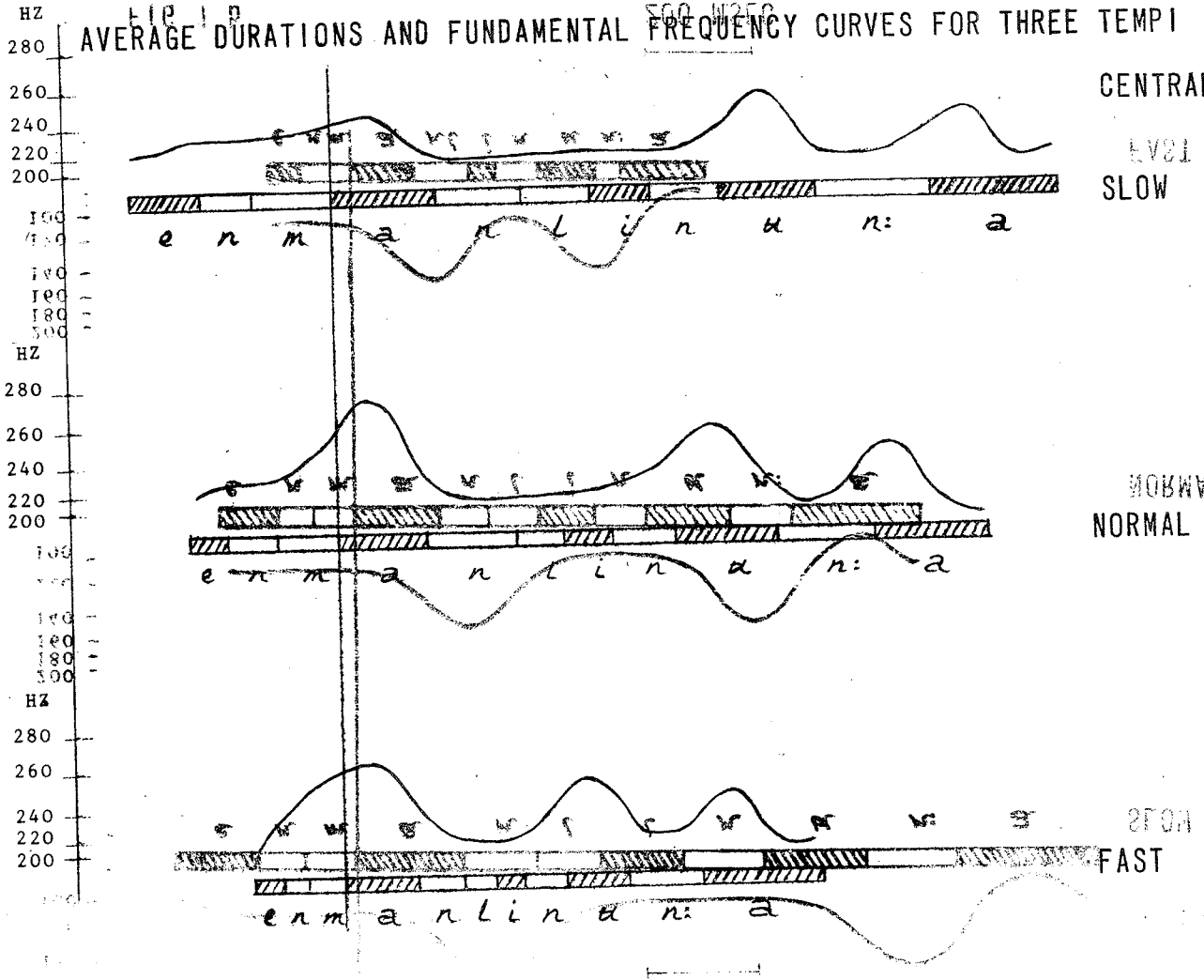

AVERAGE DURATIONS AND FUNDAMENTAL FREQUENCY CURVES FOR THREE TEMPI
CENTRAL SWEDISH
HZ
280
260
240
220
200
SLOW
e n m a n l i n ɑ n: a
HZ
280
260
240
220
200
NORMAL
e n m a n l i n ɑ n: a
HZ
280
260
240
220
200
FAST
e n m a n l i n ɑ n: a
200 MSEC

FIG 1 a

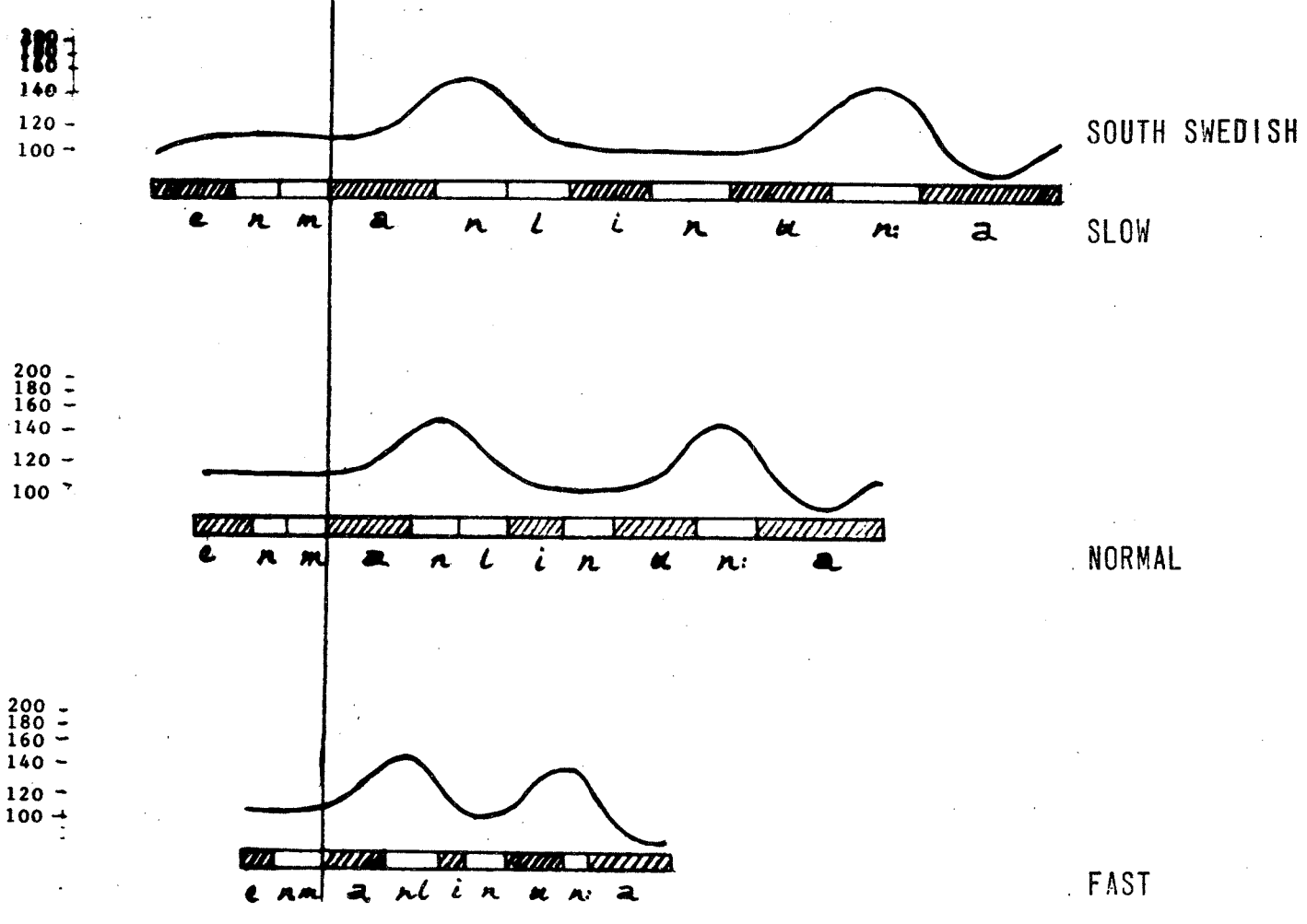

140
120
100
SOUTH SWEDISH
SLOW
200
180
160
140
120
100
NORMAL
200
180
160
140
120
100
FAST
200 MSEC

FIG 1 b

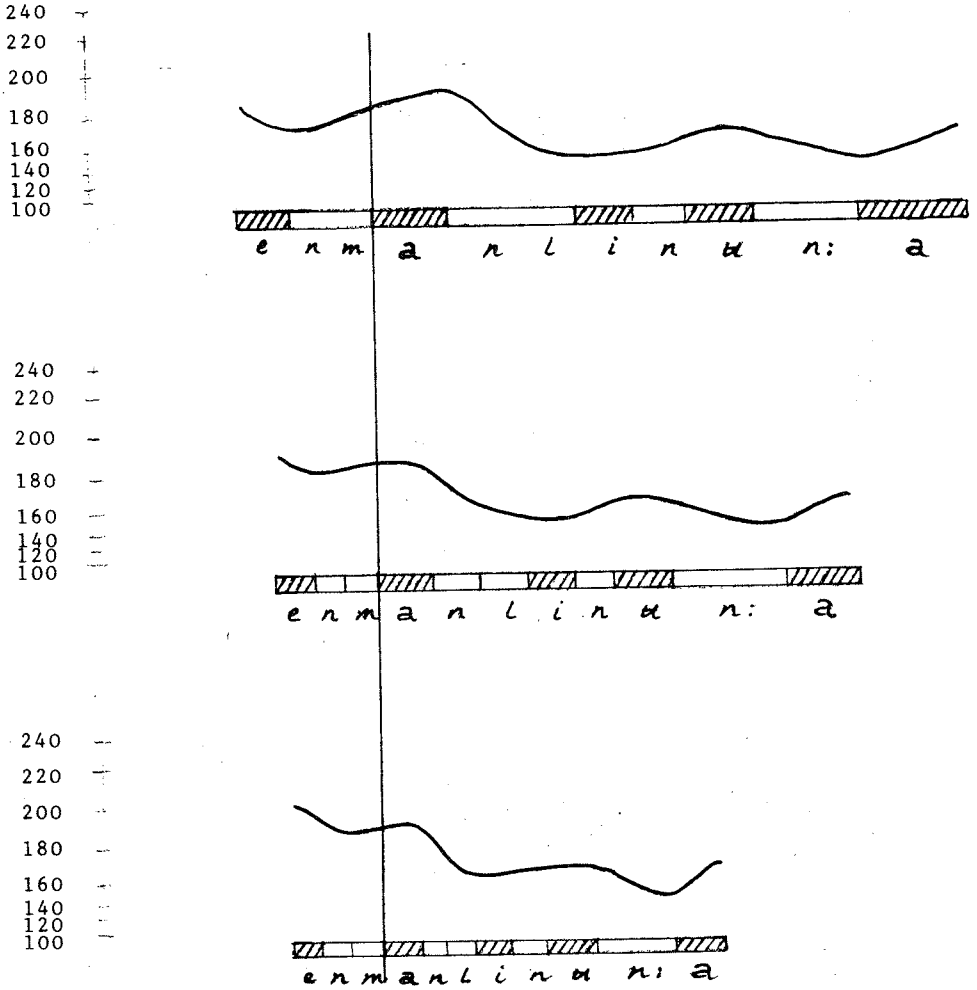

240
220
200
180
160
140
120
100
EAST SWEDISH
SLOW
e n m a n l i n ʉ n: a
NORMAL
FAST
200 MSEC

FIG 1 c

RELATIVE DURATIONS

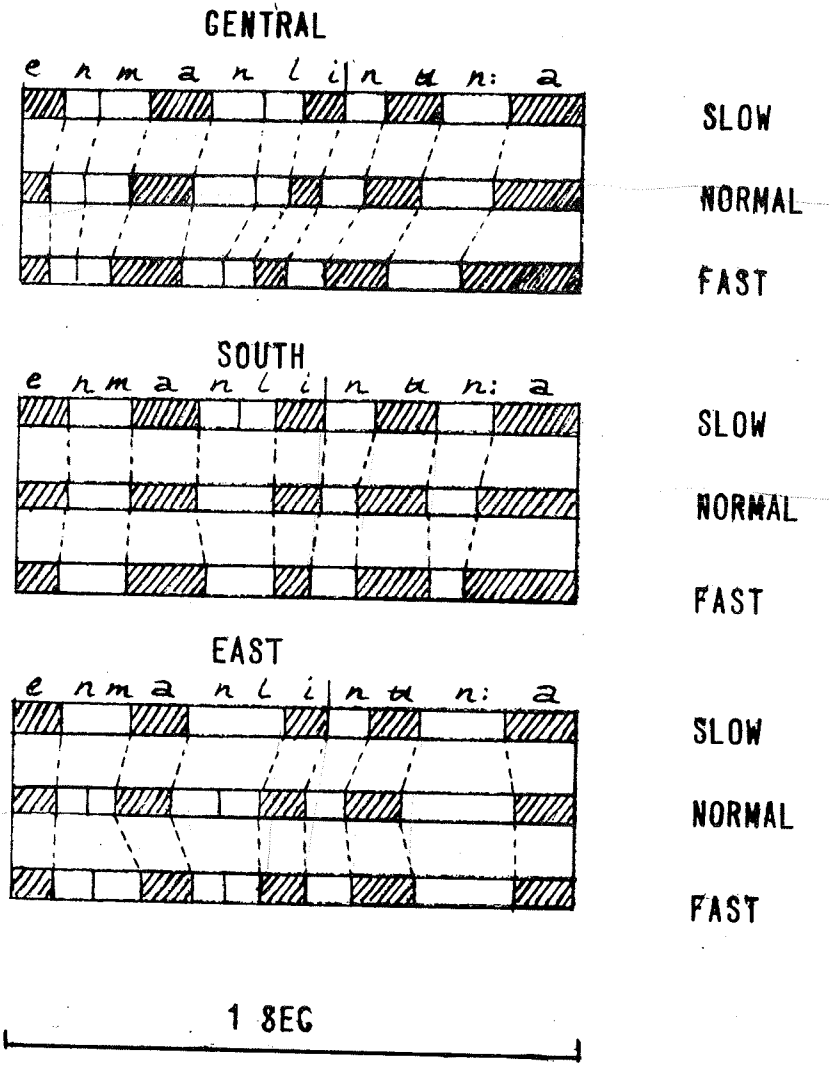


FIG 2

RELATIVE FUNDAMENTAL FREQUENCY CURVES

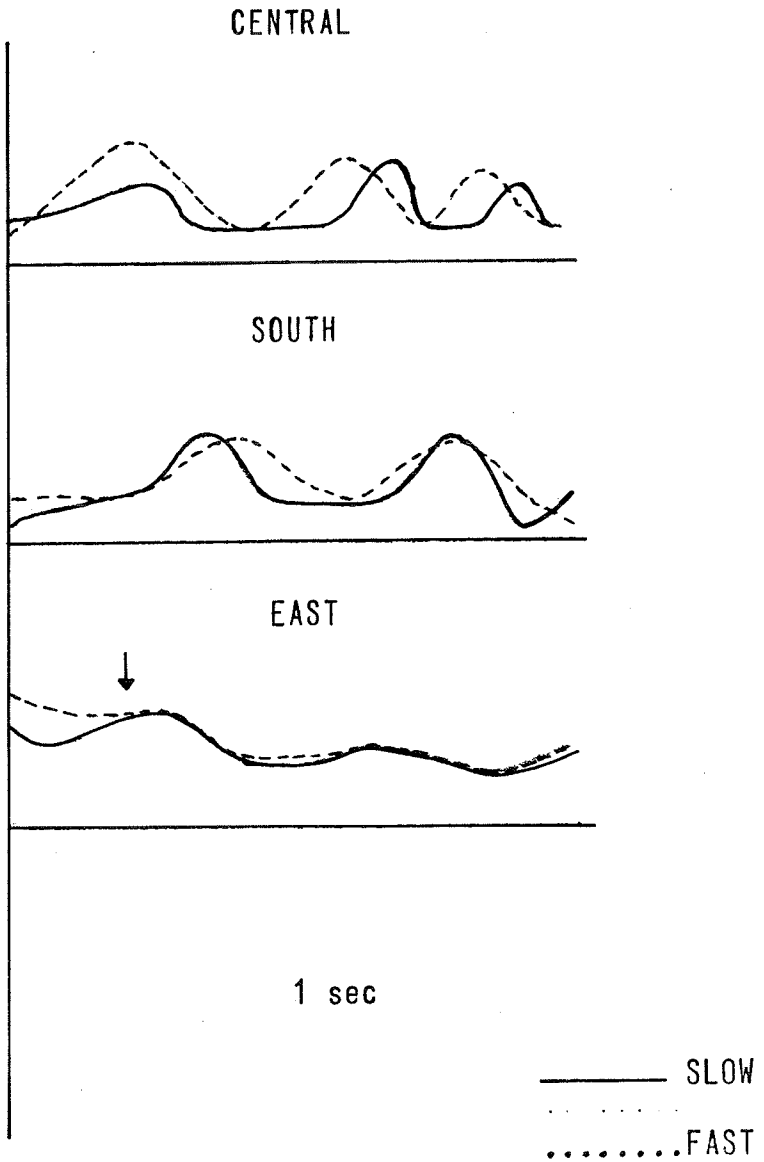


FIG.3

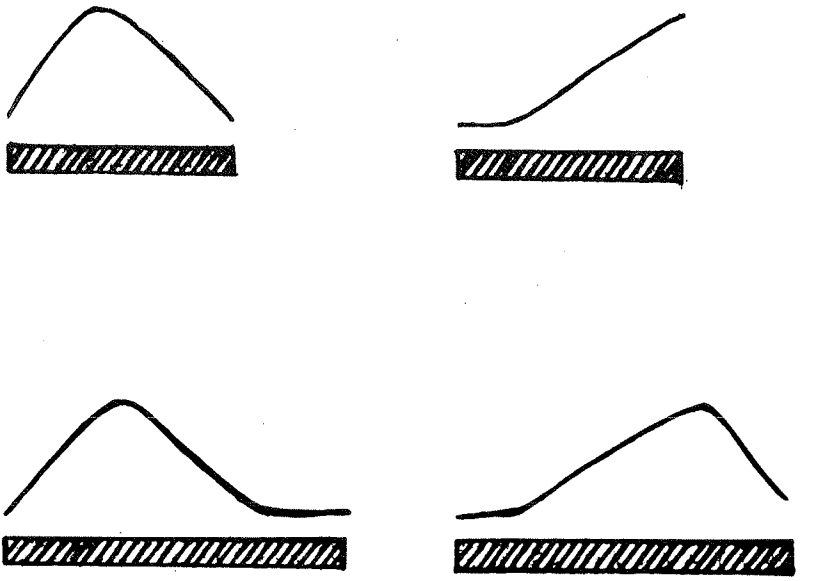


Fig. 4. ILLUSTRATION OF FIX POINTS

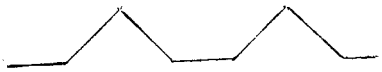
The peaks of the curves to the left are fix points but not the peaks of the curves to the right.

FUNDAMENTAL FREQUENCY VARIATION FOR THREE TEMPI

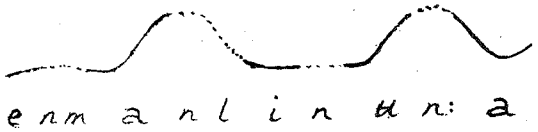
SOUTH

SCHEMATIC

OBSERVED



SLOW



NORMAL

FAST

FIG 5