COLLECTION OF TEMPORAL DATA WITH THE DURATION TABULATOR[1]

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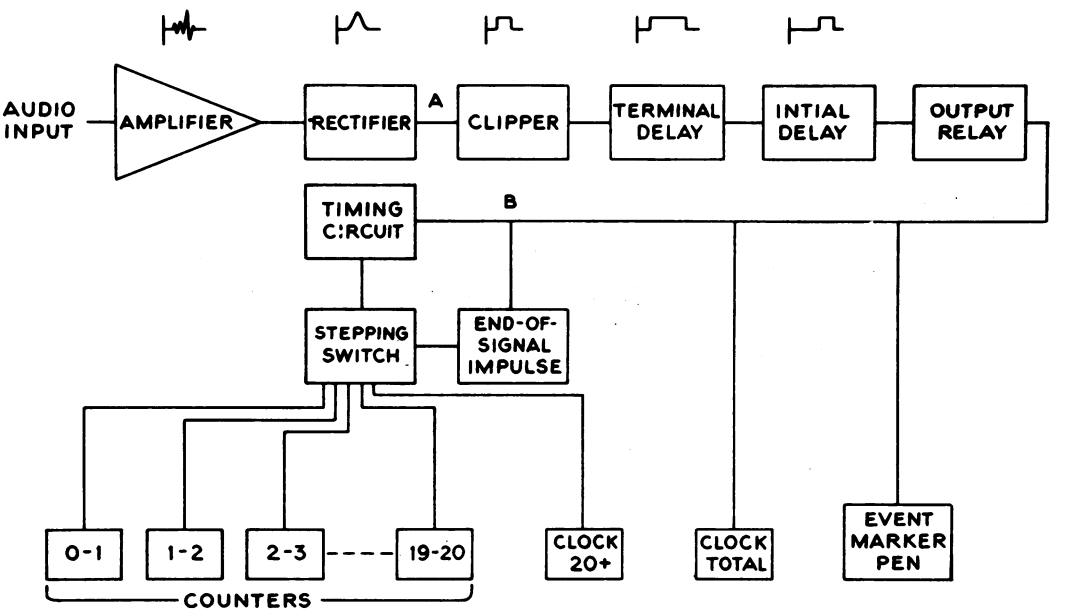
During an investigation of possibly useful measures of the physical dimensions of vocal behavior, we wished to obtain the distribution of the durations of units of speech. In an early paper, Chapple (1940) claimed that stable differences exist between subjects in the characteristics of this distribution. Although a good many studies have since been published which use Chapple's Interaction Chronograph, there has been little description of the distribution of durations. One reason for this is undoubtedly the extensive time usually necessary to obtain the distribution, a fact which is especially well-known to one of us (Hargreaves, 1955).

Verzeano and Finesinger (1949) have described an analyzer which presents the distribution of durations automatically on a series of counters. Their distribution differs, however, from that obtained by other workers. This difference, at least in part, is an artifact due to the use of arbitrary delay in order to define the length of an utterance. Their analyzer was published in block-diagram form, and was a starting point for the apparatus to be described here.

APPARATUS

Our apparatus, the Duration Tabulator, is arranged to operate automatically from the recording of a single voice, but may be keyed by hand where two or more voices are superimposed in a recording and only one is to be analyzed. We here present a block diagram of



Block diagram of duration tabulator

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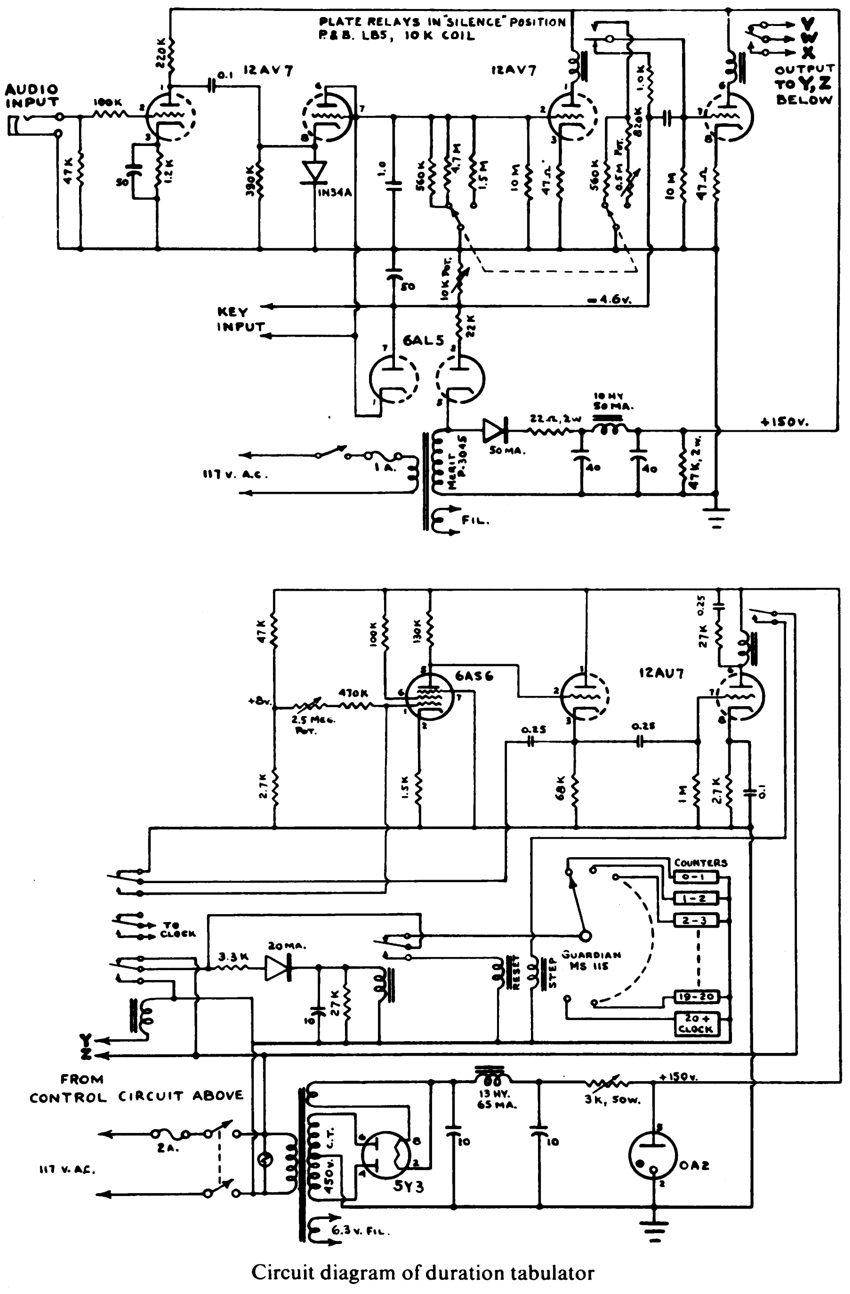

Circuit diagram of duration tabulator

the Duration Tabulator, as well as a complete circuit diagram. The first six units in the block diagram may be considered as a voice key and as a circuit which defines a single utterance and which closes a switch at point B for each speech duration.

The circuit beyond point B may be used to obtain the frequency distribution of any phenomenon whose successive values can be transformed into temporal durations. Thus, it could be keyed by an operant response in order to obtain the distribution of interresponse times, and part of the circuit is in fact quite similar to apparatus designed for this purpose. An example of another possible use of the Duration Tabulator conceivably could be to obtain the distribution of heart-rate variability during an experimental procedure, since heart rate is commonly measured in psychophysiological research as the duration between successive beats. Such a use, of course, would entail a shorter class interval than that of 1 second which we use for speech.

In the present use, a timing circuit provides a stable repetitive impulse at 1-second intervals. The impulse begins to operate a stepping switch at the beginning of an incoming signal at point B. The switch connects in turn to a series of 20 counters, one after another; and at the end of the incoming signal, an impulse goes to the appropriate counter. Each of the 20 counters corresponds to an equal interval unit in duration, and durations longer than 20 units are fed to a clock. For automatic voice-key operation, a signal device is useful for such long durations so that times shown on this clock may be recorded as they occur. The total operation time is also accumulated on a second clock. Analysis of hesitation pauses rather than speech durations can be accomplished by a reversal of the signal at point B, a point which appears in the circuit diagram as inputs y and z. Referring to the circuit diagram, in order to tabulate speech durations, one would connect outputs w and x to y and z; and, in order to tabulate pause durations, one would connect outputs v and w to y and z.

RELIABILITY TESTS

In order to assess the reliability of data produced by the Duration Tabulator, repetitive analyses were made from the same recorded material. We desired to reduce the judgment difficulty of a listener as much as possible, and so selected a clear recording of a single male voice delivering a lecture. A listener attempted to judge the presence or absence of vocal activity by pressing a key connected to the apparatus when the subject spoke. This is similar to the timing activity required of an interaction-chronograph observer, except that our listener worked from auditory cues alone. The disappointing result of this repeated analysis may be seen in Fig. 1, where the solid and dashed lines are first and second attempts, respectively. Such data obviously are not reliable enough to be useful.

A remedy which has often been used for such a lack of reliability in judgments is to train the judge in many practice sessions so that his performance becomes more predictable. Not only does this involve an investment in listener training, but judges' responses may become stereotyped in undesirable ways. We chose to take a different approach and tried to remove some of the judge's difficulty. One difficulty lay in the lack of auditory cues to indicate that the subject was about to continue speaking or that he was about to stop. The verbal content is not of much help, since vocal behavior is not made of neat grammatical units. Speakers do not always complete a thought without pause; or, if they do, they may begin another one immediately. In the first case, the listener may hold the key too long, with a feeling that the speaker will begin again; and, in a second case, he may make the opposite error by starting to time a new utterance when, in fact, the speaker has continued talking. The judge's major difficulty seemed to lie in this need to define the utterance unit, and was not simply a matter of reaction time.

The task of making this judgment was removed from the judge by an additional timing circuit. The circuit defines an utterance as ending when the speaker pauses as long as some arbitrary length of time. The judge could then respond as fast as possible to starts and stops of the speaker, and the apparatus would begin to time a new utterance only if the judge's

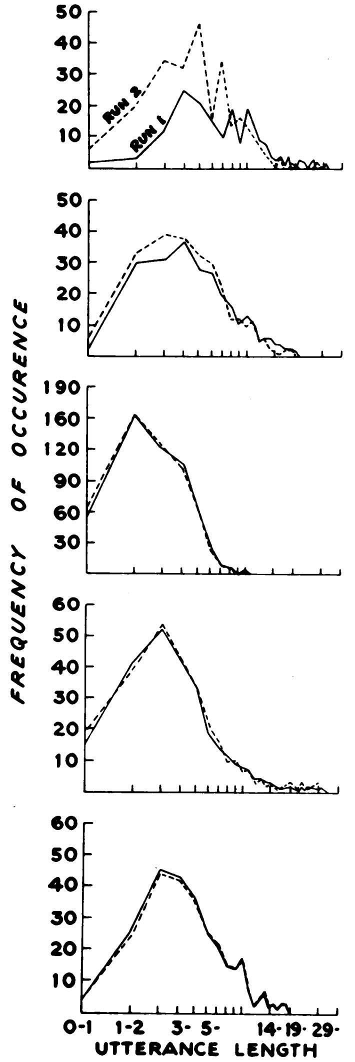

FIGURE 1
HAND KEY DIRECT TO COUNTERS
$X^2 = 237.3$, 15 df
$P < .01$

FIGURE 2
HAND KEY WITH 0.5 SEC. CRITERION PAUSE
$X^2 = 11.841$, 14 df
$P > .50$

FIGURE 3
AUTO. VOICE KEY 0.5 SEC. CRITERION PAUSE
$X^2 = 1.108$, 8 df
$P > .995$

FIGURE 4
AUTO. VOICE KEY 1.0 SEC. CRITERION PAUSE
$X^2 = 4.202$, 15 df
$P > .995$

FIGURE 5
HAND KEY WITH 1.0 SEC. CRITERION PAUSE
$X^2 = 0.510$, 16 df
$P > .995$

key remained off more than this criterion pause. A pause of 0.5 second had been previously used by Verzeano and Finesinger (1949) as such a criterion.

The circuit designed for our purpose[2] was also built to discriminate on the basis of a 0.5-second pause; but, in addition, it overcame a systematic error in the timing of utterances which was produced by the earlier apparatus. The circuit delays at the end of an utterance for the time necessary to determine if the speaker will continue. If the speaker continues in less than 0.5 second, the pause is ignored and the total is timed as a unit. If the speaker does not continue, the timing stops at the end of the delay. To compensate for this consistent addition to the termination of each utterance measured, an equal delay is introduced at the beginning of each measurement.

[2]We are indebted to R. Vreeland, L. Williams, and the Research and Development Laboratory of the University of California Medical Center for design and construction of portions of this apparatus.

Using the same recorded speaker as in our first reliability attempt, two analyses were made using a defining pause for the beginning of a new utterance of 0.5 second. A listener keyed the defining circuit, trying to react immediately to starts and stops of the speaker, but with no attempt to judge whether he would continue. Figure 2 shows acceptable reliability and indicates that a large source of error has been removed.

The circuit was constructed so that when it was possible to obtain a single clear voice, the apparatus would operate automatically from the recording. We hoped that data produced in this way would prove comparable to hand-keying, so that automatic operation could be used when possible. Figure 3 shows high reliability for data obtained in this completely automatic fashion.

Although automatic voice-key operation results in high reliability, the results are not comparable to human judgment of utterance length, even with the addition of the same criterion pause in the manual judging. The difference may be seen by a glance at the frequency scales of Fig. 2 and 3. Data produced by the automatic voice key appear to be broken into many more short utterances than are perceived by the human listener. Since our basic interest is in the possibility of information which may be perceived and used by a listener, the machine was modified so that it would group utterances in a way similar to the judge's grouping. With the criterion pause lengthened to 1 second, data are produced as in Fig. 4, a result much closer to human judgment. In order to be consistent, we then made a check on manual keying of this same recording using the 1-second criterion pause. The results of two runs under these conditions, which are shown in Fig. 5, seem to be acceptable both for reliability and for comparability with automatic data from the same source.

SUMMARY

An apparatus for the partial analysis of temporal data, called the *Duration Tabulator*, produces a frequency distribution of durations on a series of counters. The device includes automatic triggering from an audio signal and a circuit which discriminates one duration from the next. A block diagram, circuit diagram, and reliability data for use with voice recordings are presented.

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