A simplified wow and flutter indicator

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Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERB); no. ERB-414, 1957-06

ERB-414

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NATIONAL RESEARCH COUNCIL OF CANADA
RADIO AND ELECTRICAL ENGINEERING DIVISION

A SIMPLIFIED WOW AND FLUTTER INDICATOR

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OTTAWA
JUNE 1957

NRC NO. 4409

ABSTRACT

A simple instrument for oscillographic observation of frequency fluctuations in the reproduced output of any type of audio recording system is described. Fluctuations as low as 0.1% can be measured. The instrument indicates the instantaneous rather than the average or rms frequency deviation, with either visual or photographic observation of the oscilloscope. With the addition of a simple phonic wheel generator it is possible to study the variations of speed of a motor during a single revolution.

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- L.G. Cox -

INTRODUCTION

The unwanted fluctuations of pitch which occur in the reproduced output of all types of sound recording systems are commonly known as "wow" or "flutter". The term "wow" is applied to slow variations of pitch which occur at a rate less than about 10 cps, and which are common in disk recording, whereas "flutter" is applied to variations at a rate above 10 cps, such as the 96 cps sprocket-hole flutter in 35-mm sound-on-film records.

For low modulating frequencies, the ear hears a note that sweeps in pitch across the frequency band. For higher frequencies the ear hears a group of notes with unrelated frequencies giving a harsh sound. Wow and flutter are objectionable with any combination of audio frequency and modulation rate, but are most noticeable when high audio frequencies are modulated at a low rate.

A wow meter is essentially an instrument to measure the amount of frequency modulation in the reproduced output when a constant frequency has been recorded. Various commercial wow meters are available, but the instrument to be described has the advantage of simplicity and direct display of the characteristics of the frequency variations.

GENERAL DESCRIPTION

A magnetic drum recorder designed in this laboratory required an integral ratio between input drive shaft and magnetic drum shaft, necessitating a gear drive. The wow meter described in this report (see Plate I) was designed to aid in locating the sources of, and measuring the amounts of wow and flutter caused by non-repetitive gear irregularity, and eccentricity.

Any mechanical process which is repetitive on recording and play-back causes a change in output level due to changed surface speed, but no change in frequency.

The wow meter consists of two basic parts, a sawtooth generator and a pulse generator. The sawtooth generator may be either free-running or synchronized with a precision audio oscillator to provide a vertical deflection voltage for an oscilloscope. The pulse generator is a squaring amplifier driven by the audio output voltage of the recording system play-back amplifier, followed by a differentiating network to provide brightening or blanking pulses for the oscilloscope.

The normal sawtooth horizontal sweep of the oscilloscope is used,

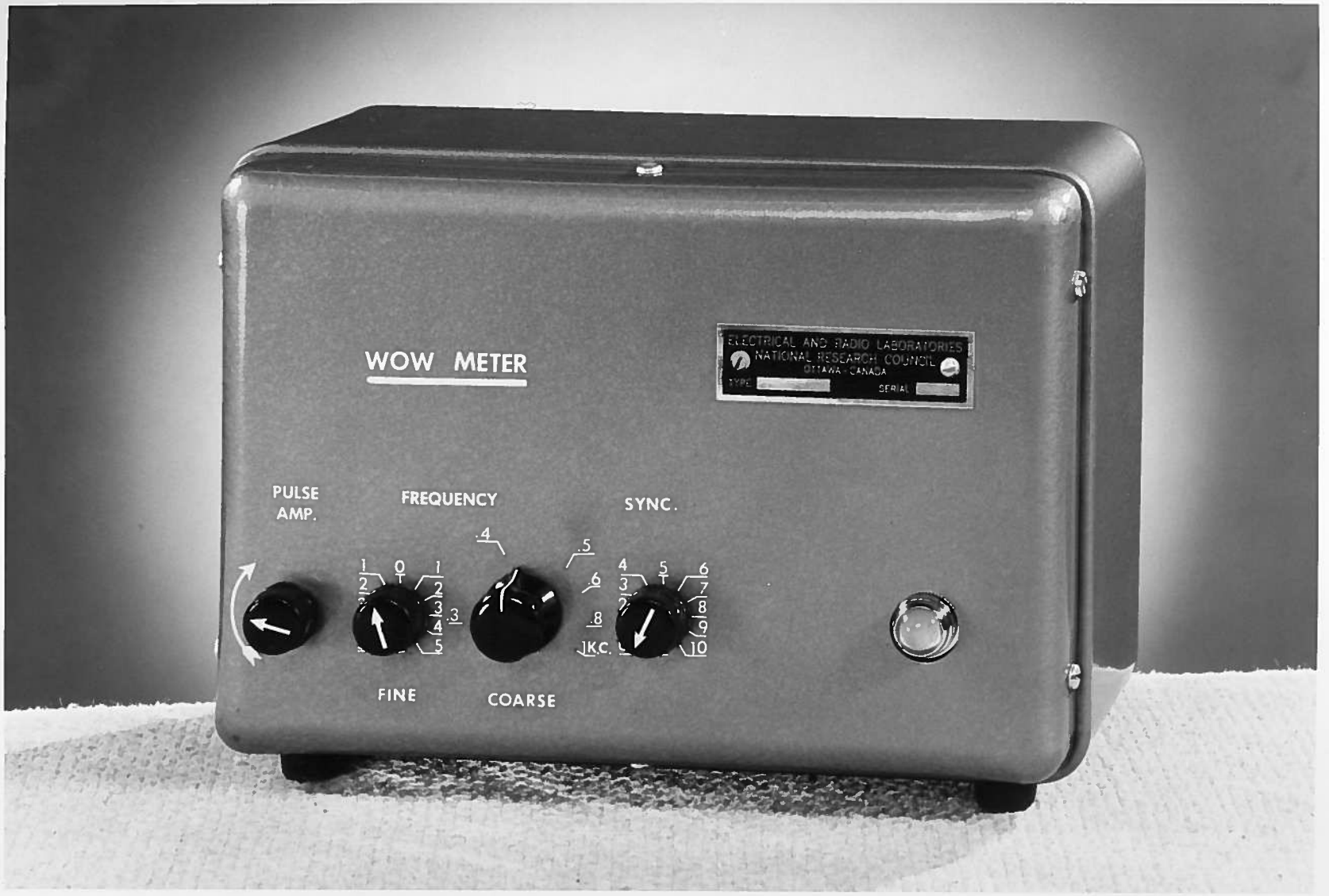


PLATE I SAWTOOTH AND PULSE WAVEFORM GENERATING UNIT FOR WOW AND FLUTTER MEASUREMENT

usually free running at a very low frequency. If the wow meter sawtooth oscillator output and reproduced output waveforms have the same period the oscillogram will be blanked or brightened at the same point on each vertical sweep, and a line joining the blanked or brightened spots will be horizontal. If, however, the periods are different the line will have a slope whose tangent is proportional to the difference in periods. If the slope is such as to give a difference of 1 complete cycle in 100 sawtooth cycles, the wow is 1%.

CIRCUIT DESCRIPTION (see Fig. 1)

The sawtooth generator is a Potter* cathode-coupled multivibrator circuit, with a "boot-strap" cathode follower to provide low output impedance and better linearity. The charging circuit consists of resistors R8A and R9, and capacitor C5. The remainder of the multivibrator circuit is for the purpose of rapidly discharging C5. V1A normally conducts with V1B cut off. As the plate voltage of V1B rises, this rise of voltage is coupled through the cathode follower and C4 to the junction of R8A and R7. Thus the capacitor C5 is charged through a resistance R8A and R9 with a constant potential across the resistors giving a quite linear sweep. R8A controls the charging rate of C4 and R8B controls the multivibrator recurrence frequency, so that the sawtooth amplitude is fairly constant with frequency since R8A and R8B are ganged.

V2B and associated components operate as a squaring amplifier. The grid of V2B is driven from beyond cutoff to grid current point, providing a square wave output to C8. A differentiating network, C8 and R17, provides positive and negative pulses and R17 is adjustable for optimum pulse amplitude (and width). The pulse coupling capacitor C9 is rated at 3 kv to allow direct connection to the cathode-ray tube grid of most oscilloscopes.

Plate II is a photograph of the phonic wheel generator used to study speed variations of a motor during a single revolution. The magnetic circuit consists of a steel frame, laminated iron pole piece, Alnico magnet, and a 24-tooth steel spur gear mounted on a steel shaft. There is about 1/32" clearance between the gear teeth and the pointed end of the pole piece, and a coil removed from a Hammond type-150 filter choke is mounted on the pole piece. The generator is coupled to the shaft of the motor being tested by means of a bellows coupling to allow for some misalignment of the shafts.

The permanent magnet provides a magnetic flux which varies as the gear teeth move past the pole piece, inducing an alternating voltage in the pickup coil. This voltage is amplified by a playback amplifier and then applied to the audio input terminal of the wow meter.

*J.L. Potter, "Sweep Circuit", Proc. IRE 26: 713-19, 1938

COMPONENTS

RESISTORS

R1	220K	½w
R2	47K	½w
R3	25K	VAR.
R4	100K	½w
R5	470Ω	½w
R6	47K	2w
R7	100K	½w
R8	DUAL	0.5M VAR.
R9	100K	½w
R10	100K	½w
R11	25K	VAR.
R12	2.2K	2w
R13	18K	2w
R14	1M	½w
R15	1M	½w
R16	22K	2w
R17	0.25M	VAR.

CAPACITORS

C1	0.1mfd	400v	Paper
C2	0.1mfd	200v	Paper
C3	1800pfd	Mica	
C4	0.25mfd	400v	Paper
C5	0.05mfd	400v	Paper
C6	DUAL 10mfd	450v	Electrolytic
C7	0.01mfd	Discap	
C8	330pfd	Mica	
C9	0.01mfd	3kv	Glassmike
C10	0.1mfd	200v	Paper

TUBES

V1, V2	12AT7
V3	6X4
V4	0A2
V5	0B2

MISCELLANEOUS

I1	PILOT LAMP #47
L1	HAMMOND 152 CHOKE
T1	HAMMOND 270B TRANSFORMER

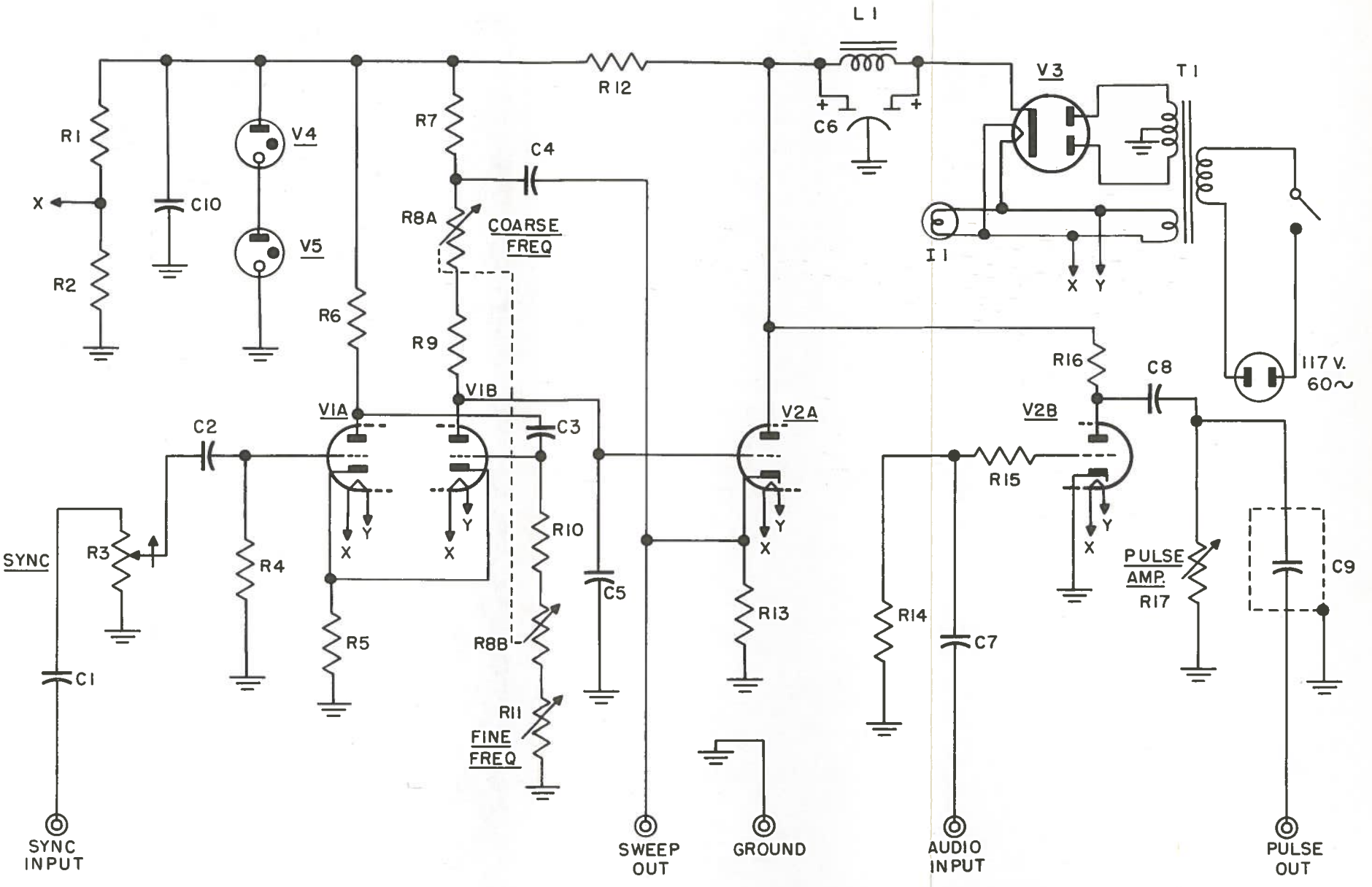


FIG. 1 SCHEMATIC DIAGRAM AND PARTS LIST

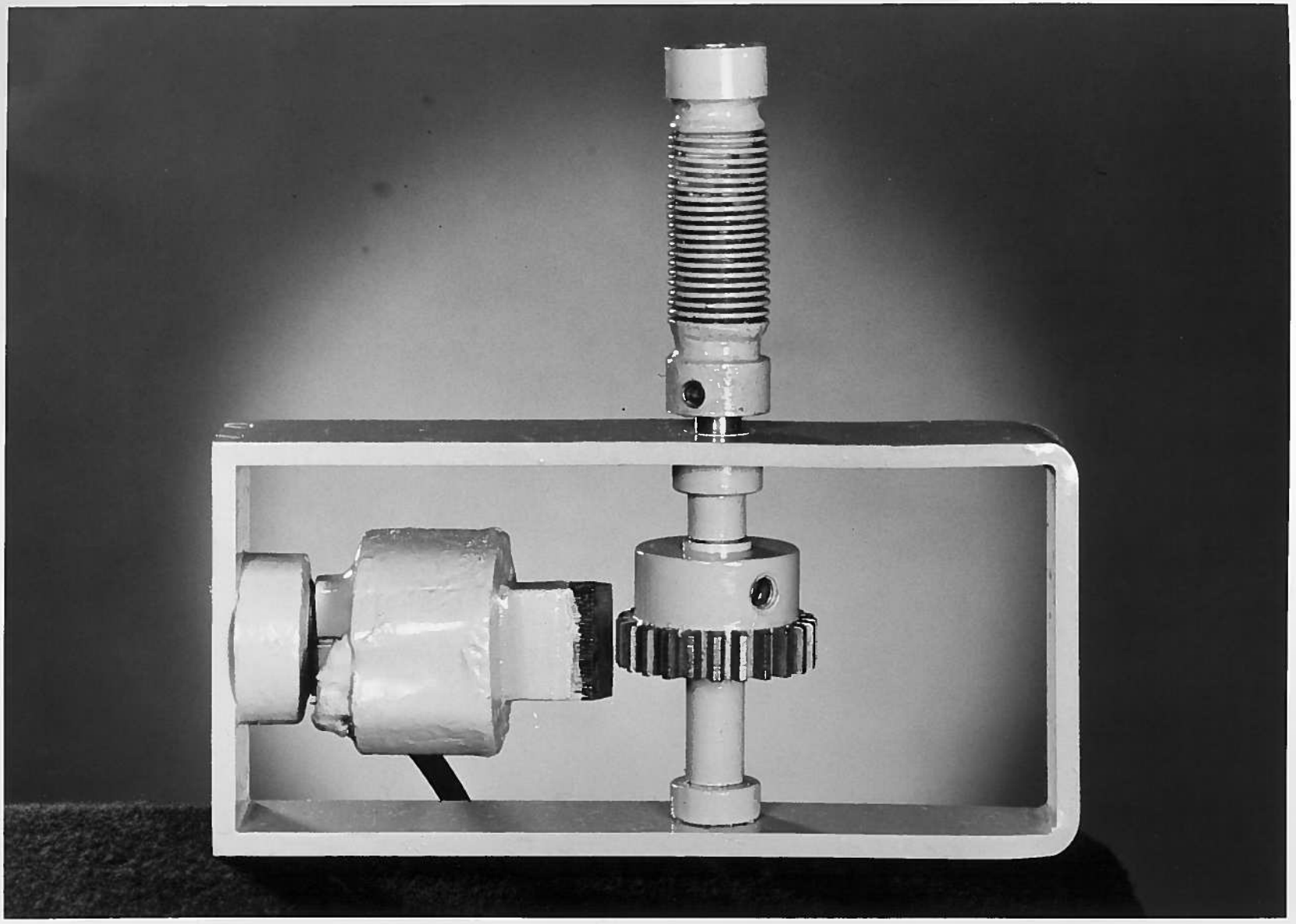


PLATE II PHONIC WHEEL GENERATOR

MISCELLANEOUS

The unit draws about 35 ma at 320 volts d-c and 0.6 amp at 6.3 volts a-c. The power supply is self-contained. The plate supply for the oscillator tube is regulated by means of a type-OA2 tube and a type-OB2 tube in series to give 260 volts d-c.

The free-running frequency is very stable with respect to line voltage, since an increase of heater voltage has the opposite effect to an increase of plate voltage, and the effects almost cancel. A change of line voltage of ± 4 volts about the normal 117-volt line potential will change the oscillator frequency less than 0.05%.

Ease of synchronization is very good. If the free-running frequency is within ± 10% of the synchronizing frequency, a synchronizing input of only 0.01 to 0.05 volts is required, and up to 1.0 volts on the grid of V1A does not affect the sawtooth waveform appreciably.

The fine frequency control allows the free-running frequency to be set exactly. The frequency range in mid-position of the fine frequency control is 275 to 1130 cps, and the fine control allows a variation of ± 5 to ± 95 cps at the extremes of the course control.

There is a slight tendency for the free-running oscillator to be locked by the pulse output, but this is minimized by shielding the output pulse coupling capacitor, C9.

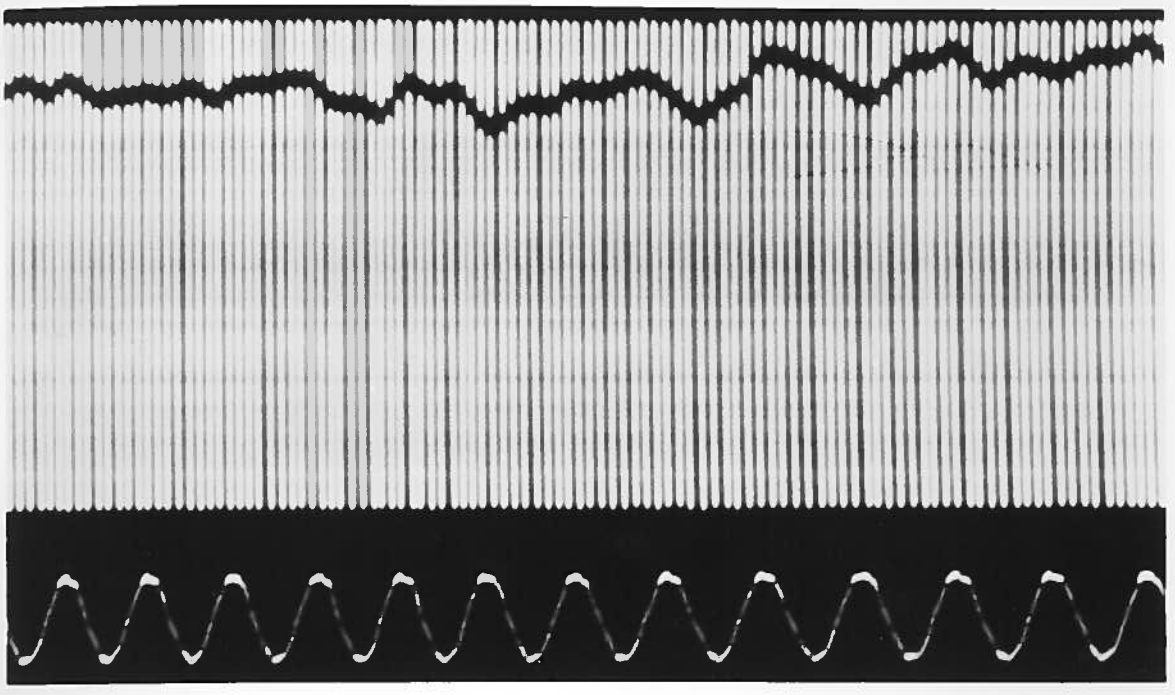
The complete unit, including power supply, was built on a 4"×8"×2" chassis, and enclosed in a Hammond 1402B cabinet. A photograph of the complete unit is shown in Plate I.

WAVEFORMS

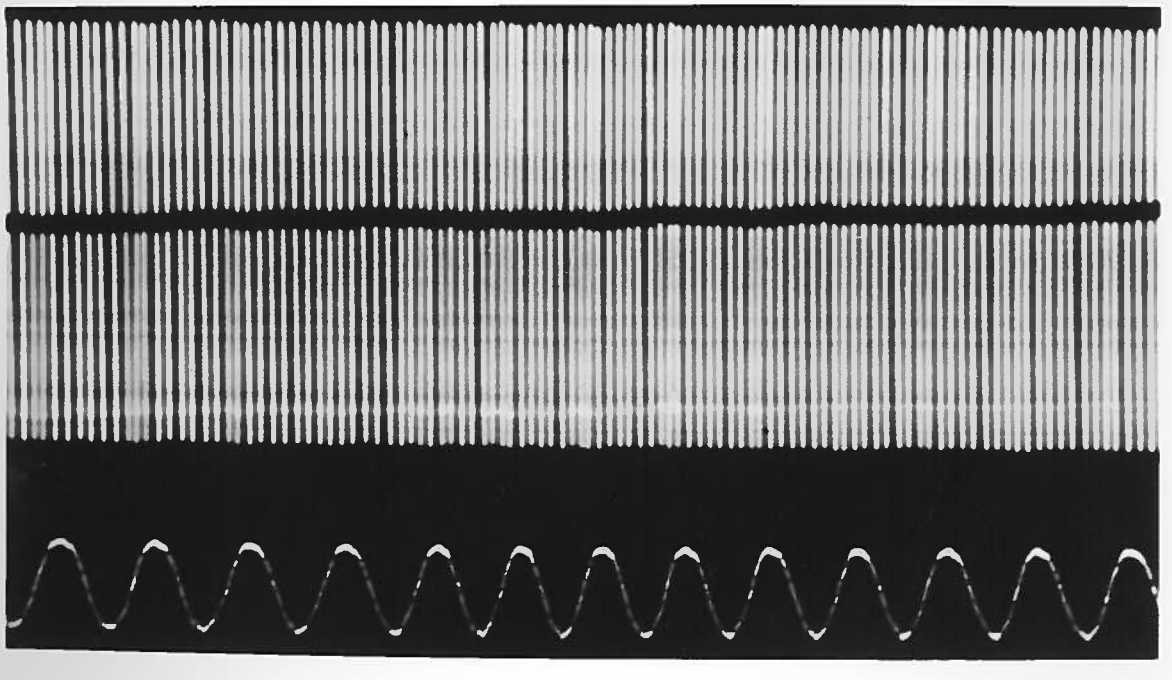
The waveforms shown in Figs. 2 and 3 were photographed with a Cossor Model 1428 camera running with an open shutter at 6"/sec for 500 cps recorded frequency and 12"/sec for 1000 cps. Tri-X film was used with D-19 developer, and medium brilliance with a Cossor Model 1035 oscilloscope. In each case a 60-cps timing waveform was also photographed on the Y2 trace.

Fig. 2 shows the flutter originally obtained in the drum recorder, along with the results after modification.

Fig. 3 shows the wow in two commercial record players with an RCA standard frequency record (#12-5-65). The maximum wow of the rim-drive model is 1%, while that of the center-drive model is only 0.15%. Both photographs were taken at a turntable speed of 78 rpm.

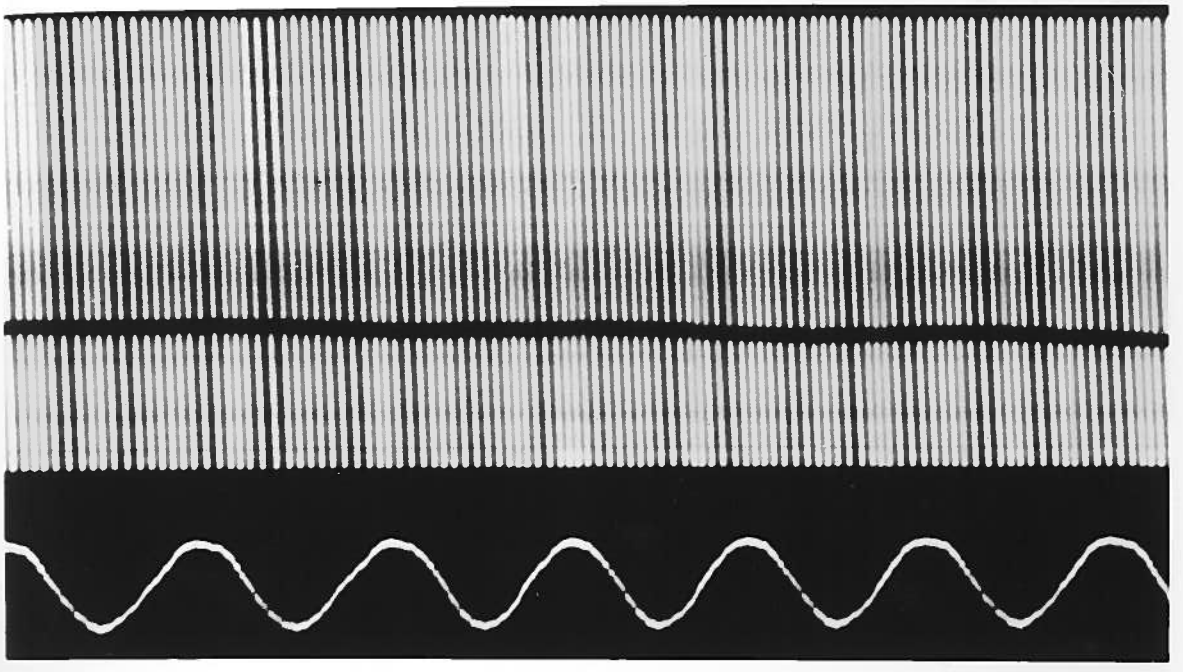


a) PRELIMINARY MODEL OF RECORDER

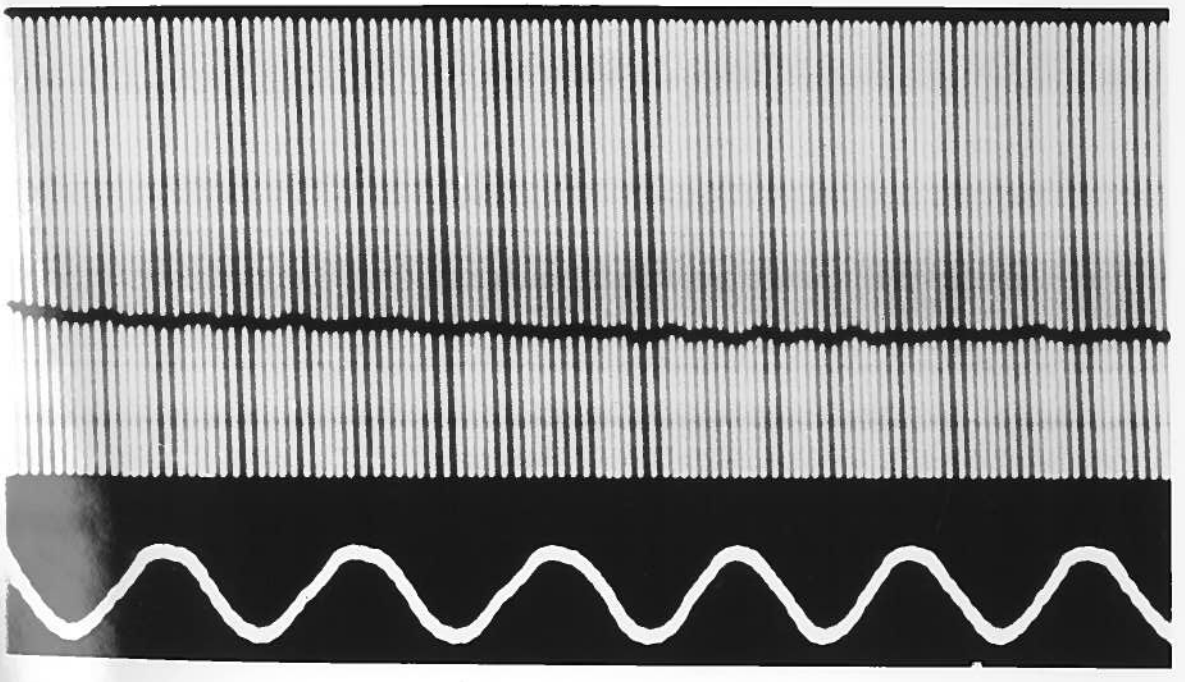


b) FINAL MODEL OF RECORDER

FIG. 2 FLUTTER IN DRUM RECORDER

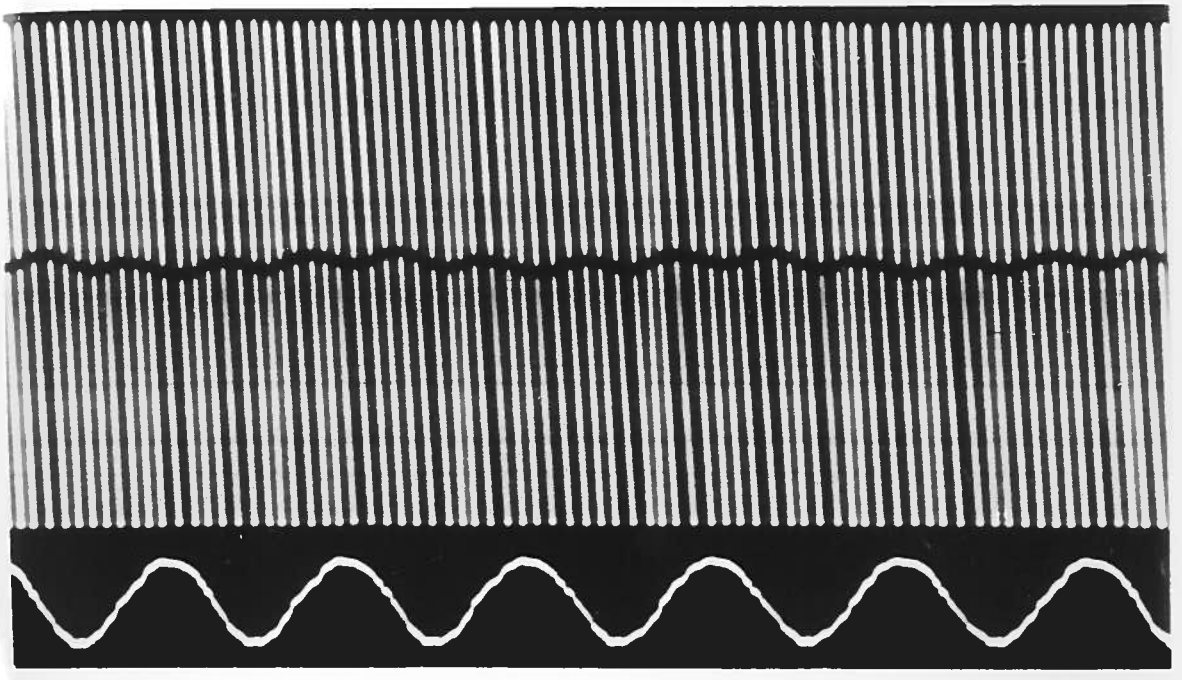


a) CENTER-DRIVE MODEL

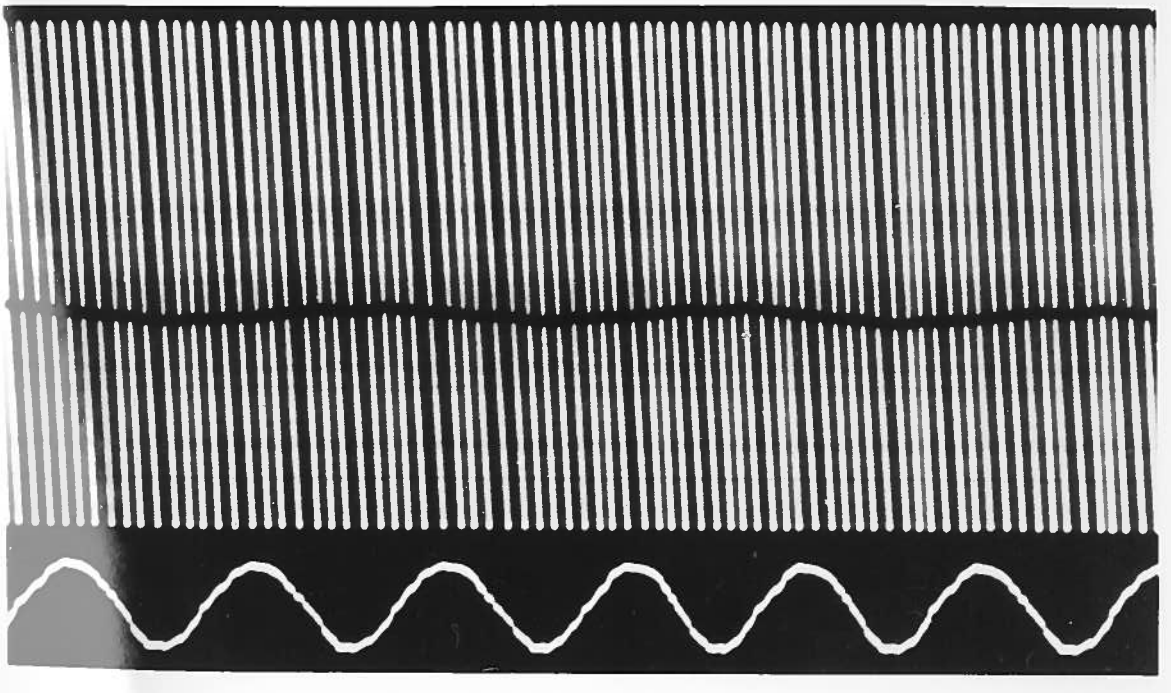


b) RIM-DRIVE MODEL

FIG. 3 WOW IN RECORD PLAYERS



a) SPLIT-PHASE MOTOR



b) HYSTERESIS MOTOR

FIG. 4 SPEED VARIATIONS IN SYNCHRONOUS MOTORS

Fig. 4 shows the photographic record obtained when testing hysteresis and split-phase synchronous motors for variations in speed during revolutions. Both motors were 1800-rpm types, and the split-phase motor showed a speed variation of ± 1%, at a 120-cps rate. This speed variation was almost independent of load, from zero load to above full rated load.

The hysteresis motor appeared to have a 30-cps speed variation of approximately 0.25%, but this frequency change in the phonic wheel generator output was due to slight eccentricity in the gear used. This was proved by rotating the frame of the phonic generator, which varied the phase of the 30-cps ripple with respect to the line frequency. The actual speed variation of the hysteresis motor was much smaller than that of the 30-cps component.

CONCLUSION

Although simple in design and construction, peak wow and flutter of less than 0.1% can be measured at low or high modulation rates.

The unit was very effective in locating sources of flutter and evaluating modifications of the drive system during development of the drum recorder mentioned previously.