# WESTON MODEL 271 METER

## Tracking Accuracy Check Procedure

The Weston Model 271 Meter magnetic circuit is designed to produce a tracking accuracy, or linearity, of 2% or better, but is not user specified. The following test procedure is an adequate check on a model 271 meter's tracking behavior, and indirectly, of its adequacy in terms of sensitivity.

Equipment Needed: A Waukesha Model 501-T Detonation Meter and a stable signal source such as the Waukeshe Model 111605 Detonation Meter Calibrator* or a size D flashlight battery. If the battery is used, a battery holder (e.g., Keystone No. 175) and an Amphenol No. 80 Mc2M cable plug are convenient for connecting to the 501-T, Pier 2 positive, Pin 1 negative.

Test Procedure: Note: The engine must be stopped during this procedure.

1. Zero the 271 meter mechanically with the 501-T power switch off.

2. Connect the Detonation Meter Calibrator (or battery) to the 501-T.

3. Turn on the 501-T power switch and set the coarse spread control to 5 (the fine control should be kept fully ccw during this entire procedure).

4. Set the time constant to 1 and adjust the 501-T Meter Reading controls (MR) to produce a mid-scale reading on the Weston 271 (M). When no drift has been observed for at least 10 minutes, proceed as follows:

5. Set the Spread Control (S) to 8 and adjust MR to produce an M of 80. Then set S to 2 and using the METER ZERO control (Z), adjust M to 20 (the operational switch must be in operate position at all times). After each change, allow at least 10 seconds for equilibrium, then tap the 271 near its pivot point before reading.

6. These are interacting adjustments and must therefore be repeated in trial and error fashion until readings of precisely 20 and 80 are obtained at S = 2 and 8 respectively.

7. As now adjusted, the 501-T should produce equal increments of voltage at the Model 271 Meter terminals for each incremental change in S, i.e., at S = 1, M = 10; S = 2, M = 20 etc. - or M = 10XS. Deviations of more than two divisions from this relationship indicates excessive tracking error and the Model 271 Meter should be repaired or replaced.

A favorable result in this tracking error test is an indirect but adequate indication that the 271 meter sensitivity is also satisfactory since too low a sensitivity could force the 501-T to operate in a non-linear fashion.

* in Variable MODE

Instrumentation Study Group
~~6/29/77~~ 12-5-78

# KNOCK METERING SYSTEM CHECK

PRELIMINARY 12-5-78

The two reference fuel (bracketing) procedure presumes linearity between knock intensity and knockmeter read-out. If there is evidence of excessive non-linearity such as significantly different spread results from changes of + and - one octane number, the system linearity should be checked by the following procedure.

## Apparatus Required

1. 501-T/271 system to be tested.

2. A stable d. c. voltage source continuously variable from 0 to 500 millivolts.

3. A precision millivolt meter accurate to 0.01 millivolts in the 0-20 millivolt range and to 0.1 millivolts in the 500 millivolt range.

## Preliminary Procedure - D.C. SIGNAL

The following should be performed in the absence of potentially interfering electrical signals such as ignition noise.

1. Adjust the Model 271 meter to mechanical zero.

2. Turn on 501-T, and after 30 minutes (minimum) warm-up, adjust electrical zero.

3. Connect voltage source to 501-T input, J202-1 negative, J202-2 positive.

4. Set the course SPREAD control (S204) to 6 and the fine control (R218) to zero.

5. Set the coarse METER READING control (S203) to 9 and the fine control (R212) to 10.

6. Set the Time Constant switch to 1.

## Test Procedure

1. Increase the input voltage until the Model 271 meter reads 10 (approx) and record the input and output millivolts (at the Model 271 meter terminals) and the exact 271 meter reading.

2. Repeat 1 with input increased to produce a 271 meter reading of 20, 30, etc., to 100.

3. Plot the observed 271 meter readings versus 501-T input millivolts and draw a best straight line through the 30 through 80 meter reading points. If all points in this range are within ±2 division of the line, the knock-metering system is considered to be of adequate linearity. If not, proceed to 4.

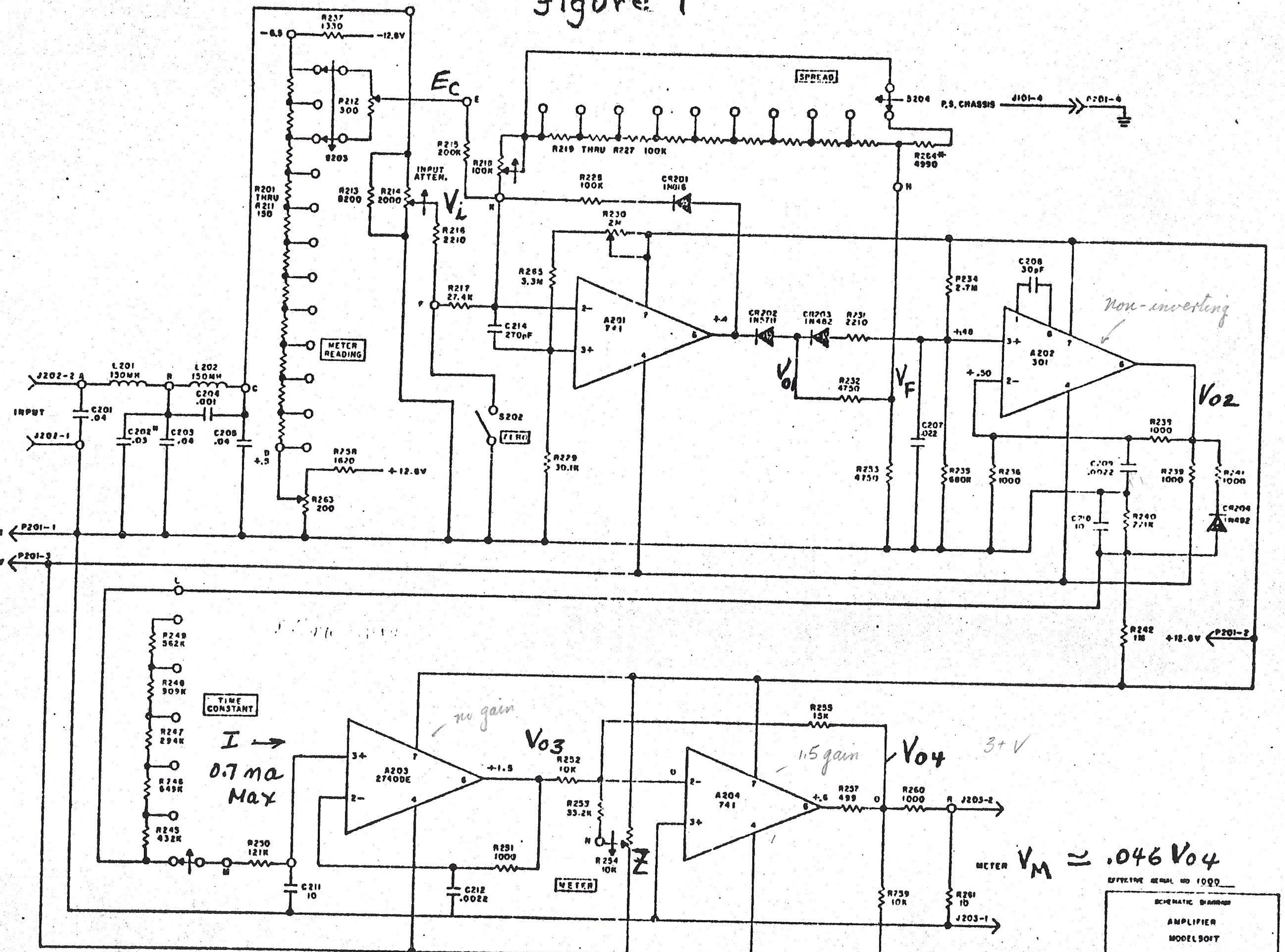
4. Plot observed 271 meter readings versus 501-T output, draw best straight line through the 30 through 80 meter reading points. If points in this range deviate by more than ± 2 division from the line, or if the millivolts required for a meter reading of 90 exceeds 14.5 millivolts, the Model 271 meter should be repaired or replaced.

5. Plot 501-T output millivolts versus input millivolts. Draw a best straight line through the 2 through 14.5 millivolt range of points. Deviations of more than ± 0.25 millivolts are considered excessive and the 501-T should be repaired.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REV. A | 3-69 | MADE CORRECTIONS | REV. D | 8-69 | ADD RES. R262 | REV. H | 7-71 | [illegible] ADDED R265 AND C214 | REV. L | 1-73 | CR202 WAS IN628; CR203 WAS IN5711 |
| REV. B | 6-69 | MADE CORRECTIONS | REV. E | 2-71 | ADD RES. R263 & R264 | REV. J | 3-72 | CONN. R263 TO METER READING | REV. M | 1-73 | MADE CORRECTIONS FOR ECO 15517 |
| REV. C | 5-69 | Added VOLTAGES | REV. F | 3-71 | REMOVED F204 & J204 | REV. K | 10-72 | R239 WAS 221, CR203 WAS IN482 | | | |

1A-9813-75

# Figure 1




METER $V_M \simeq .046\, V_{04}$

EFFECTIVE SERIAL NO 1000

SCHEMATIC DIAGRAM
AMPLIFIER
MODEL 501T

NOTE:

- * FACTORY SELECTED VALUE.
- CHASSIS CONNECTION.
- VOLTAGE TAKEN WITH DIALS SET AT MID-RANGE. NO SIGNAL INPUT.

ALL RESISTOR VALUES IN OHMS UNLESS OTHERWISE NOTED.
ALL CAPACITOR VALUES IN MICROFARADS UNLESS OTHERWISE NOTED.



ON ALL FRACTIONAL MACHINE DIMENSIONS ALLOW ± .010 UNLESS OTHERWISE SPECIFIED REF DWG.

MODEL: CFR
DRAWN: HALVERSON
TRACED: 1-15-69
CHECKED: SFG
APPROVED

C

WAUKESHA MOTOR CO.
WAUKESHA, WIS.

SC-6186-41
PART NO.

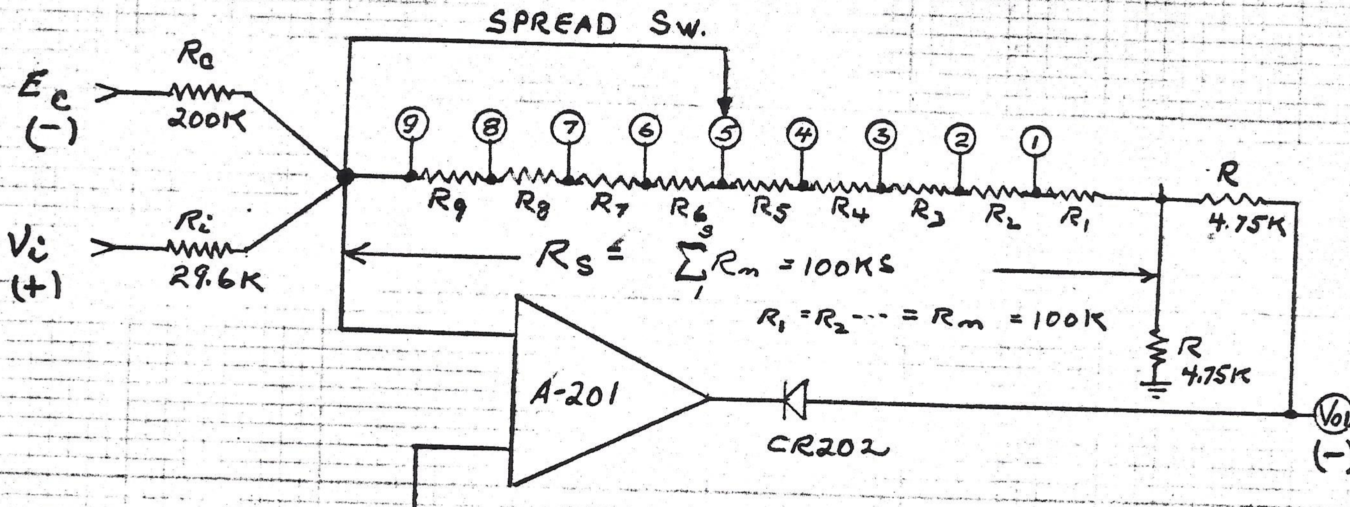
67.433

By Doug Roddick

12-6-78 Atlanta

<u>FIGURE 2</u>

EFFECTIVE CONFIGURATION OF 501-T INPUT STAGE




$E_c$ = - volts from MR (Meter Reading Control)

$V_i$ = + volts from the Input Attenuator

(1) $\frac{E_c}{R_c} + \frac{V_i}{R_i} + \frac{V_F}{R_s} = 0$

(2) $V_F = V_{01} \frac{R_s}{R+2R_s}$

(3) let $V_c = E_c \frac{R_i}{R_c}$ then since $V_c$ is negative

(4) $V_{01} = -(V_i - V_c) \cdot (R+2R_s)/R_i$

(5) $V_{04} = -3xV_{01} = 3(V_i - V_c)\frac{R}{R_i} + 6(V_i - V_c)\frac{R_s}{R_i} + V_z$

$R_s = 100KxS$

(6) $V_{04} = .4814(V_i - V_c) + 20.27\ (V_i - V_c)S + V_z$

(7) KNOCKMETER VOLTAGE

$$V_M = V_{04} \times \frac{R_M}{101R_m+1000} = 4.6 \times 10^{-3}\ V_{04} \text{ volts}$$

(8) KNOCKMETER READING

$$M = 4.6 \times 10^{-3} \times \frac{100}{V_M(\text{full scale})} \times V_{04} = 30.48\ V_{04}$$

(9) $$M=30.48\ [.4814(V_i-V_c)+20.27(V_i-V_c)S+V_z]$$

(10) Make $V_z = -\ .4814(V_i-V_c)$

$$M = 617.8(V_i-V_c)S$$

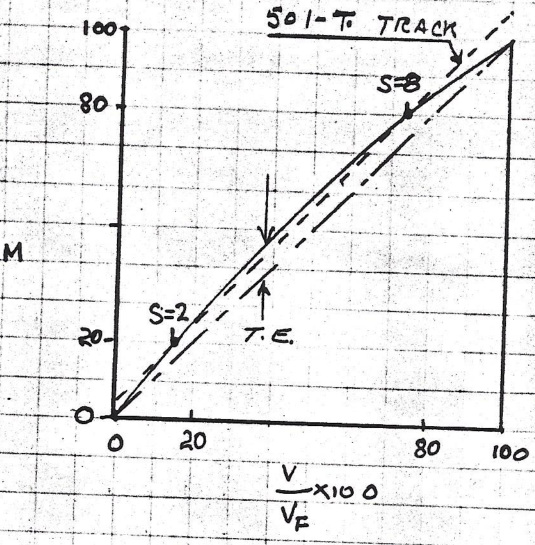
(11) Adjust $(V_i-V_c)$ to 0.0162 volts

$$M = 10\ S$$

(See <u>Figure 3</u> For Test Results

# FIGURE 3

A



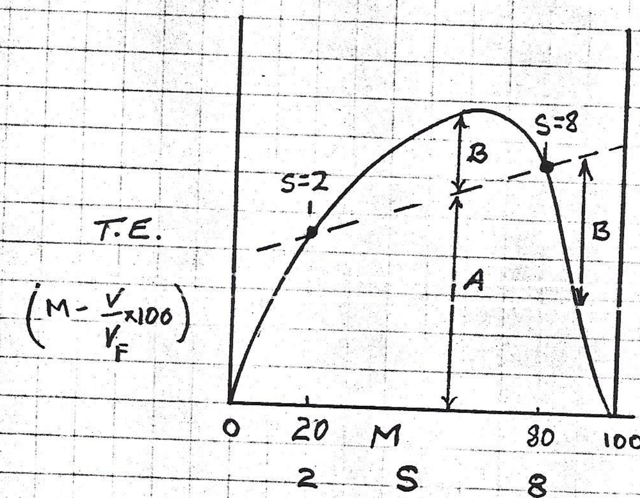

M = WESTON METER READING

V = " " VOLTAGE

$V_F$ = " " FULL SCALE VOLTAGE

T.E. = TRACKING ERROR

B

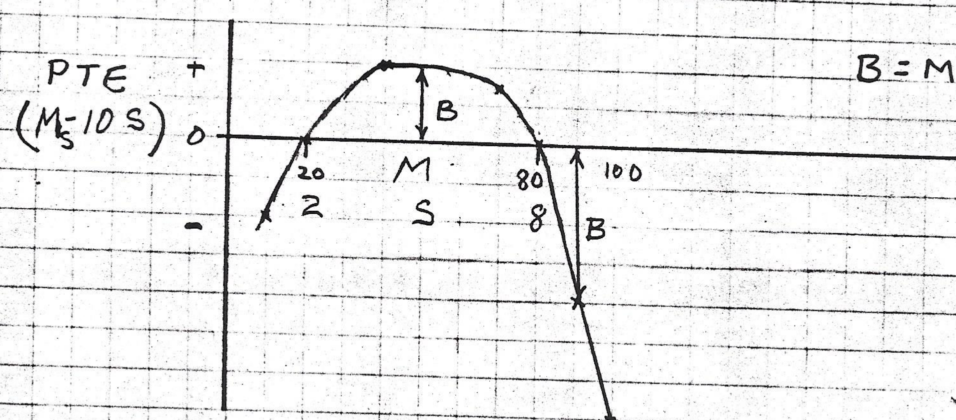



$$A = TE_{20} + \frac{TE_{80} - TE_{20}}{60}(M-20)$$

$$B = M_S - 10S = TE_S - A$$

$$M_S - 10S = TE_S - \left[TE_{20} + (TE_{80} - TE_{20})\frac{(M_S - 20)}{60}\right]$$

C




$$B = M_S - 10S$$

## ERRORS

1. Effect of SPREAD Resistor Tolerances on the TRACKING ERROR TEST.

From eq (9) and Figure 2

$$M = a(V_i - V_c) + b(V_i - V_c)\sum_{n=1}^{n=S} R_n$$

(12) $80 = a(V_i - V_c) + b(V_i - V_c)(R_1 + R_2 \text{-------} + R_8)$

(subtracting)

(13) $20 = a(V_i - V_c) + b(V_i - V_c)(R_1 + R_2)$

(12-13) $\Delta M = 60 = 0 + b(V_i - V_c)(R_3 + R_4 \text{---} + R_8)$

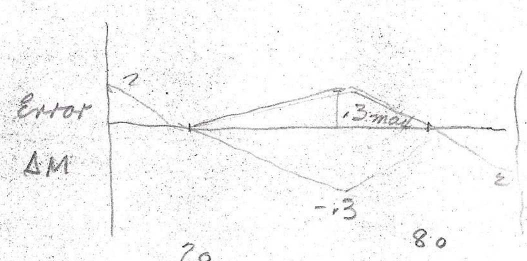
$$\frac{\Delta M}{\Delta S} = \frac{60}{6} = 10 = b(V_i - V_c)\frac{(R_3 + R_4 \text{---} + R_8)}{6}$$

$$(R_3 + R_4 + \text{---} R_8)/6 = \overline{R_n}$$

$$b(V_i - V_c) = \frac{10}{\overline{R_n}}$$

(14) $$\frac{\Delta M}{\Delta S} = 10\,\frac{R_n}{\overline{R_n}}$$

$$\frac{R_n}{\overline{R_n}} = 1.00 \pm .02 \text{ (max.)}$$




WORST CASE: $\Delta M = 10 \pm .2$

ERRORS ARE ZEROED AT S=2 and S=8
CUMULATIVE: S=2-8 + 0.3 or -0.3
BUT NOT $\pm 0.3$

AT ΔS 2-1 and 8-9 ΔM may = $\pm$ 0.2

2. ERRORS DUE TO A201 VOLTAGE and CURRENT OFFSET: THESE ARE ERRORS PRESENT IN ALL D.C. AMPLIFIERS.

BY the TEST PROCEDURE THESE ERRORS ARE CORRECTED TO ZERO at S=2 (BY $V_Z$) and ARE ELSEWHERE LINEAR WITH GAIN (i.e., S). THEIR OVERALL EFFECT IS NIL.

3. ERROR DUE TO OPEN-LOOP GAIN DEFICIENCY OF A-201.

BASIC GAIN CALCULATIONS ASSUMED INFINITE OPEN-LOOP GAIN·OF OP-AMP-201. A TYPE 741 IS SPECIFIED AT A TYPICAL GAIN OF 200,000 AND A MINIMUM OF 50,000. IF O.L. GAIN HAS DETERIORATED TO e.g., 1000, CIRCUIT GAIN WOULD BE TOO LOW BY ∿ 5%. HOWEVER, THIS ERROR TOO IS VERY NEARLY LINEAR WITH S, AND DOES NOT INTERFERE.

## PULSE SIGNAL RESPONSE TEST

The d.c. test may not reveal certain 501-T malfunctions in the peaking and averaging area. High leakage (reverse current) of CR203 or CR204 (Figure 1), leakage or low capacitance of C207 or C210 or low input resistance of A202 can result in excessive voltage requirements of A201 and A202 on narrow pulse signals.

The Waukesha Calibrator (Part 111605) supplies two signals at 7.5 HZ (∿ 1/8 of line frequency). In KNOCK mode the pulse supplied is 0.10 m.s. wide and in variable mode, 1.5 m.s. wide. The KNOCK mode pulse is too narrow for linear 501-T operation and the variable mode pulse may be too wide to adequately stress the 501-T. A pulse of about 0.5 m.s. would probably be about right.

This test should be done using the Tracking Error Test Procedure, i.e., fixed input, variable Spread settings since measuring a variable peak input would be different.