

BEFORE PROCEEDING WITH COMPLETE UNPACKING AND SETUP,
CONSULT UNPACKING AND INSPECTION INSTRUCTIONS ON PAGE 6

model 964
DIGITAL METRONOME



United Recording Electronics Industries

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SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION AND APPLICATION. The U.R.E.I. Model 964 Digital Metronome is a precision instrument that provides 320 different tempo beats for use in producing live music scores for motion pictures. The 964 is crystal controlled to permit accurate operation independent from fluctuations in line frequency. Computer-type integrated circuits assure reliability and long equipment life.

The tempo beats correspond to various multiples of motion picture film frames, based on standard sound speed of 24 frames-per-second. The metronome design eliminates disadvantages associated with certain "click track" schemes of producing tempo beats. Because no motors, relays, or other noise-producing elements are used, the Digital Metronome can be operated on the scoring stage or in the studio.

Three thumb wheel switches are used to select the tempo, which may be set from 1/8 frames-per-beat to 39-7/8 frames-per-beat, in 1/8-frame steps. A control is provided to adjust the output volume. Earphones may be driven directly, or through an external amplifier. The output produces sharp, uniform "clicks", without distracting background noise usually present in film loops.

The tempo beats are started either by depressing the front-panel START button or by an externally generated trigger signal (e.g., a "bloop" on the film track). The latter can take the form of a momentary or continuous contact closure or may be a sharp positive pulse or DC-level change. The minimum amplitude of this pulse or DC-level should be +0.25 volts or maximum +20 volts with a rise time of at least 0.1 volts per millisecond.

The Model 964 Digital Metronome can be rack mounted or placed on any level surface. The new 1/2 rack size requires only 3-1/2 inches of rack space and extends 8 inches into the rack. Output is available from a T.R.S. jack on the front panel or from a terminal strip on the rear panel. The terminal strip output is interrupted when a plug is inserted into the front panel jack.

1-2. TECHNICAL SPECIFICATIONS

- OUTPUT SIGNAL : Pulse Amplitude: 0-25 volts peak
(600 ohm load).
0-10 volts peak: (10 ohm load).
Pulse Duration : 651 usec.
Output Power : 15 watts max. peak.
- NOISE : At least 70 dB below pulse peaks.
- ACCURACY : Crystal controlled $\pm 0.01\%$.
- TEMPO RANGE : 1/8 frame to 39-1/8 frames-per-beat,
in 1/8-frame steps. (Based on 24
frames-per-second.)
- TRIGGER INPUT : Momentary or continuous contact closure
to ground, or a +0.25 to +20 volt pulse
into input impedance of 600 ohms.
(Rise time ≤ 0.1 volts per millisecond)
- CONTROLS : 3-Section thumbwheel tempo switch.
START and STOP buttons.
VOLUME CONTROL
POWER SWITCH
- CONNECTORS : T.R.S. signal output front panel jack.
Terminal strip at rear of chassis for
signal output and trigger signal input.
- ENVIRONMENT : Operating temperature from 0° C to $+55^{\circ}$ C.
Storage temperature from -20° C to $+60^{\circ}$ C.
- POWER REQUIREMENTS : 115/230 volt AC, $\pm 15\%$, 50/60 Hz,
less than 10 watts.
- DIMENSIONS : Height : 3- $\frac{1}{2}$ "
Width : 8- $\frac{1}{2}$ "
Depth : 8" behind panel
Weight : 6 lbs. (shipping weight 9 lbs.)
- OPTIONAL ACCESSORIES : SR-3A Rack Mounting Kit for single
mounting in 19" rack.
DR-3A For side-by-side mounting of two
964's in 19" rack.

SECTION II

THEORY OF OPERATION

2-1. GENERAL. The Model 964 Digital Metronome generates accurate tempo beats from an oscillator whose frequency is controlled by a quartz crystal. The oscillator frequency is divided down to generate time base pulses of 192 Hz. Counters provide the necessary subfrequencies from which the tempo beats are selected through the thumb-wheel switches.

Various gates and the START-STOP circuitry guarantee coincidence of the first pulse with the start command (either manual or remotely generated). The output amplifier provides up to 15 watts of peak power.

2-2. OSCILLATOR. The oscillator has a dual function. It generates the signal necessary to drive the subsequent dividers and also serves as a frequency standard. The frequency of the oscillator is crystal controlled and remains stable over a wide range of power supply and environmental changes. The frequency is 786.432 kHz with a maximum tolerance of $\pm 0.01\%$.

2-3. FREQUENCY DIVIDER CHAIN. Three 4-bit Binary Counters (IC 1, 2, 3) form the divider. The dividing factor is 4096, the resulting output frequency is 192 Hz. An intermediate frequency of 1536 Hz is also obtained and used to gate the output pulse width ($1/1536 = 651 \mu\text{s}$).

2-4. COUNTER. The counter section provides the various subfrequencies necessary to select any tempo beat from $1/8$ frames-per-beat to $39-7/8$ frames-per-beat. IC 6 generates 3 binary outputs for the "eighths". The decade information for the "units" is taken from the output of IC 4, and IC 5 provides the binary signal levels for the "tens". All signals are buffered to isolate the outputs from each other (IC 7 and 8). A separate section of the counter (FF "A" in IC 6) is used to generate the "start coincidence pulse".

2-5. THUMBWHEEL SELECTOR SWITCH. This switch is manually set to select the desired frames-per-beat. There are three independent switch sections: tens, units, and $1/8$. The outputs are connected together to produce a positive signal level when the selected count has been accumulated.

2-6. GATING CIRCUIT. The input of this circuit is a NOR gate (IC 10) which will pass either the first trigger pulse or any subsequent pulse from the counter. When a signal is passed, the output of the NOR gate will change to logic 0. This signal is fed to the data input of the following D-type edge-triggered flip-flop (1/2 IC 9). The input information is transferred to the outputs on the positive edge of the clock pulse and the \bar{Q} output changes to a logic 1. This transition is used to reset the counter which in turn causes the NOR gate output to change to a logic 1. When the clock pulse (1536 Hz) starts its next cycle, the input data information is transferred through IC 9, and the \bar{Q} output changes to logic 0. Thus, the clock frequency of 1536 Hz determines the duty cycle of the pulse used to drive the output amplifier.

2-7. OUTPUT AMPLIFIER. The resulting pulse is passed through an isolation amplifier (IC 8). The output amplifier supplies the necessary gain to achieve the required output level and is of conventional design. The output is transformer isolated. The T.R.S.-jack is normalled to the rear terminal strip.

2-8. START-STOP CIRCUIT. The Model 964 Digital Metronome may be activated by any of three different methods:

1. START button on the front panel.
2. Remote contact closure between the GROUND terminal and the "CONTACT-CLOSURE" terminal of the trigger input at the rear of the chassis.
3. Remote injection of a trigger signal into the SYNC-input at the rear terminal of the chassis. This trigger signal must be a positive pulse of 0.25 volt to 20 volt with a rise time not less than 0.1 volts per millisecond.

The first pulse occurs simultaneously with the START command (supplied either manually or remotely). The input of the Start-Stop circuit is a pulse shaping network of conventional design followed by a buffer amplifier (Q4, IC 8). This drives a flip-flop (1/2 IC 9). When activated, its \bar{Q} output will change to a logic 0. The transition produces the first "Start" pulse in the previously described flip-flop "A" of IC 6. The 0 state of \bar{Q} also removes the disable voltage from the frequency divider chain which then feeds the 192 Hz clock-frequency to the counter and the 1536 Hz frequency to the output gate. The \bar{Q} output of the above-mentioned 1/2 IC 9 changes simultaneously to a logic 1. This signal is fed through a buffer amplifier to the output of the thumbwheel switch, removing the ground condition from its common bus. The next signal from the counter will be able to pass through the gating circuit into the output amplifier.

2-9. POWER SUPPLY. The Metronome may be operated from either 115 or 230 volt mains and is not dependent on accurate line frequency. A nominal DC voltage of 15 to 18 volts is supplied for the output stage of the power amplifier. The power supply for the logic circuitry ($V_{CC}=5$ volt) is well regulated and additionally fused on the PC board to protect sensitive integrated circuits.

SECTION III

INSTALLATION

3-1. UNPACKING AND INSPECTION. Carefully examine the contents of the shipping carton for any sign of physical damage which could have occurred in transit. Although your Model 964 was carefully packed at the factory, and the container was designed to protect the unit through rough handling, accidents do happen.

IF DAMAGE IS EVIDENT, DO NOT DESTROY ANY OF THE PACKING MATERIAL OR CARTON. IMMEDIATELY NOTIFY THE CARRIER OF A POSSIBLE CLAIM FOR DAMAGE. SHIPPING DAMAGE CLAIMS MUST BE MADE BY THE CONSIGNEE.

In addition to the Model 964 unit itself, you should verify that the shipment included the following:

- a. This instruction manual.
- b. A two-part warranty card, bearing the same serial number as the unit.
- c. If ordered, Rack Mounting Kit SR-3A or DR-3A.

Complete the Warranty Card, and mail the return portion immediately to activate you one-year warranty. No postage is required.

3-2. ENVIRONMENTAL CONSIDERATIONS. The Model 964 will operate satisfactorily over a wide range of ambient temperatures, from 0° C to +55° C (32° F to +131° F). If included in an equipment rack with high heat producing equipment, such as power amplifiers, adequate ventilation should be provided to prolong life of components.

3-3. POWERING. The Model 964 may be operated from either 110-120 VAC or 220-240 VAC mains supply, 50 or 60 Hz, depending upon the position of the power transformer input switch. This is a recessed slide-switch which is located adjacent to the fuse post and line cord entry at the rear of the chassis. Unless a tag on the line cord specifies otherwise, your Metronome was delivered ready for operation from 110-120 VAC mains. Verify this before applying power to the unit by observing that the numbers 115 appear near the bottom of the slide-switch window. The AC fuse should be 1/8A, Slo-blo.

To change for operation from 220-240 VAC, use a small screwdriver in the horizontal slot of the slide-switch. Push down firmly until the numbers 230 appear at the top of the window. (To change for 110-120 VAC, push up. For 220-240 VAC the line fuse should be changed to 1/16A Slo-blo, for proper protection.

No change is required for alternate 50 or 60 Hz supply, so long as the mains voltage is correct as above.

3-3 (CONTINUED).

The internal fuse on the printed circuit board is 1/2A. This fuse will open only when an IC in the logic part of the Metronome is short circuited. Special precautions must be taken to avoid damage to sensitive IC's when replacing this fuse. (Do not use "Slo-blo").

3-4. CONNECTIONS. Provisions are made for connection to the output of the Metronome through a terminal strip at the rear of the unit. The output can thus be permanently connected inside a rack. This output is interrupted when a plug is inserted in the tip-ring-sleeve jack at the front panel OUTPUT. Either a tip-ring-sleeve (ADC PJ 051 or equivalent) plug, or tip-sleeve (phone) plug may be used. If the latter is used, the shield and signal common (low side) will connect to the sleeve. When using tip-ring-sleeve plugs, best grounding practice is to connect only the shield to the sleeve and the signal common to the ring.

TRIGGER INPUT connections must be made through the rear terminal strips.

GROUND is common for the CONTACT CLOSURE and the SYNC inputs. The length of the connecting wires is not critical since the input impedances are relatively low.

SECTION IV

OPERATING PROCEDURE

4-1. CONTROL FUNCTIONS. The Model 964 Digital Metronome is very simple to operate when the front panel functions are understood. Therefore, the following description of control functions is given before operating procedures are discussed:

- a. Power Switch: When in "up" position the Metronome is switched "on"; the pilot light will be "on".
- b. Volume Control: The volume control adjusts the intensity (amplitude) of the output tempo beats.
- c. Thumbwheel-Select-Switch: This switch consists of three cascaded sections. All settings are additive.

Tens : This switch provides three basic tempo beats; 10, 20, 30 frames-per-beat. In the zero position, tempo beats with less than 10 frames-per-beat may be selected.

Units: This switch section provides nine basic tempo beats; 1 through 9.

8ths : This switch adds the indicated fractions of a frame to the selected basic tempo beat.
(1/8 frame = 1/2 sprocket hole in standard 35mm. motion picture film).

- d. START: This button causes the Metronome to start after the power is switched on or after the output has been stopped with the STOP button. A beat is produced at the instant the button is depressed and beats are produced at the indicated intervals thereafter.
- e. STOP: The stop button interrupts the count pulses of the Metronome.

4-2. MANUALLY STOPPING AND STARTING. If it is desired to mute the Metronome and then start it again, depress the STOP button for muting and then the START button when operation is to be resumed. The first tempo beat is produced at the instant the START button is depressed.

4-3. EXTERNAL TRIGGERING. An external pulse or contact closure (momentary or prolonged) may be used to synchronize the Metronome with other equipment. The following are the requirements for the pulse and contact closure:

- a. If a pulse is to be used, it must be positive at the SYNC input with respect to the associated GROUND terminal and must have a minimum amplitude of +0.25 volt and a maximum amplitude of +20.0 volt. The rise time should be 0.1 volts per millisecond or faster. A burst of audio frequency, with the same minimum specifications as for the pulse described above, may also be used at the SYNC input.
- b. If a contact closure is to be used for triggering, it must be used between the "CONTACT CLOSURE" and "GROUND" terminal.

4-4. SYNCHRONOUS OPERATION. Connect the Model 964 Digital Metronome and the external equipment as described in the previous paragraph. The external contact closure or sync pulse must occur when the first tempo beat is desired.

First depress the STOP button; then start the external equipment. The first tempo beat will coincide with the contact closure or sync pulse.

4-5. TEMPO BEAT SELECTION. The tempo beats are selected by dialing the desired numbers in the three sections of the thumbwheel selector switch. Shown is the number of frames-per-beat and it is based on a rate of 24 motion picture frames-per-second.

Sometimes it may be desired to convert the number of frames-per-beat into the musical term of beats-per-minute. Since there are 24 motion picture frames-per-second, there are 1440 frames-per-minute. Therefore:

$$\text{Beats-per-minute} = \frac{1440}{\text{window setting}}$$

Example: Given 16 frames-per-beat (window setting 1.6.0)

Beats-per-minute = ?

$$\frac{1440}{16} = 90 \text{ beats-per-minute}$$

4-5. (CONTINUED)

If the beats-per-minute are known but the frames-per-beat have to be determined, the formula is applied as follows:

$$\text{Window setting} = \frac{1440}{\text{beats-per-minute}}$$

Example: Given 50 beats-per-minute

Frames-per-beat = ?

$$\frac{1440}{50} = 28.800 \text{ or a window setting of: } 2.8.6$$

NOTE: The decimal number of .800 must be converted to the nearest 8th for the window setting. In this case one would choose 6/8 as the closest setting. See Table II, next page.

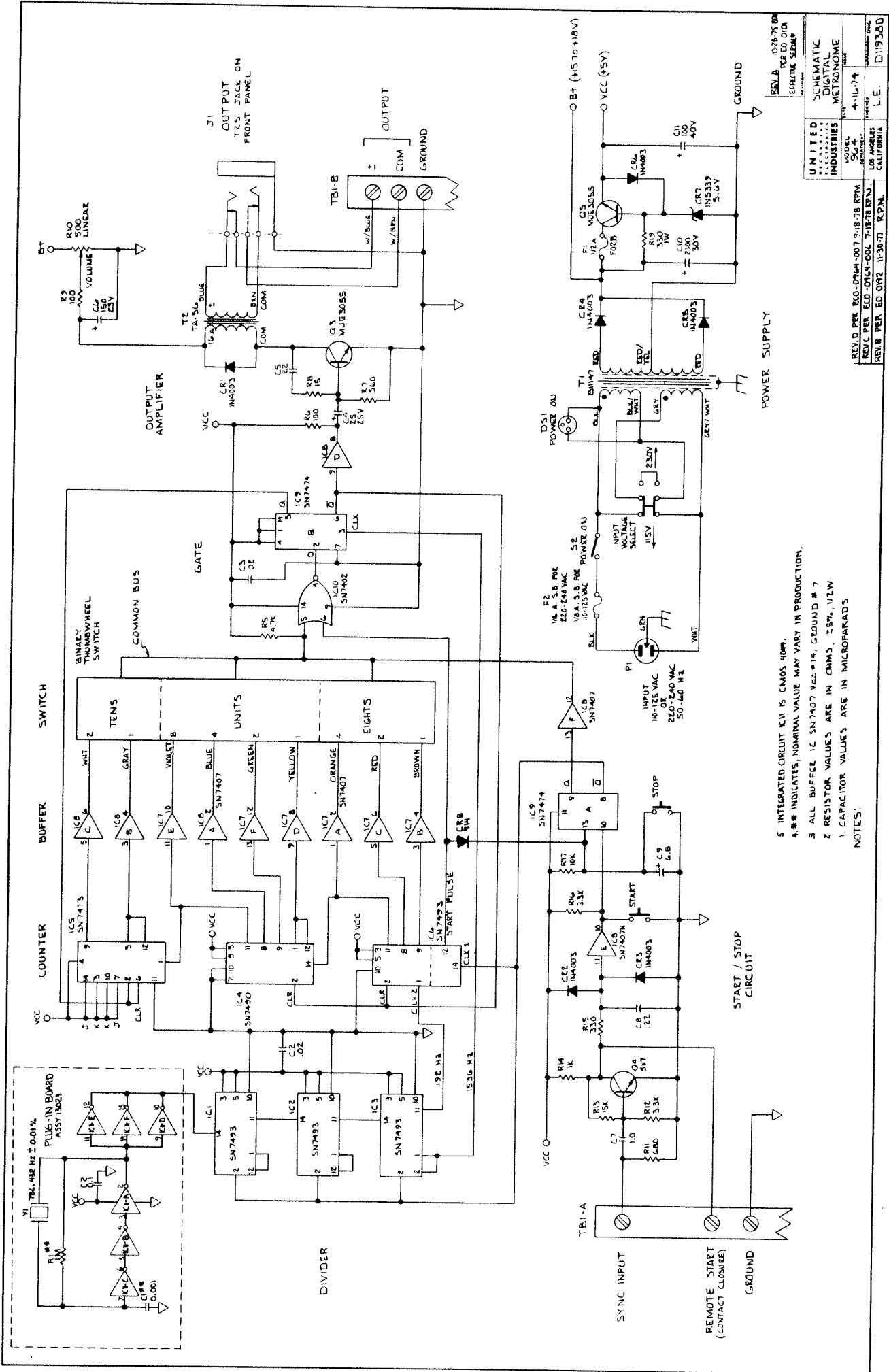
The following table lists beats-per-minute and their closest equivalent frames-per-beat thumbwheel switch settings. (Numbers marked with an asterisk are precise window settings; numbers without asterisk are rounded off to the nearest setting.)

TABLE I

<u>Beats-per-minute</u>	<u>Window setting</u>	<u>Beats-per-minute</u>	<u>Window setting</u>	<u>Beats-per-minute</u>	<u>Window setting</u>
40	= 3.6.0*	62	= 2.3.2	94	= 1.5.3
41	= 3.5.1	64	= 2.2.4*	96	= 1.5.0*
42	= 3.4.2	66	= 2.1.7	98	= 1.4.6
43	= 3.3.4	68	= 2.1.1	100	= 1.4.3
44	= 3.2.6	70	= 2.0.5	104	= 1.3.7
45	= 3.2.0*	72	= 2.0.0*	108	= 1.3.3
46	= 3.1.2	74	= 1.9.4	112	= 1.2.7
47	= 3.0.5	76	= 1.9.0	116	= 1.2.3
48	= 3.0.0*	78	= 1.8.4	120	= 1.2.0*
49	= 2.9.3	80	= 1.8.0*	126	= 1.1.3
50	= 2.8.6	82	= 1.7.4	132	= 1.0.7
52	= 2.7.6	84	= 1.7.1	138	= 1.0.4
54	= 2.6.5	86	= 1.6.6	144	= 1.0.0*
56	= 2.5.6	88	= 1.6.3	152	= 0.9.4
58	= 2.4.7	90	= 1.6.0*	160	= 0.9.0*
60	= 2.4.0	92	= 1.5.5		

TABLE II

<u>Decimal</u>	<u>Fractional</u>
.175	1/8
.250	2/8
.375	3/8
.500	4/8
.625	5/8
.750	6/8
.875	7/8



REV. B 10-28-75 BR
 EPCING SERVO

SCHEMATIC
 DIGITAL
 METRONOME

MODEL
 50-4

DATE
 4-16-74

DESIGNED BY
 L. E.

DRAWN BY
 L. E.

DATE
 11-30-71

REV. D PER ECO-0914-007 9:18-78 RPM
 REV. C PER ECO-0914-004 7:18-78 RPM
 REV. B PER ECO-092 11-30-71 R.O.N.

- 5 INTEGRATED CIRCUIT K11 IS CMOS 40PM.
 4. ** INDICATES NOMINAL VALUE MAY VARY IN PRODUCTION.
 3 ALL BUFFER IC SN7407 VCC #19, GROUND # 7
 2 RESISTOR VALUES ARE IN OHMS, 25%, 1/2W
 1. CAPACITOR VALUES ARE IN MICROFARADS
- NOTES: