OPERATING INSTRUCTIONS

MODEL [redacted] 403

AUDIO OSCILLATOR

Waveforms, inc.

333 SIXTH AVENUE, NEW YORK 14, N. Y. WATKINS 9-2795

TECHNICAL MANUAL

MODEL [redacted] 403

AUDIO OSCILLATOR

DESCRIPTION

The WAVEFORMS Model 401A Audio Oscillator is a stable, precise source of low-distortion sinusoidal signals in the audio and low ultrasonic range. It is conveniently small, and sturdy enough for field use. It can be operated on power lines of from 50 to 400 cycles, making it ideal for field testing and aircraft work. Among the many uses of this versatile instrument are testing of telephone lines, public address systems, high fidelity installations, broadcast equipment, intercommunication systems, aircraft radio and intercommunication equipment, loudspeakers, low-power transducers, and servo amplifiers. It may be used as a frequency control for square-wave and pulse generators, as a signal source for bridge measurments, and as a source for measuring band-width or frequency by interpolation methods.

The model 401A is a resistance-capacitance tuned oscillator using a bridged T circuit configuration. Amplitude is stabilized by heavy feedback in conjunction with an amplitude sensitive element in the feedback loop. Because only signals current passes through the amplitude sensitive element, the 401A is unusually free from switching and tuning transients.

Oscillator power is supplied to the load through a push-pull cathode follower power amplifier with a power capability of one-half watt. The output impedance of this amplifier is less than 100 ohms, and its current capability is 25 milliamperes.

The 401A may be removed from its case for inspection and maintenance by removing the two screws at the rear.

SPECIFICATIONS

Frequency Range:	9 cycles to 120 kilocycles in four overlapping decade ranges: 9-120 cycles, 90-1200 cycles, 900-12000 cycles, 9000-120000 cycles.
Frequency Accuracy:	2%. Instruments especially calibrated to have a 1% maximum deviation are indicated by the letter A in their serial numbers.
Frequency Stability:	½% for line voltage variations of from 105-130 volts, or temperature changes in the range 0° to + 50° C.
Output Level:	½ watt into 600 ohms (+ 27 dbm, 17.3 volts), or 20 volts open circuit.
Output Controls:	Continuously variable logarithmic control calibrated approximately in volts. A toggle switch control inserts a 40 db (100:1) attenuator in cascade. Levels as low as one milliwatt can be conveniently controlled without external attenuators.
Impedance:	Approximately 100 ohms.
Output Variation:	The output voltage is constant within ± ½ db over the entire tuning range.
Distortion:	Less than 0.25% for any output level or load of 600 ohms or above from 100-120,000 cycles. Less than 0.25% on the x1 Range (9-120 cycles) provided the instrument is terminated in a 600 ohm load for all output levels. The distortion on the x1 Range when the instrument is operated into a high impedance is below 0.25% for all output levels up to 3 db below full output.
Hum:	20 V Range: 80 db below full output or 1 millivolt; whichever is greater. .2 V Range: 60 db below signal or 10 microvolts; whichever is greater.
Size:	8" high, 6" wide, 11" deep.
Weight:	12 lbs..
Power Source:	105-130 volt, 50-400 cycles, 60 volt-amperes.
Tube Complement:	1-6AU6, 1-5687, 1-6X4, 2-12B4A.

CONTROLS

Frequency: The output frequency is controlled by the large dial, in conjunction with the Range Switch.

Amplitude: The output voltage is controlled by the output control and the output range switch. The output control is a continuously variable potentiometer which is logarithmically tapered and calibrated approximately in volts delivered to a high impedance. When the output range switch is on the "20V" position, the output may be read directly in volts on the output control scale. When the output range switch is on the ".2V" position, the voltage reading on the output control scale must be divided by 100.

The output range switch should always be set so that the output control setting is as high as convenient to insure the best signal-to-hum ratio.

Power: Turning the output control fully counter-clockwise turns the instrument power off.

Sync: The third binding post on the panel delivers a constant 24 volt signal at the output frequency, regardless of the setting of the output attenuation system. This high-impedance signal is especially useful for synchronizing oscilloscopes used in conjunction with the 401A.

OPERATION

The output of the Model 401A Oscillator appears across the output binding posts. The ground binding post is connected directly to the oscillator chassis. The DC resistance across these binding posts is 10,100 ohms with the output range switch in the 20 V position, and 100 ohms with the output range switch in the .2 V position. Under open circuit conditions, a DC potential of about .1 V will appear across the output terminals with the output range switch in the 20 V position. This is reduced when the output range switch is in the .2 V position.

The output capability of the Model 401A is 30 milliamperes into a resistive load. Distortion will increase at higher output currents, and may increase if the load is predominantly reactive.

Connecting the output terminals of the oscillator across a potential difference of more than 50 volts on the 20 V range, or 5 volts on the .2 V range, may burn out the output attenuator. If the oscillator is to be connected across a DC potential difference, it is always well to use an external blocking capacitor, to eliminate the possibility of damage to the output coupling capacitor.

HUM

As cited in the SPECIFICATIONS, the hum output of the Model 401A oscil-

lator is extremely low. When making measurements requiring exceptional freedom from hum, one power-plug orientation of the oscillator, the equipment under test, or any other associated equipment, may be better than another. The Model 401A should not be located too near low level circuits, since the hum field of its power transformer may be disturbing. In order to keep the signal-to-hum ratio as high as possible, it is desirable to operate with the output control set as high as possible. The output range switch should, therefore, always be set at .2 V when output voltages of less than .2 V are required.

CIRCUIT DESCRIPTION

The oscillator section of the 401A Oscillator is of the R-C Bridged T type. It consists of a gain stage (6AU6) and a low impedance output stage (5687) which is of the self-driven single-ended push pull variety. The upper triode of this stage is similar to a conventional cathode follower, with the lower triode serving as a dynamic load. The lower tube is driven out of phase with the upper tube.

The oscillator action depends upon the rejection characteristic of the Bridged T network at a particular frequency. At other frequencies the circuit provides negative feedback to the grid of the 6AU6, which counter-balances the positive feedback to the cathode through the amplitude control lamp. At the frequency of oscillation the positive feedback predominates over the negative feedback signal which is sharply reduced by the rejection of this frequency by the Bridged T. The resulting oscillations are stabilized by the positive resistance-temperature characteristic of the lamp. The lamp resistance increases as it is heated by larger signals, reducing the positive feedback.

Various trimmer capacitors are used in conjunction with the range switching resistors to maintain the impedance and phase-shift characteristics of the network at the optimum values over the entire tuning range of the instrument. Two of these trimmer capacitors are of the screwdriver adjust type. THEIR SETTINGS SHOULD NOT BE ALTERED.

The amplitude of oscillation - which should be 24 volts - is controlled by the 1000 ohm rheostat in the cathode of the 6AU6: the frequency of oscillation is controlled by a variable capacitor within the ranges and by switching the resistors of the R-C positive feedback network when changing ranges. Because of the large amount of negative feedback and the carefully chosen operating conditions, distortion of the oscillator is exceptionally low. It is less than 0.07% at 1000 cycles.

The oscillator output is taken from the cathode of the upper triode of the 5687 stage, and fed to the output amplifier and - through an isolation resistor - to the SYNC terminal of the instrument.

The output amplifier makes use of two 12B4A tubes in a push-pull cathode follower arrangement. Signal is fed into the top 12B4A which operates as a cathode follower with the bottom 12B4A in parallel with the load as its cathode impedance. A resistor in the plate circuit of the top 12B4A develops a voltage which is 180° out of phase with its cathode voltage, and this voltage is used to drive the grid of the bottom 12B4A, which operates as an amplifier with the top 12B4A and the load resistance as its

plate impedance. The two tubes are driven in push-pull, so that their output currents add in the load circuit. The inherent degeneration of this circuit is high, and its distortion is correspondingly low.

The power supply arrangement is conventional.

MAINTENANCE

All the critical surfaces in the Model 401A Oscillator are ceramic or of other high grade insulating material, treated to repel moisture. However, if the oscillator has been left in a very moist atmosphere, erratic behavior may be noticed on the lowest ranges. This will usually clear up after the unit has been operated for a short time, and the moisture films have been vaporized. If erratic behavior persists, the insulating surfaces should be cleaned to remove conductive dust particles. Care should be taken to not disturb the adjustment of the trimmer capacitors or the amplitude rheostat.

Erratic behavior may also be caused by loose tubes, electrolytic capacitors, or the 10 watt lamp. All of these should be checked for tightness of fit in case of any malfunction.

When replacing tubes or the stabilizing-lamp, it is desirable to measure the oscillator distortion on a sensitive distortion meter. A poor tube or lamp may increase the distortion without otherwise affecting the performance.

High distortion on all ranges and at all output levels is generally caused by either the 10 watt lamp or the oscillator 6AU6. Distortion occurring only at high output levels will probably be due to the output 12B4A's. Distortion occurring only on the lowest range is usually due to grid current in the 6AU6.

The upper 12B4A plate resistor is a continuously variable rheostat to permit the establishment of the optimum operating conditions for the particular 12B4A tubes in this stage. Its main effect is on the distortion of the amplifier when operated under load. When the 12B4A tubes are replaced, the distortion should be checked under conditions of no-load and 600 ohm resistive load. Should the distortion be above that set forth in the specification, the rheostat should be set for minimum distortion at full output with a 600 ohm load connected to the output terminals.

To preserve balance, each tube is operated from its own cathode resistor, and these resistors are left un-bypassed to provide further signal degeneration. As a result, changes in the tube characteristics with age have very little effect on operating conditions or performance.

IT IS RECOMMENDED THAT FOR ANY MAINTENANCE BEYOND TUBE REPLACEMENT OR SIMILAR ROUTINE SERVICING, THE UNIT BE RETURNED TO THE FACTORY.

GUARANTEE

This instrument was carefully tested, inspected, and packed and left our factory in perfect operating condition. It should be inspected and tested as soon as it is received. If damage is discovered, a claim should be filed with the carrier at once, and WAVEFORMS should be notified.

WAVEFORMS unconditionally guarantees its instruments to be free of defects in materials and workmanship. Our liability under this guarantee is limited to the repair and adjustment of any instrument returned to the factory for that purpose within one year from the date it was delivered to the purchaser, and to the replacement of any defective parts except tubes and fuses.

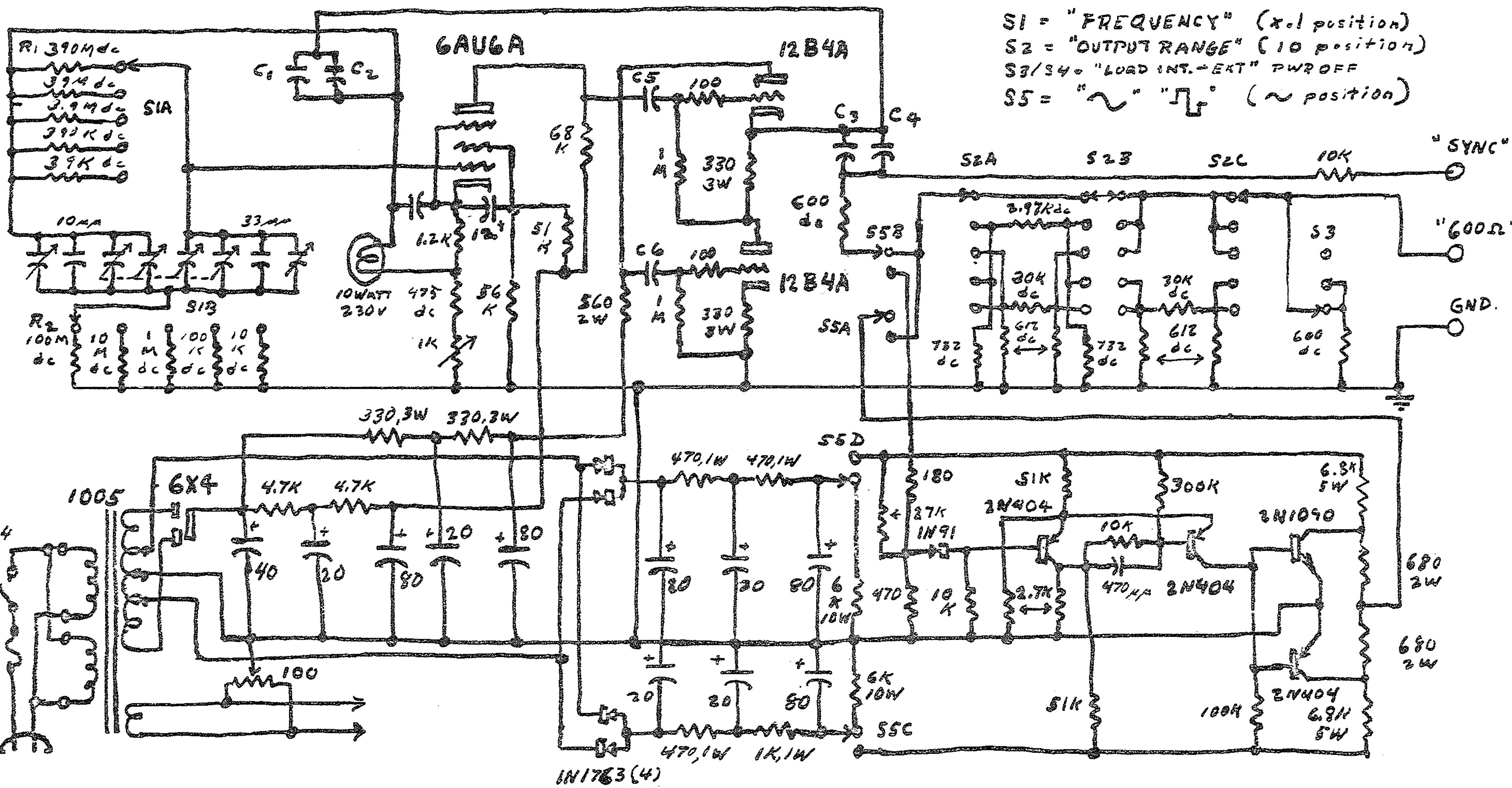
Tubes are subject to the standard RETMA guarantee. Equipment returned to us for servicing must be carefully packed and shipped with the transportation charges prepaid.

If any difficulty should develop with this instrument, please notify us, giving the details of the difficulty, including the type and serial number of the instrument, together with the name of the distributor from whom it was purchased. We shall reply promptly, giving service information or shipping instructions.

If the difficulty proves to have been caused by misuse or abuse of the instrument, or if the guarantee has expired, we shall repair and re-calibrate the instrument. When it leaves our factory it will meet all tests and specifications of a new instrument. The charge for this service is $20.00.

IF WE CAN BE OF ANY ASSISTANCE, PLEASE CALL ON US.

S1 = "FREQUENCY" (x.1 position)
S2 = "OUTPUT RANGE" (10 position)
S3/S4 = "LOAD INT.-EXT" PWR OFF
S5 = "∿" "⊓⊔" (∿ position)



dc = deposited carbon ±1%

403B	403A
R1 = 390M	Not used
R2 = 100M	Not used
C1 = 150 μμf	150 μμf
C2 = 150 μμf	Not used
C3 = 150 μμf	150 μμf
C4 = 150 μμf	Not used
C5 = .5 μf	.1 μf
C6 = .5 μf	.1 μf

Engineering 1/9/62 WHM.

WAVE FORMS MODELS 403A + 403B GENERATORS

Waveforms, Inc. 333 6 AVE.
New York 14, N.Y.
WA.9-2795

DWG#2-1-2-04

403 Parts List

Stock No.	Qty	Price each	Description				
EB1011	1	$ 0.04	Resistor,	Allen-Bradley		½W	100 Ω ±10%
EB1221	1	.04	"	"		"	1.2K Ω ±10%
EB2725	2	.14	"	"		"	2.7K Ω ± 5%
EB4721	3	.04	"	"		"	4.7K Ω ±10%
EB1031	4	.04	"	"		"	10K Ω ±10%
EB5135	2	.14	"	"		"	51K Ω ± 5%
EB5631	1	.04	"	"		"	56K Ω ±10%
EB6831	2	.04	"	"		"	68K Ω ±10%
EB1041	2	.04	"	"		"	100K Ω ±10%
EB2741	1	.04	"	"		"	270K Ω ±10%
EB1061	2	.04	"	"		"	1M Ω ±10%
GB1215	2	.14	"	"		1W	120 Ω ± 5%
GB6815	2	.14	"	"		"	680 Ω ± 5%
DCH39M	1	2.38	"	Phaostron	CAH-2	2W	39M Ω ± 1%
DCH100M*	1	3.00	"	Dale	DCH-2	2W	100M Ω ± 1%
DCH390M*	1	6.00	"	"	"	"	390M Ω ± 1%
DCN60	1	.54	"	Electra	DC½C	½W	60 Ω ± 1%
DCN475	1	.34	"	"	"	"	475 Ω ± 1%
DCN600	2	.54	"	"	"	"	600 Ω ± 1%
DCN660	1	.54	"	"	"	"	660 Ω ± 1%
DCN732	3	.48	"	"	"	"	732 Ω ± 1%
DCN5.94K	4	.48	"	"	"	"	5.94K Ω ± 1%
DCN10K	1	.34	"	"	"	"	10K Ω ± 1%
DCN39K	1	.54	"	"	"	"	39K Ω ± 1%
DCN100K	1	.48	"	"	"	"	100K Ω ± 1%
DCN390K	1	.54	"	"	"	"	390K Ω ± 1%
DCN1M	1	.48	"	"	"	"	1M Ω ± 1%
DCN3.9M	1	.70	"	"	"	"	3.9M Ω ± 1%
DCN10M	1	.80	"	"	"	"	10M Ω ± 1%
P-T600	1	5.16	"T" pad	Mallory (3-deck) 600/600 Ω			±5%
P-CL39-512	1	.30	Pot.	Wirt WC817A			100 Ω ±20%
RH-CL39-102	1	.24	Rheo.	Wirt WC807			1K Ω ±20%
3X330	2	.70	Resistor	Ward Leonard "3X"			330 Ω ± 5%
3X660	1	.70	"	"	"		660 Ω ± 5%
3X6.8K	1	1.10	"	"	"		6.8K Ω ± 5%
10F2000	1	.74	"	"	10F		2K Ω ± 5%
10F6000	4	.84	"	"	"		6K Ω ± 5%
10F10000	1	.84	"	"	"		10K Ω ± 5%
6AU6	1	1.04	Electron Tube,	RCA			
5687	1	3.80	"	"			
6X4	1	.82	"	"			
2N404	4	1.98	Transistor	"			
2864	2	3.14	Diode	"			
1N90	1	.60	"	Hughes			

* Used in 403B only

403 Parts List

Stock No.	Qty	Price each	Description			
C621M1MF	2	$ 01.26	Good-all,	Condenser	663UW	1µf 400V
DM15-471J	1	.40	El-Menco	"	DM15	470µµf ± 5%
DM15-100K	1	.16	"	"	DM15	10µµf ±10%
DM15-330K	3	.16	"	"	"	33µµf ±10%
DM15-680K	1	.16	"	"	"	68µµf ±10%
FP117	4	2.16	Mallory	"		150µf 150V
FP214	2	2.14	"	"		50-50µf 150V
FP227	1	.88	"	"		20-20µf 350V
FP234	1	2.56	"	"		20-20µf 450V
FP227.35	2	3.50	"	"		80-20µf 350V
TS2A4	3	.84	Erie	"	NPOK	4-30µµf
V4	1	6.00	All-Star	"	Variable #3068 Rev.	450µµf
1005	1	5.56	Melco	Power transformer spec. M1202		
1052	1	.68	Westinghouse	1OS6/230V lamp		
1053	1	.18	Gen Elec	#51 lamp		
1073	1	.18	Bussman	MDL 7.5/10 Amp Fuse		
2013	1	.22	Eby	9702 7 pin long shield		
2015	1	.22	"	9704-14 9 pin medium shield		
2026	1	.28	"	9718	9 pin shield base socket	
2025	1	.12	Dialco	6-11 Resistance lamp socket		
2027	1	.28	Eby	9735-11	7 pin shield base socket	
2028	1	.10	Cinch	13499	7 pin mica filled socket	
2032	1	.30	Dialco	755-622	Pilot light socket $\frac{1}{4}$" shank	
2041	1	6.40	Waveforms	Case per 401A		
2066	1	5.10	"	Chassis per 402A		
2074	1	.86	PHC	7800	Handle	
2083	1	.32	Waveforms	Nameplate per 512		
2101	1	.60	"	Dial retaining ring	per 512	
2102	1	.64	"	Drive plate	per 512	
2105	1pr	1.16	"	Condenser brackets	per 512	
2088	1	1.80	"	Elec. cond. bracket	per 512	
2106	1	1.12	"	Shield	per 401A mod.	
2111	1	1.24	Kurz-Kasch	Knob, dial	S312-64BB-X	
-	2	1.04	"	Knob	S656-3L-BB	
-	2	.64	"	"	S645-5L-BB	
-	1	.70	"	"	S647-3L-BB	
2116	1	1.00	Waveforms	Index	per 512	
2118	1	2.14	"	Dial	per 401C	
2136	1	.32	Bussman	Fuse holder	HKP	
2137	4	.50	Johnston	Binding Post	111-103	
2144	2	.08	Cinch	2pt tie pts	2003	
2142	4	.02	"	1pt tie pt	1510A	
-	1	.16	"	4pt tie pt	17-4	
-	10	.05	Mallory	Cond plates	BP-4	
-	1	5.00	Waveforms	Terminal Board set		
2145	4	.04	Atlantic	Bumpers	18B6040	
2146	3	.16	National	Insulators	GS-10	
2149	1	3.00	"	Vernier	SB2231-19	

403 Parts List

Stock No.	Qty	Price Each	Description		
2152	1	.86	Millen	Coupling	39006
2192	1	1.16	Smith	Switch	510
2193	1	.64	Royal	Power Cord	
2196	1	.04	Heyman	Grommet	5P
-	1	3.46	Waveforms	Panel 403A or 403B	
-	1	2/56	"	Panel, rear	
-	1	2.30	Centralab		PA300
-	2	1.32	"		PA32
-	1	1.60	"		1460
-	1	.58	Hudson		DCB
-	1	.12	"		DCC
-	1	2.30	Centralab		PA300
-	1	2.50	"		1450
-	1	2.00	"		PA2
-	1	1.80	"		PA0
-	1	1.46	"		PA37

POWER TRANSFORMER CONNECTIONS

ALL WAVEFORMS instruments may be operated from either 110 V or 220 V (50-400 cps) mains. Connections are shown below.

	110V		220V	
MODEL	LINE TO	STRAP	LINE TO	STRAP
401-2-3	Black,White	Brown-Black Orange-White	Black-Orange	Brown-White
452/454	Black,White	Brown-Black Orange-White	Black-Orange	Brown-White
510/520	Black,Brown	Blue-Black White-Brown	Black,Brown	Blue-White
512	Black,Brown	Blue-Black White-Brown	Black-Brown	Blue-White

Waveforms INC.

OSCILLATORS • VOLTMETERS • TRANSMISSION SETS

for LABORATORY; precise, stable instruments for wide range measurements

for FIELD; convenient, compact units for laboratory performance in the field

for SYSTEMS INSTALLATIONS; rack, half-rack, and special mountings simplify systems use

Model 401C Oscillator

Model 510-R Extended Range Oscillator

Model 520-A Amplifier Voltmeter

Model 512 Sine Wave Generator

400 SERIES OSCILLATORS—Stable, low-distortion Bridged-T oscillators with step (except 401A) & continuous output controls for fine amplitude adjustment over wide range. Output amplitude constant with frequency within ± ½ db; for most frequency response measurements oscillator output need not be monitored. The series provides choice of frequency range, power capability, sine or sine/square wave operation, & low or ultra-low distortion.

401A OSCILLATOR—The ultimate in mechanical quality and reliability at the lowest cost. A basic, inexpensive building-block for systems use.

401 SERIES OSCILLATORS—For sub-audio through ultrasonic and servo applications.

402A OSCILLATOR—A unique instrument for telephony & telemetering use. Output down to —80 dbm readable with ± 1 db accuracy.

403 SERIES OSCILLATORS—For square or sine waves; sine wave properties identical to 401 series.

510B EXTENDED RANGE OSCILLATOR—Wide range, low-distortion output adjustable by log control marked in volts. Delivers lab-quality signals in the field. Fits into briefcase together with 520A Voltmeter. Bolt-on balancing transformers available.

512 SERIES SINE WAVE GENERATORS—No other single instrument produces such signal purity, wide range, & high power level from such a small package (1/10% distortion; 50 volts; 2 watts/600Ω). Output constancy & adjustment features same as 400 Series. Excellent for servo, electro-mechanical, & magamp work.

520A SENSITIVE AMPLIFIER VOLTMETER—Another briefcase-portable instrument for laboratory-grade measurements anywhere. Sensitive and wide-range, yet substantially unaffected by powerline transients. Illuminated 4¼" Weston meter. Smaller and more convenient than any instrument of equivalent performance. Use as amplifier does not affect meter accuracy.

452 SERIES TRANSMISSION SETS—Contain all equipment needed to measure gain, send/receive levels, noise, & frequency response rapidly, accurately, without computations—at all levels mike to line. Continuous tuning & metering (with ± ¼db accuracy 15cps—15KC; ± ½db, 15 cps—50KC; ± ¼db, 10cps—100KC unbalanced). Output level continuously variable —70 to + 20dbm; meter reads —72 to + 52dbm. All common broadcast & telephone impedances. Less than 1/10% distortion. 7 inch relay-rack panel.
452A calibrated in dbm, **$600.** 452B calibrated in VU, **$700.**

454B TWO-TONE GENERATOR — For SSB measurement & intermodulation testing. Simple, reliable design for technician use in the field. Each tone available at up to + 10dbm or, after combination through the hybrid system, at up to + 12dbm. Total cross-modulation products 60db below combined output. Includes level meter.
454B mounted on 7 inch relay-rack panel, **$600.**

precision in miniature **ELECTRONIC INSTRUMENTS**

OSCILLATORS • VOLTMETERS • TRANSMISSION SETS

SUMMARY OF SPECIFICATIONS

Oscillators	Frequency Range	Dial * Accuracy	Bands	Frequency Response	Unloaded Output Volts	Output Power	Distortion	Source Impedance	Power Drain	Weight (lb.)	Size (in.) H x W x D	Price *
401 A	9cps-120KC	±2%	4 Decades	± ½db	10 V	10ma/1000Ω	¼%	V'ble (pot)	40W	12	8 x 6 x 10½	$125
401 B	9cps-120KC	±2%	4 Decades	± ½db	20 V	+22dbm/600Ω	1/10%	600Ω	60W	12	8 x 6 x 10½	$160
401 C	9cps-120KC	±2%	4 Decades	± ½db	20 V	½W/600Ω	¼%	100Ω	60W	12	8 x 6 x 10½	$180
401 D	9/10cps-120KC	±2%††	5 Decades	± ½db§	20 V	+22dbm/600Ω	1/10%	600Ω	60W	12	8 x 6 x 10½	$220
401 E	9cps-1.2MC	±2%	5 Decades	± ½db	20 V	+22dbm/600Ω	1/10%	600Ω	60W	12	8 x 6 x 10½	$225
401 F	9/10cps-1.2MC	±2%††	6 Decades	± ½db§	20 V	+22dbm/600Ω	1/10%	600Ω	60W	12	8 x 6 x 10½	$250
402 A	9cps-1.5MC	±2%	4 Decades & 120KC-1.5MC	± ½db	16 V	+20dbm/600Ω	1/10%	600Ω	60W	12	8 x 6 x 10½	$225
403 A	9cps-120KC	±2%	4 Decades	± ½db	Sine: 20V Square: 20V, p-p	+22dbm/600Ω	1/10%	600Ω 600Ω	70W	12	8 x 6 x 10½	$210
403 B	9/10cps-120KC	±2%††	5 Decades	± ½db§	Sine: 20V Square: 20V, p-p	+22dbm/600Ω	1/10%	600Ω 600Ω	70W	12	8 x 6 x 10½	$250
510 B	18cps-1.1MC	±2% 18cps —210KC ±5% 210KC —1.1MC	4 Decades & 180KC-1.1MC	± ½db 18cps-210KC	10 V	4ma/2500Ω	2/10%	400Ω	40W	6	6 x 4¼ x 6	$150
512	9/10cps-510KC	±2% 9cps —510KC ±5% 9/10 —9cps	5 Decades & 90KC-510KC	± ½db	50 V	2W/600Ω	1/10%	6Ω (55Ωon ½V range)	110W	18	9½ x 7¼ x 11½	$350
512 F	½cps-510KC	±2% 5cps —510KC ±5% 1/2 —5cps	6 Decades	± ½db above 5cps ± 2db below 5cps	50 V	2W/600Ω	1/10%	6Ω (55Ωon ½V range)	110W	18	9½ x 7¼ x 11½	$375

Voltmeter	Accuracy (% full scale)	Voltage Ranges	Input Impedance	Stability	Amplifier	Power Drain	Weight	Size (in.) H x W x D	Price
520 A	3% 20cps-1MC 5% 10cps-2MC Null indication to 4MC	1mv(—60dbm)—300V(+50dbm); 12 overlapping ranges	10MΩ shunted by 24μμf	±1% with line variation 105-130 volts	Max. voltage gain 1000. Max. output 1 volt.	40W	6	6½ x 4¼ x 7½	$220

††±5% on lowest range *†Depth behind panel* *§±2db on lowest range*

ADDITIONAL SPECIFICATIONS—ALL OSCILLATOR MODELS
DIAL ACCURACY: ±2%; ±1% on special order.
HUM: Less than 0.01% rated output (—80db).
FREQUENCY STABILITY: ±½% 105-130 v 0-50°C.
LINE FREQUENCY BEAT: ¼ db maximum excursion in vicinity of supply frequency.
SUPPLY POWER—ALL WAVEFORMS INSTRUMENTS: 105-130 or 210-260 volts, 50-400 cps.

OPTIONAL FEATURES Prices, weights and dimensions above for portable instruments. See Mountings section for instruments designed for systems installation. The 512, 401 and 402 type instruments may be obtained with special decade ranging for non-recurring set-up charge of $200. Instruments may be held to a response far closer than ± ½db over a portion of their range. This can eliminate the need for metering the output in production testing of amplifiers, etc. Send us your specification requirements for quotation.

*Prices shown are for ± 2% calibration accuracy. Add $25. for ± 1% accuracy, any model. Price includes 6 ft. two conductor type SJ line cord. For three conductor line cord add $5.

RACK & PANEL MOUNTING

All Waveforms instruments are available for rack or panel mounting in systems.

PANEL MOUNT — "P"
An oversized front panel is both mounting plate and escutcheon. Instrument installs in rectangular cut-out with 4 screws. Removable for field use. Add suffix "P" to instrument number. **Price: $10.**

RACK MOUNT — "R"
Instrument(s) are assembled on a 7"x19" relay-rack panel. Up to 2 of any instrument described above.
Price: One instrument: **$20.** Two instruments: **$25.**

HALF-RACK MOUNT "1/2R"
One instrument assembled to a 7" x 9½" panel.
Price: $20.

CUSTOM MOUNT — "PR"
A 7"x19" panel cut for up to 3 510B's and/or 520 AP's.
Price: One instrument: **$20.** Each additional instrument: **$5.**

Full Catalog Available. Write for copy.

Waveforms INC.
333 SIXTH AVENUE, NEW YORK 14, N. Y. • WAtkins 9-2795

reprinted from Electronic Engineers Master (eem), 1961 Edition
Printed in U.S.A.