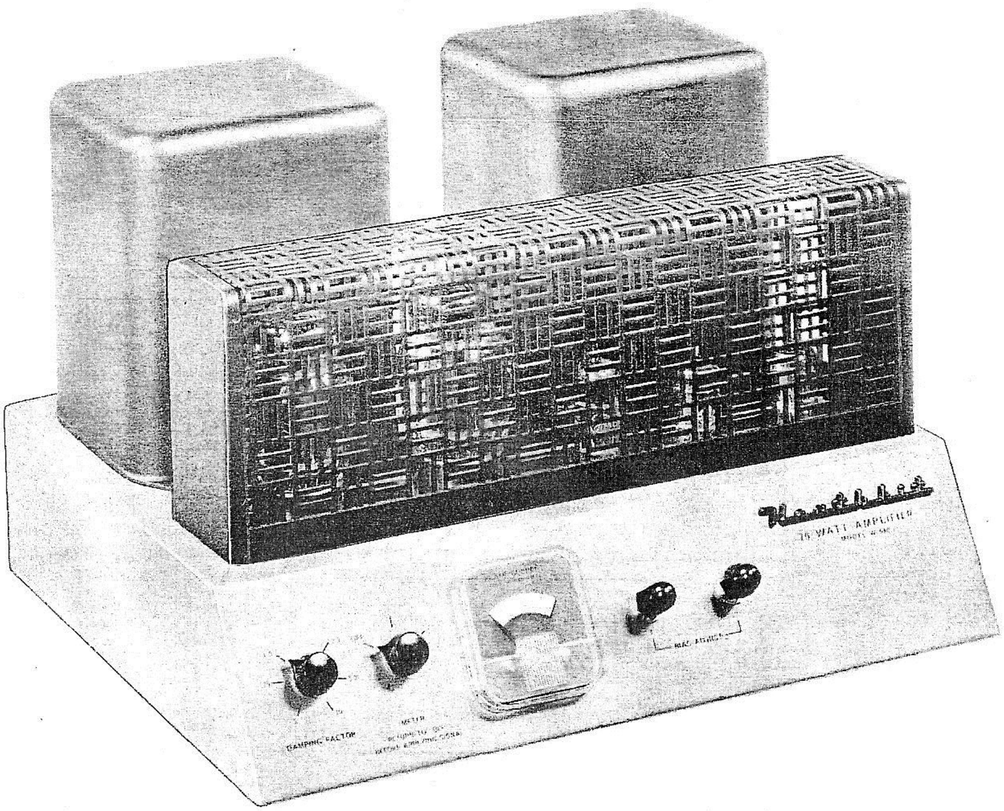
ASSEMBLY AND OPERATION OF THE HEATHKIT HIGH FIDELITY AMPLIFIER

MODEL W-6M

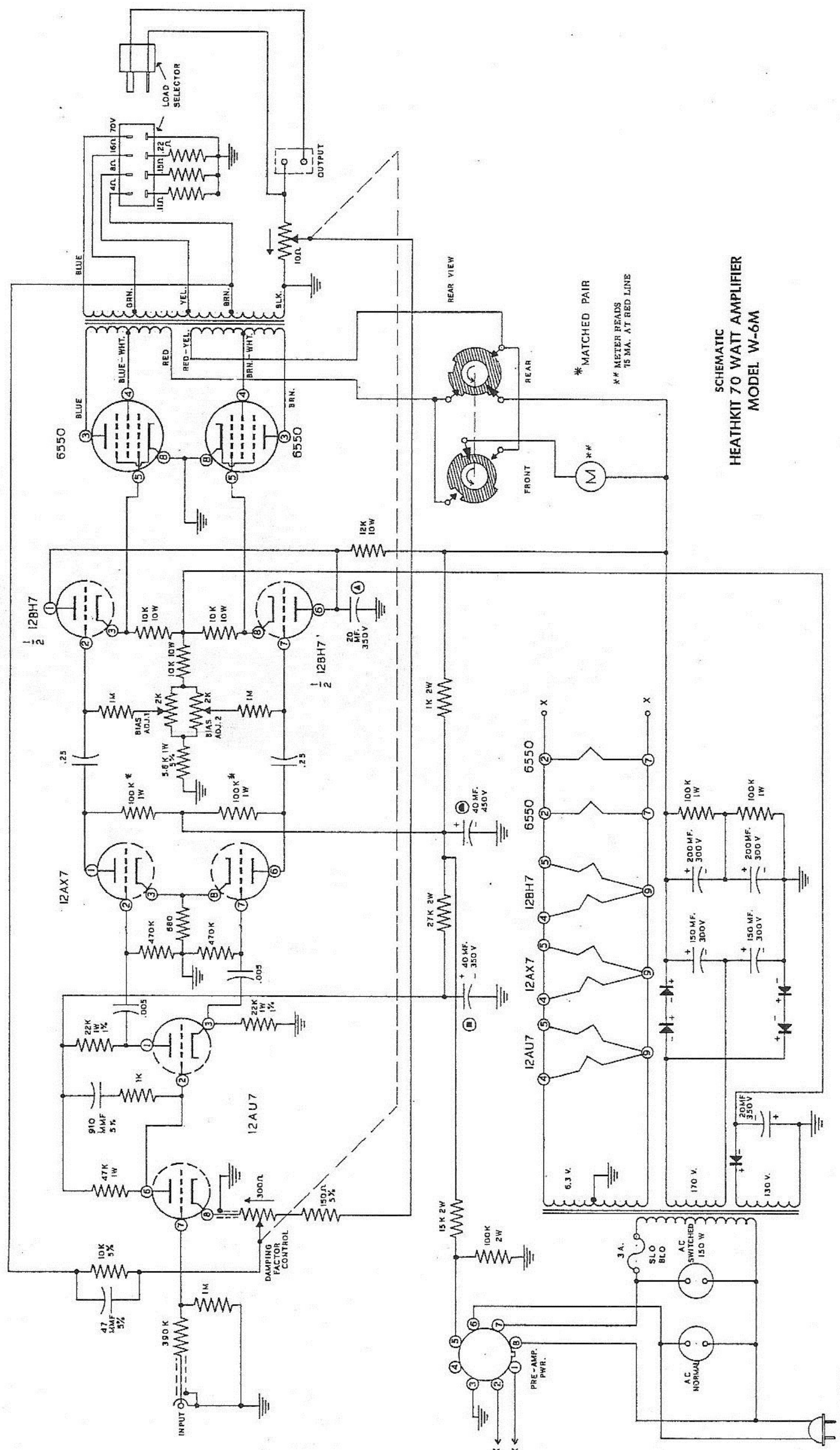


SPECIFICATIONS

The following specifications on the Model W-6M amplifier are presented in the belief that you are entitled to a factual and comprehensive technical report on the performance of the amplifier.

These specifications are based on actual measurements taken on a typical W-6M amplifier, using the most modern and accurate test equipment available today. Measurements were made under the most carefully controlled conditions; not to present the most favorable advertising information, but in strict accordance with all generally accepted standard conditions. These conditions are listed at the end of the specifications.

Minor variations from these specifications may be encountered in kit-assembled amplifiers. Such factors as exact lead placement, component variations and tube characteristics are possible sources of deviations. In a highly stable amplifier such as the W-6M, these variables may be disregarded from a performance point of view.



SCHEMATIC
HEATHKIT 70 WATT AMPLIFIER
MODEL W-6M

POWER OUTPUT:

Rated Power (rms)..................... 70 watts
Peak Power............................140 watts

FREQUENCY RESPONSE:................... ± 0.5 db from 6 to 70,000 cycles at 0.5 watt level. Controlled high- and low-frequency roll-off, for maximum transient stability. The frequency response curve is shown in Figure 1.

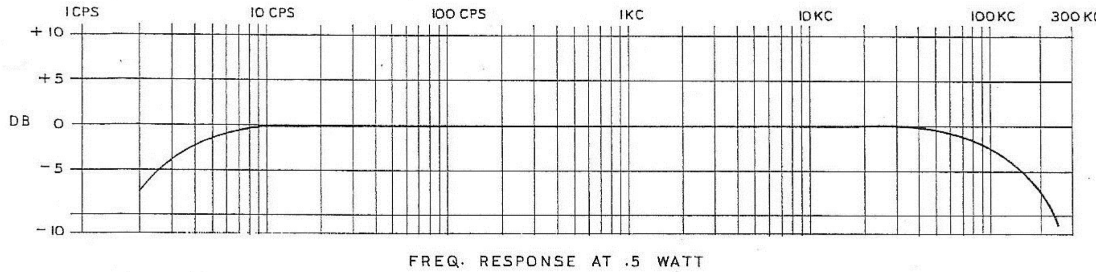


Figure 1

POWER RESPONSE:........................ ± 0.25 db from 20 to 20,000 cycles. See Figure 2. In any amplifier, the output transformer places a limit on the undistorted power output available at very low frequencies. No equipment was available to measure harmonic distortion below 20 cycles; however, the graph of Figure 3, based on oscilloscope observations, shows power levels the W-6M amplifier will deliver at low distortion (essentially a pure sine wave) at frequencies between 5 and 20 cycles.

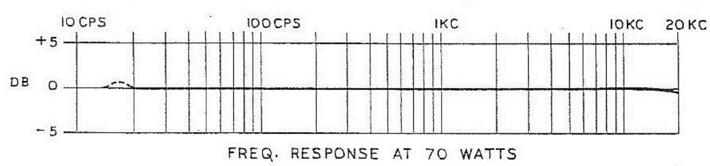


Figure 2

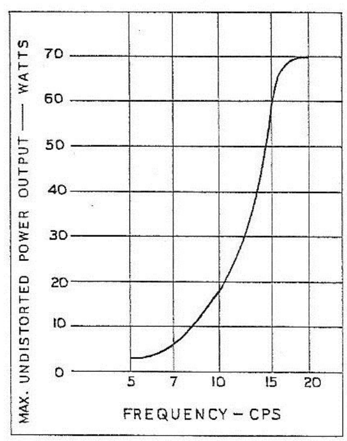


Figure 3

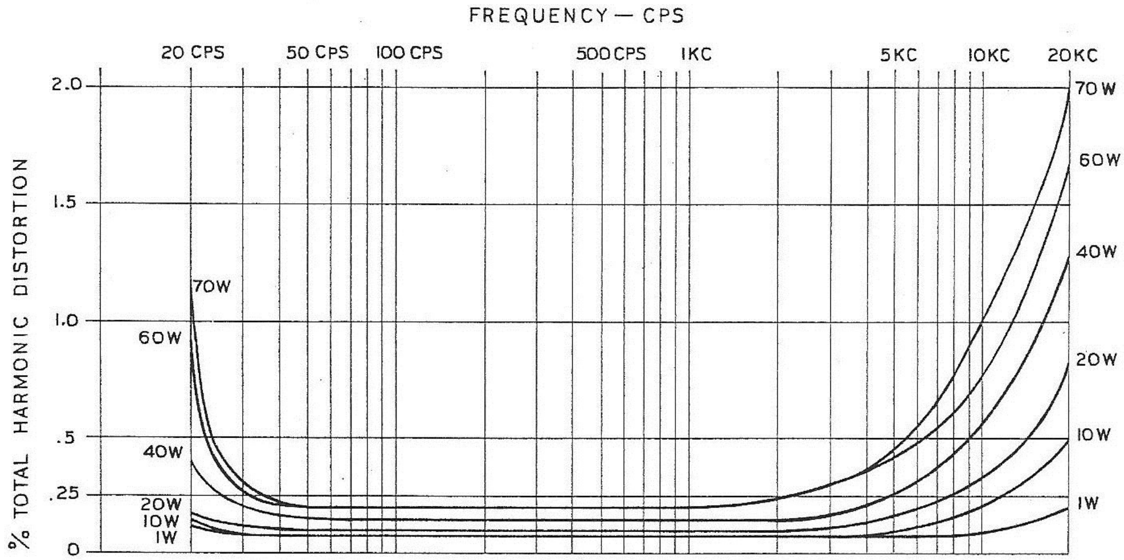


Figure 4

HARMONIC DISTORTION:.................. Figure 4 shows total harmonic distortion versus frequency at several power levels. Competent authorities seem to agree that a total of 2% total harmonic distortion is tolerable for musical reproduction through wide-range audio equipment. Harmonic distortion below 0.7% is completely imperceptible, even to highly trained critical observers. Figure 5 shows the power output obtainable at these distortion levels.

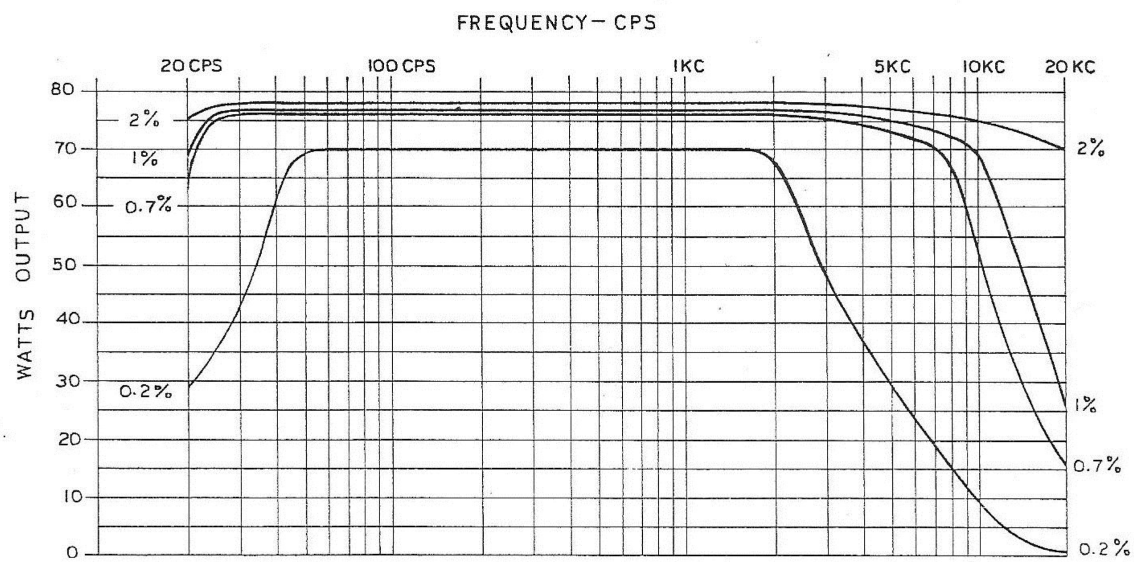


Figure 5

INTERMODULATION DISTORTION: .... Figure 6 shows intermodulation distortion versus power output under two separate test conditions. Note that the generally accepted limit for "extremely high fidelity" amplifiers (1% IM distortion) is not exceeded, even at full rated power.

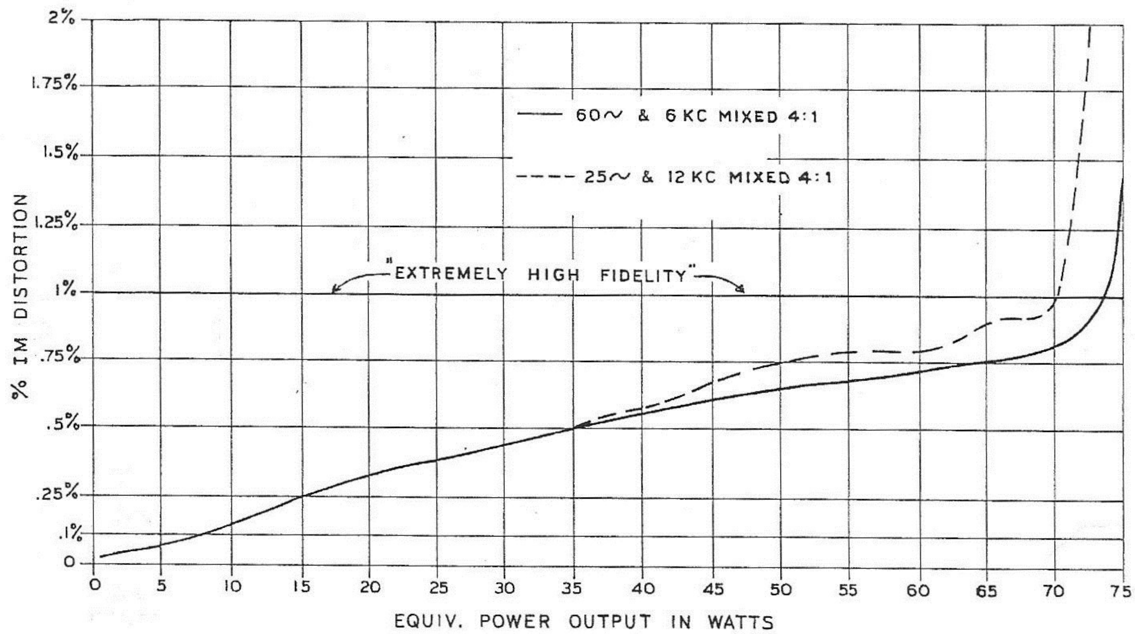


Figure 6

PHASE SHIFT: .... Figure 7 shows phase shift of the amplifier versus frequency, from 3 cps to 100 KC. Note that the phase shift characteristic is a smooth curve, without abrupt changes. This is a further indication of the stability of the amplifier.

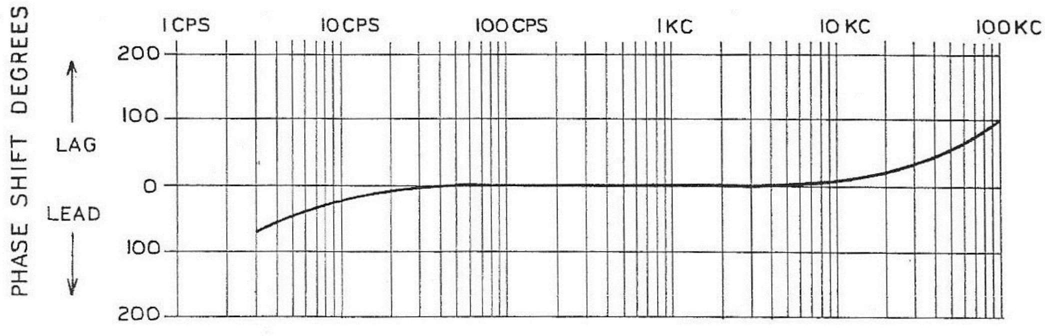


Figure 7

SENSITIVITY:............................. Figure 8 indicates input voltage requirements for any power output level (solid curve). The dashed line shows linearity of output voltage versus input voltage.

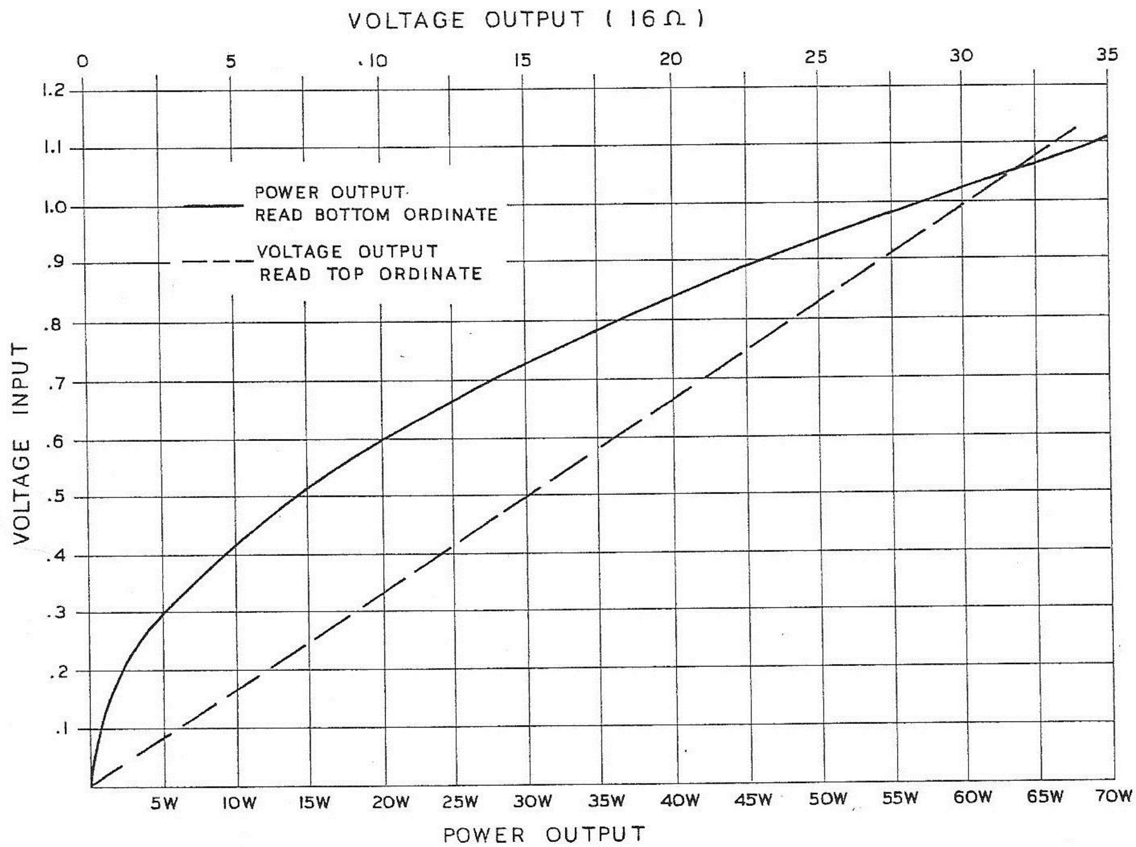


Figure 8

HUM AND NOISE:.......................... 90 db below 70 watts, unweighted.

OUTPUT TUBE BALANCE:.................. Meter, meter switch, and bias adjustments on front chassis apron for convenient and accurate adjustment of plate current and balance of output tubes.

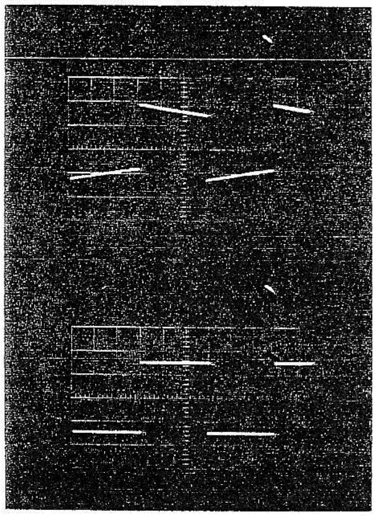
FEEDBACK:.............................. 20 db negative voltage/current feedback is applied around the entire amplifier and output transformer.

INPUT IMPEDANCE:...................... 1.4 megohms.

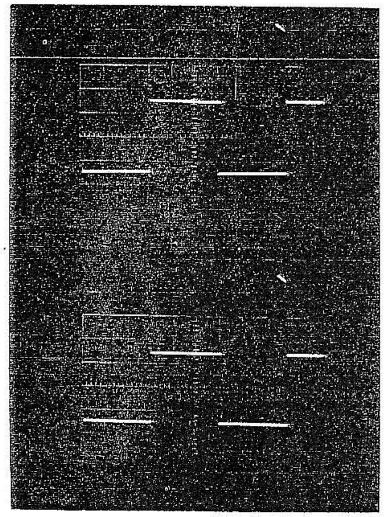
OUTPUT IMPEDANCES:.................... 4, 8, and 16 ohms, and 70.7 volt line output.

DAMPING FACTOR:........................ Variable, from 0.5 to 10 by means of calibrated control on front chassis apron.

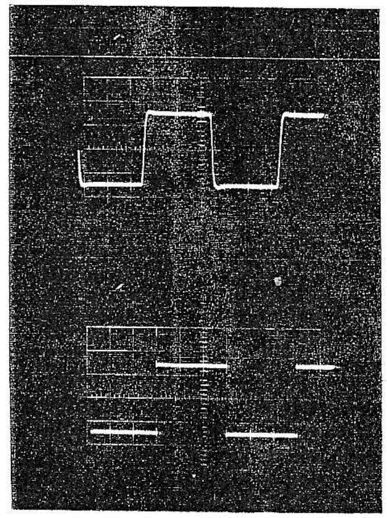
TRANSIENT RESPONSE:.................... Square-wave response characteristics are shown in oscillograms A, B, and C, below.



50 Cycles A



500 Cycles B



10 KC C

In the above oscillograms, the lower trace shows the signal applied to the input of the amplifier; the upper trace is the output signal across a 16Ω load.

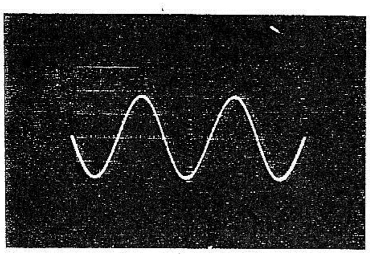
In A, B, and C, note the similarity between the input and output traces. The output wave shape in A is tilted slightly, owing to low-frequency phase shift (approximately 4^{o} at this frequency).

The output wave shape at C, which shows no ringing and negligible overshoot in the presence of a 10 KC square wave, is a rigorous test of high-frequency stability under transient conditions. It should be noted that a square wave of 10 KC will show response characteristics to at least 100 KC and that the transient represented by a 10 KC square wave is far steeper than that found in any known source of program material.

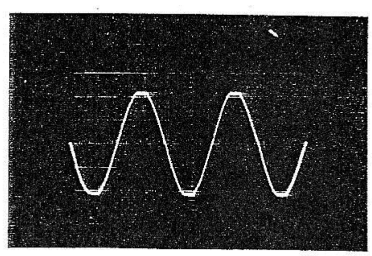
OVERLOAD RECOVERY:

Even a high-power amplifier such as the W-6M may occasionally be subjected to overload by heavy bass passages and transients. But regardless of the rated power output of an amplifier, it is extremely important that the overload be symmetrical, and that recovery after overload be smooth, without oscillation.

Oscillogram D shows the output waveform at 70 watts: note that this is still below the overload point. In oscillogram E, the amplifier is delivering approximately 77 watts, and has begun to overload; observe, however, that the clipping is perfectly symmetrical.

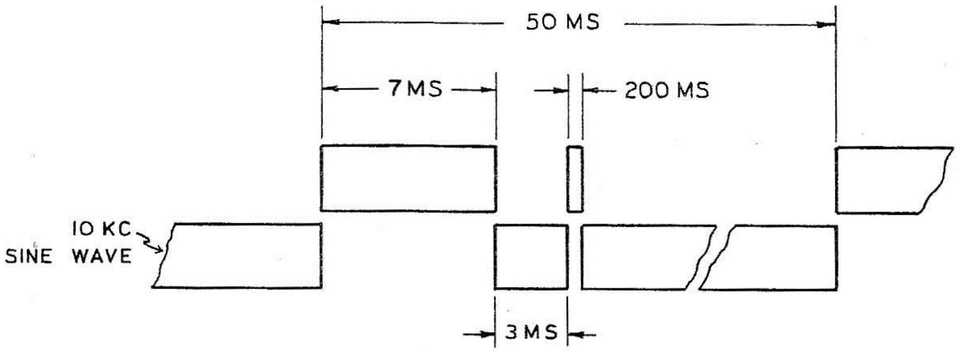


D



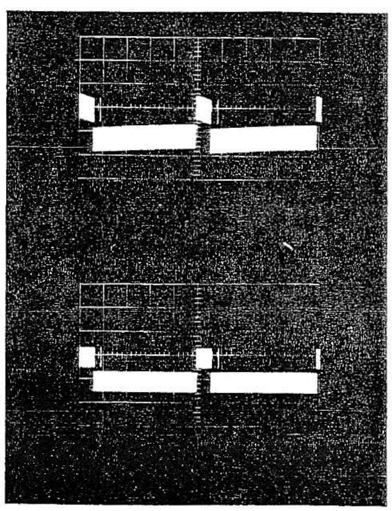
E

Tests for overload recovery were made by applying a special composite signal defined in the sketch below:

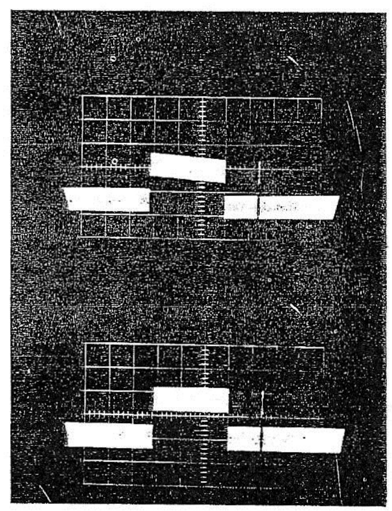


The 10 KC component represents normal mixed program material. The heavy 7 millisecond rectangular pulse simulates an overloading transient of sufficient length to show up any "ringing" or "hangover" effect following the sharp rise in signal level. The short 200 microsecond pulse follows this component after 3 milliseconds. This pulse could be placed at any point on the waveform. Its purpose was to determine if overload recovery was sufficient to faithfully reproduce a short transient immediately following overload.

The results are shown in oscillograms F, G, H, and J. In each case, the lower trace is the input signal to the amplifier; the upper trace is the output signal across a 16 ohm dummy load.



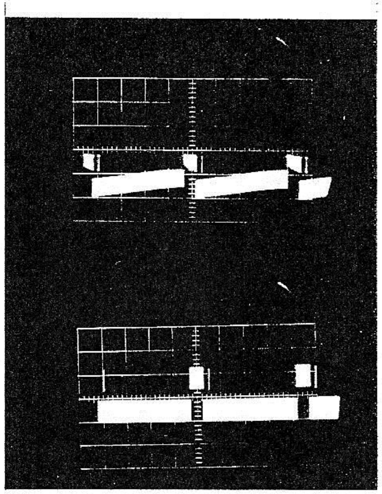
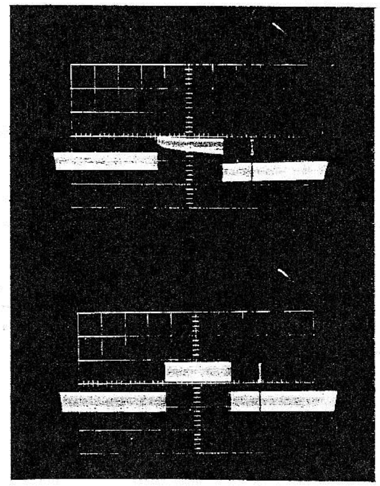
F



G

In oscillogram F, the amplifier is operating well below overload. Vertical sensitivity of the oscilloscope was 20 volts per centimeter; therefore the amplifier is delivering a signal of approximately 45 volts peak-to-peak.

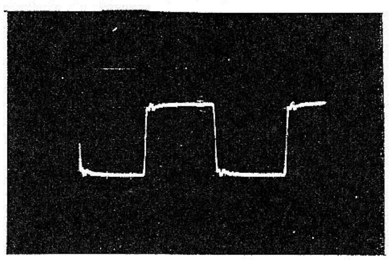
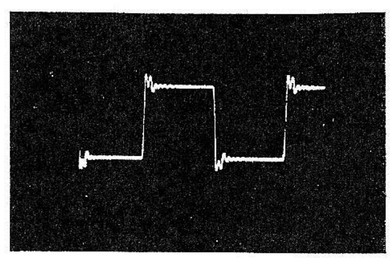
Oscillogram G is a 5 times expansion of oscillogram F. (The tilt observed in the upper trace of F and G is due to phase shift in the amplifier.

H  J 

At H, the test signal has been increased in amplitude; the amplifier is now trying to deliver an output signal of 90 volts peak-to-peak.. Again, J represents a 5 times expansion of this condition. Observe that the 7-millisecond pulse is severely distorted; it has driven the amplifier well into overload. However, the recovery of the amplifier is smooth and gradual, without hangover or ringing. The short pulse is reproduced faithfully, even during the gradual recovery, which is particularly important.

STABILITY

An important criterion of any feedback amplifier is the oscillation stability with no load, and with reactive loads.

K  L 

Oscillogram K shows the 10 KC square-wave response of the W-6M amplifier when driving the Heathkit SS-1 and SS-1B four-way speaker system, from the 16-ohm tap. Only a small degree of ringing is present.

A more stringent test is shown in oscillogram L; this is the 10 KC square-wave response with no load. The amplitude of the ringing is greater than in K, but nevertheless is well below the point of sustained oscillation. As a matter of fact, the W-6M will tolerate shunt capacities up to 1.0 μfd without oscillation, with no other load connected.

MECHANICAL PROTECTION

Decorative tube cover prevents accidental contact with hot tube envelopes. Cover is easily removed without tools. Meter and controls on front chassis apron; connectors and fuse on rear apron.

TUBE COMPLEMENT:.....................	1-12AU7 1-12AX7 1-12BH7 2-6550
RECTIFIER:...............................	Four 500 ma. silicon rectifiers in full-wave voltage-doubler circuit.
INPUT AND OUTPUT TERMINATIONS:	
Input..................................	Standard pin-jack.
Output...............................	Heavy-duty, 2-terminal "barrier strip".

A unique "quick-change" plug and receptacle permits instant selection of output impedance tap, without changing speaker lead connections.

FINISH:..................................	Chassis, satin gold enamel. Cover, satin-black.
POWER REQUIREMENTS:..................	117 volts, 50-60 cycles, 140-225 watts.
ACCESSORIES:............................	Octal socket on rear chassis apron for preamplifier power. Will supply 300 volts at 10 ma and 6.3 volts at 1.0 amperes.
DIMENSIONS:.............................	11 7/8" deep x 9 1/16" high x 14 1/4" wide.
WEIGHT:..................................	43 1/2 pounds
TEST CONDITIONS:	
Load impedance.......................	Dummy load, 16.11 ohms, resistive.
Line voltage...........................	117.0 volts, 60 cycles, regulated.
GENERATORS:............................	For harmonic distortion measurements, Krohn-Hite model 440-A, inherent distortion less than 0.1%. Also used for very low frequency response measurements. For frequency response measurements, Hewlett-Packard model 650-A test oscillator. For square-wave tests, Tektronix type 105 square-wave generator.
DISTORTION:.............................	Total harmonic distortion measurements, Hewlett-Packard model 330-B distortion analyzer. Intermodulation distortion, Heathkit AA-1 audio analyzer.
POWER OUTPUT METERING:...............	Ballantine model 310-A electronic voltmeter, across 16.11 ohm resistive load.
PHASE SHIFT:............................	Advance type 405 precision phase meter.
OSCILLOGRAMS:..........................	Fairchild camera on Tektronix Model 515 oscilloscope.

INTRODUCTION

The question so often heard, "Why do I need 70 watts?" is a logical one since in many situations, 10 watts may be adequate. The answer is that the present upward trend in amplifier power is necessary to keep abreast with other recent advancements in the audio art. As loudspeaker systems have been improved in bass response, their efficiencies have, in general, been reduced; this means more amplifier power for the same acoustic output from the speaker. Another important factor is the ever-increasing dynamic range of LP records and pre-recorded tapes, approaching that found in the concert hall.

This all means that if amplifiers are to be compatible with present day speakers and source material, some increase in amplifier power is inevitable. Even though the full rated power output may be demanded only on the loudest musical passages and transients it is extremely important that the amplifier be capable of supplying the reserve power with negligible harmonic and intermodulation distortion.

The design objectives behind the Heathkit amplifier model W6-M were to provide a high power amplifier of the highest quality, at a price well within reach of the average audiophile. The high degree of performance achieved, through the use of advanced, up-to-the-minute design techniques, is more than sufficient to satisfy the most critical audio connoisseur.

CIRCUIT DESCRIPTION

The circuitry of the W6-M amplifier is simple and straightforward. Signal from the input jack is fed through an isolation network to the grid of one triode section of the 12AU7 tube. Direct coupling is used to feed the amplified signal to the second section of the 12AU7, which operates as a phase-splitter. The push-pull signal from the phase-splitter is fed to the grids of the 12AX7 push-pull amplifier stage. This stage feeds the grids of the 12BH7 cathode follower driver stage. The cathodes of the 12BH7 are direct-coupled to the grids of the 6550 output tubes. Two potentiometers, in the grid return circuit of the driver stage, provide bias adjustment of each output tube. Fixed bias, obtained from a half-wave selenium rectifier, is applied to the output tube grids via the driver cathode resistors.

The output stage is operated in Class AB; the screen grids of the output tubes are connected to taps on the primary of the output transformer. As is well known, this results in greater power output than the triode connection and with much less distortion than the pentode connection.

Uniquely, the W6-M amplifier uses the newly-developed silicon rectifiers in its power supply. These are connected in a full-wave, voltage-doubler configuration and supply 470 volts DC with low ripple content, and at better regulation than could be obtained from vacuum tube rectifiers.

Variable damping is provided, whereby the damping factor of the amplifier may be adjusted from 0.5 to 10, by means of a control calibrated directly in DF. This control is a dual potentiometer connected in a NEGATIVE voltage-current feedback path. As the control is rotated, the ratio of voltage feedback to current feedback changes, thereby changing the effective internal resistance of the amplifier and hence the damping factor, since

$$\text{DAMPING FACTOR} = \frac{\text{LOAD RESISTANCE}}{\text{AMPLIFIER INTERNAL RESISTANCE}}.$$

At the same time the total amount of feedback remains constant. This is important, for it means that the gain and distortion remain constant for any setting of the control. This desirable condition holds for all load impedance taps; likewise, the calibration of the damping factor control remains correct for all load impedance taps.

A "quick-change" plug and receptacle are provided, for selecting the desired impedance tap on the output transformer. At the same time, with this arrangement, the proper current-feedback resistor is automatically placed in the circuit, for the particular speaker impedance. This is a feature not found in all amplifiers incorporating variable-damping. It assures constant OVERALL feedback and damping control action at all impedance taps -- 4, 8, and 16 ohms.

The output transformer is a special Peerless design; among its features are excellence of core material and tightly coupled windings, for minimum distortion from 20 cycles to 20 KC, at full power; high efficiency (low power loss); and complete lack of high frequency resonances (good square-wave response) which contributes to the wide margin of stability of the W6-M amplifier.

In addition, the circuitry of the W6-M amplifier has been carefully engineered to assure freedom from ringing and oscillation. This high degree of stability, at both high and low frequencies may be verified by observing the .5 watt frequency response curve -- See Figure 1. The smooth roll-off below 10 cycles and above 100 KC are indications of unusually wide stability margins.

The excellent power supply regulation and the direct-coupled cathode-follower drivers, minimize grid current effects as the rated power output is approached and exceeded. This results in less than 1% intermodulation distortion at the rated 70 watts; the overload above 70 watts is gradual, and clipping is symmetrical.

A plate- current balance meter and associated switch on the front of the chassis permit the user to quickly and accurately adjust for proper balanced current in the output tubes, for maximum performance and tube life.

An octal socket is provided on the rear of the chassis for preamplifier power. Provision is made for the W6-M amplifier to be turned on and off by a power switch located on the preamplifier-control unit. Although any HIGH QUALITY preamp-control unit may be used with the W-6M, the Heathkit model WA-P2 is recommended as a compatible unit.

Only the highest quality components have been used in your Heathkit W6-M amplifier. In specifying components, generous safety margins have been allowed so that all components are operating well below their maximum ratings. This is your assurance of years of dependable trouble-free operation.

DAMPING FACTOR CONTROL

"Damping Factor" is defined as the ratio of load resistance to the internal resistance of the amplifier. In other words, if the internal resistance of the amplifier is small in comparison with the load resistance (speaker impedance), the damping factor is high, and vice-versa. The term "damping" arises from the fact that cone resonance effects are controlled, or "damped" by the internal resistance of the amplifier, which is effectively in parallel with the speaker voice coil. The lower this internal resistance, the greater the degree of damping or in other words, the higher the damping factor.

It has been found that speaker systems which inherently have a high degree of acoustical damping may be overdamped when used with an amplifier having a high damping factor, with a resulting loss of bass efficiency.

On the other hand, too low a damping factor will result in boomy or "one-note" bass, which is undesirable.

The range of the damping factor control in the W-6M is sufficient for optimum damping of any conceivable speaker system. The proper setting is highly dependent upon the characteristics of the speaker in its enclosure and to some extent, upon the acoustical properties of the room. The adjustment should be made for the best and most clearly-defined bass response. Where an optimum value of damping factor is recommended by the speaker manufacturer, this should be followed. (A damping factor of unity is recommended for the Heathkit model HH-1 Speaker System.)

NOTE: The variable-damping feature is not intended to operate when the 70-volt line output is used. The control should be left in the maximum clockwise position when using this output tap.