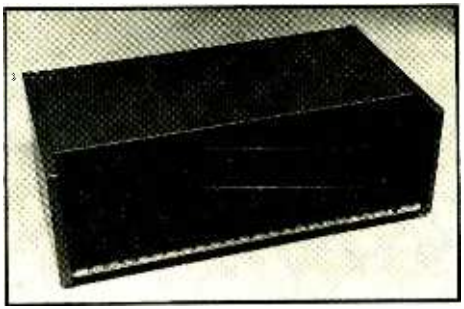
Quad 405 power amplifier



Hugh Ford

MANUFACTURER'S SPECIFICATION
Measurements apply to either channel, with or without the other channel operating.
Power output: The amplifier is intended for use with loudspeakers of 4-16 ohm nominal impedance. Power and distortion for various frequencies, continuous sinewave into 8 ohm resistive load. 100 Hz any level up to 100W <0.01% total, 1000 Hz any level up to 100W <0.01% total, 10 kHz any level up to 100W <0.05% total. For other impedances and frequencies see graphs alongside.
Notes:
1. In addition to the performance into a resistive load R, the amplifier will maintain full voltage within the same distortion rating into a load R+jX where X is any value from zero to infinity.
2. With the additional power limiter inserted the maximum output voltage is limited to 20V rms ±10% (50W 8 ohm) all other performance figures unchanged.

Output internal impedance and offset : 3.3 μH in series with 0.03 ohm. Offset <7 mV.
Frequency response: Ref 1 kHz, low frequency —1 dB at 20 Hz, high frequency —0.5 dB, 20 kHz; —3 dB. 50 kHz.
Signal input level: 0.5V rms ±0.5 dB for 100W into 8 ohms. Amplifier loads the input by 20 000 ohms in parallel with 220 pF.
Signal input slew rate limit: 0.1 V/μs; provided the rate of change of the input voltages does not exceed this figure and the amplifier is not driven into clipping, then the total of all distortions appearing in the audio range (20-20 000 Hz) due to transient or repetitive waveforms with frequency components inside or outside the audio range will be at least 80 dB below full rated power. If the major portion of the input energy is wanted signal then —80 dB (0.01%) represents the maximum possible distortion on programme.
Signal input overload: instantaneous recovery up to +20 dB overload.
Crosstalk: (input loaded by 1k ohm) 80 dB at 100 Hz, 70 dB at 1 kHz, 60 dB at 10 kHz.
Hum and noise: 'A' weighted —95 dB ref full power. Unweighted —90 dB ref full power (15.7 kHz bandwidth).
Protection: The amplifier is suitable for use under the most arduous music conditions and is electrically protected by current limiters; seven amps in-phase current at peak voltage and 3½A at zero voltage. Shorting both outputs simultaneously on signal for an extended period (minutes) is not protected.
Stability: unconditionally stable with any load and any signal.
Power input: 110-120-130V, 220-230-240V, 50-60 Hz, 30-150W depending on signal level.
Dimensions: height 115 mm, width 340.5 mm, depth 195 mm (allow an extra 38mm for plug and socket).
Weight: 9Kg.
Price: £115 plus VAT.

Manufacturer: The Acoustical Manufacturing Co Ltd, 30 St Peter's Road, Huntingdon, Cambs, UK.

IT is always exciting when a new product appears from the stable of the Acoustical Manufacturing Company, who have a long standing reputation for very high quality audio equipment and of course were the originators of the world famous Quad electrostatic loudspeaker.

The new Quad *405* power amplifier is the practical embodyment of the 'Current Dumping Audio Amplifier' described at the 50th Audio Engineering Society Convention by Peter Walker and Mike Albinson. Before proceeding with the details of the review I think that it is appropriate to quote in full the introduction to the paper: 'A new audio amplifier output stage in which the linearity of the main current carrying output transistors has no bearing on the overall amplifier performance, hence the need for biasing and allied problems associated with crossover are eliminated.'

In abbreviated terms, the principle of operation of this new amplifier is that a low power Class A amplifier with full voltage drive capability is used to drive the load at powers up to a few watts. Such an amplifier may be of extremely high quality and not complicated if it is not required to have a high current drive capability. Now, the current drive from this Class A amplifier is sensed, and this is used to control two current dumping transistors which need not be matched as their dumping current is monitored and fed back to the input of the Class A amplifier. It follows that the high current transistors need not be matched, nor is their temperature stability of interest as there are no crossover biasing circuits.

The Quad *405* takes the form of a two channel amplifier based on these principles, each channel being rated at 100W into 8 ohms, which is more than adequate for

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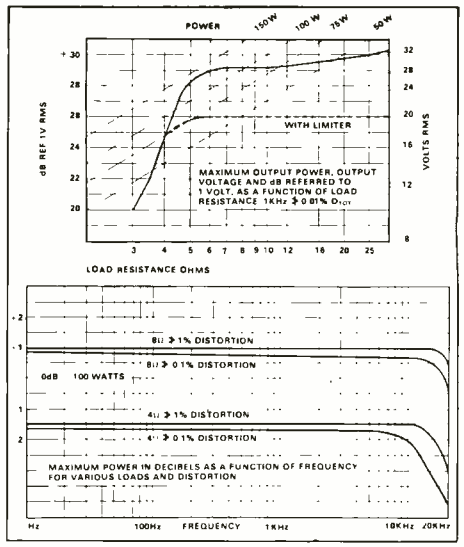
QUAD 405 POWER AMPLIFIER

domestic applications and is sufficient for many studios—that is all studio requirements where the producer doesn't want to 'feel the sound' with less efficient loudspeakers.

The presentation of the amplifier is most workmanlike, with the entire front of the amplifier taking the form of a finned heatsink to which the individual channel amplifiers are bolted as sub-assemblies. The remainder of the housing comprises the moulded plastic sides which are bolted to the heatsink and to which the two 'L shaped' covers are bolted, metal inserts being moulded into the plastic sides to take the bolts where required. No controls as such exist on the amplifier, that is with the exception of the mains voltage selector which covers all the common mains voltages. The power input is via a standard IEC connector, with its associated IEC standard fuseholder which is properly identified with the appropriate fuse ratings.

Signal connections take the form of a four pin DIN socket for the input—I loathe DIN connectors, but this type of connector has been used for the sake of compatibility with the Quad type *33* pre-amplifier. The speaker outputs are spring loaded connectors which take bare wires or AMP pins, and whilst terminal/sockets are much more convenient these are no longer permitted on high voltage amplifiers as a result of International safety regulations. I've never heard of anyone being killed by 100W of music, but it could be a very painful shock.

Internally the standard of construction is really excellent, with first class standards of wiring and construction. Each amplifier is in its entirety accommodated on a single printed board and maintenance is facilitated by every component being identified by screen printing on the boards. Furthermore, a complete amplifier channel may be removed by taking out four screws and then only five push-on type blade connectors. In addition, the instruction book includes a full circuit and parts list, plus the specification and operating hints.



Power output and distortion

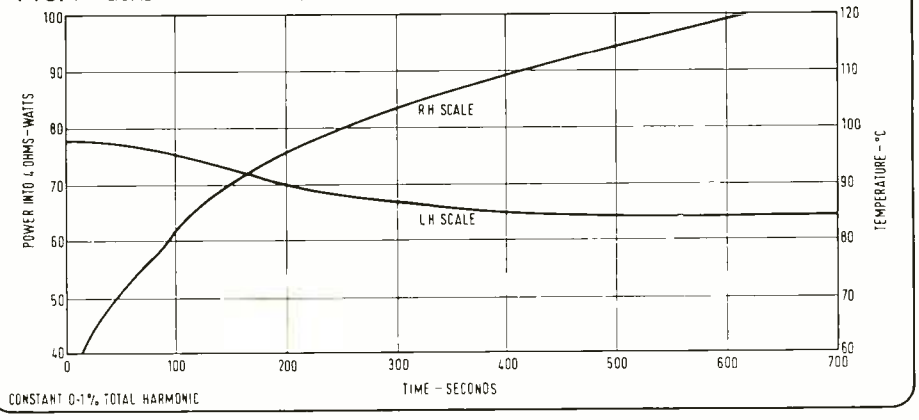
As is my normal practice, very great care was taken to produce accurate results, stabilised power being used to feed the amplifier and accurate (0.1%) digital voltmeters being used to determine voltage levels.

Initially, the power output at the onset of clipping of a 1 kHz sinewave was determined with the following results:

	Output power Left	Right
8 ohm load, both channels driven	122W	117W
8 ohm load, single channel driven	110W	107W
4 ohm load, both channels driven	68W	84W
4 ohm load, single channel driven	60W	78W

These levels are well above the rated power in the case of eight ohm loads and the amplifier did not take exception to driving into eight ohm loads continuously at very high levels. However, in the case of four ohm loads the available power was found to be very temperature sensitive, the above figures being obtained with the amplifier at its idling temperature; that is, the amplifier was left switched on with no

FIG. 1 QUAD 405 POWER / TEMPERATURE / TIME CHARACTERISTICS



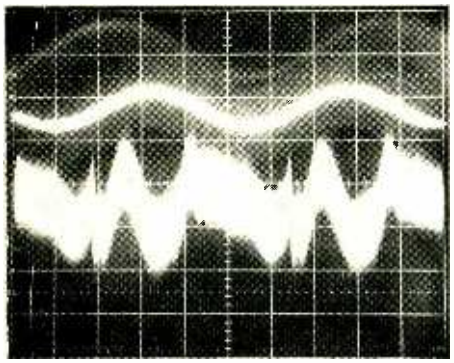


FIG. 2. Distortion components 0.011% at 10 kHz.

signals applied at an ambient temperature of 20°C. **Fig. 1** shows output power for 0.1% distortion at 1 kHz into four ohms and also dumping transistor case temperature plotted against time from idling temperature. It is to be seen that after about six minutes full power (0.1% total harmonic) operation the amplifier has stabilised its continuous drive capability at around 65W into four ohms, but the transistor temperature still continues to rise.

The real point about this issue is that certain loudspeakers with a nominal eight ohm impedance can show practical impedances as low as five ohms at selected frequencies and under these conditions (as with virtually all amplifiers) we are well down in available power; in the case of the Quad *605* the published curves for four ohms loads are rather optimistic, as they display conditions as may be found with a cold amplifier.

Anyhow, returning to the eight ohm performance, the measured distortion at 100W and below into eight ohms was astoundingly good as follows:

	Total Harmonic Distortion	
100 Hz	0.007%	0.006% *
1 kHz	0.007%	0.006% *
10 kHz	0.028%	0.011%
20 kHz	0.055%	0.08%
		* mainly noise

Analysis of the individual harmonics on a single channel gave results at 1 kHz and 100W into eight ohms of 0.005% second and 0.001% third harmonic, and at 1W 0.003% second and 0.004% third harmonic—really excellent results.

Likewise, the distortion performance at 50W and below into four ohms was first class, the following total harmonic measurements being made: at 1 kHz – 0.14%; 10 kHz – 0.02%; 20 kHz – 0.05%. Harmonic analysis at high frequencies showed that the main harmonic was the second and also that there was a notable absence of crossover distortion as is shown in **fig. 2,** which demonstrates 0.011% total harmonic distortion at 10 kHz.

As is to be anticipated, the measured levels of intermodulation distortion were very low, the SMPTE method using 50 Hz and 7 kHz tones in the amplitude ratio 4:1 giving 0.006% at 100W peak equivalent sinewave into eight ohms; it was impossible to measure meaningful results at lower levels due to noise masking the very low distortion products. A notable point made during all the distortion measurements was that the addition of a 2 μF capacitor in parallel with the eight ohm loads made negligible difference to the distortion—an unusual feature of considerable significance.

Before leaving the power output aspect of the amplifier it should be mentioned that by adding a single resistor to each channel (the resistors are supplied with the amplifier) the available voltage drive at the amplifier's output can be limited to 20V rms, so that it is safe to use the Quad *405* with loudspeakers of lower power ratings when this modification is incorporated.

Frequency response and noise

Fig. 3 shows the overall frequency response of the amplifier at 1W into eight ohms and it is noteworthy that this response curve is not only identical for both channels, but also that an identical plot was obtained at 100W into eight ohms. It is particularly nice to find that the frequency response has been carefully tailored at both the high and low frequency end—loudspeakers are just not interested in working below 20 Hz or above 20 kHz and furthermore can be easily damaged by high level 'out of band' signals.

Noise at the output was measured in

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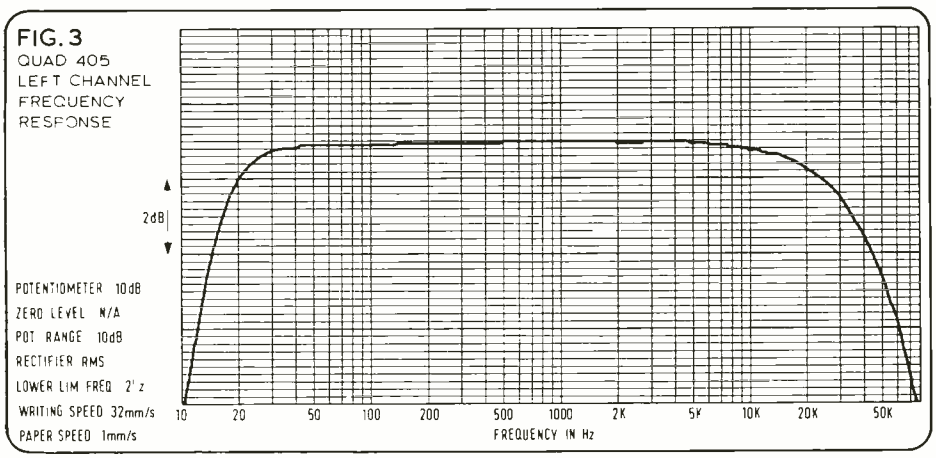


terms of rms noise relative to 100W output into eight ohms with the following results:

	Left channel	Right channel
Unweighted 20 Hz to 20 kHz	—88.2 dB	—88.4 dB
Unweighted 15.7 kHz bandwidth	—90.0 dB	—89.9 dB
'A' Weighted	—92.8 dB	—92.5 dB
CCIR Weighted ref 1 kHz	—83.6 dB	—83.4 dB

It is to be noted that while the 15.7 kHz bandwidth figure is just on the manufacturer's specification, the 'A' weighted figure falls slightly short of specification. Generally, it is felt that the noise performance meets realistic requirements and it was pleasing to find that hum levels in the output were well below noise.

Inputs and outputs

The input sensitivity for 100W output into eight ohms was found to be 0.512V on both channels, with either or both channels operating. Measurement of the input impedance gave an input resistance very close to the specified 20 000 ohms on both channels in parallel with 230/240 pF which is a realistic impedance for matching modern pre-amplifiers. It should be noted that the capacitive component of the input impedance correlates with the current specification, but that the specification has been modified from 50 pF.

Fig. 4 shows the relation between the output impedance and frequency, and serves to confirm the specified output impedance of 0.03 ohms in series with 3.3 microhenries. This works out as a damping factor of 267 relative to eight ohms, a figure which will satisy the damping factor addicts.

Investigations into the amplifier's stability gave first class results, **fig. 5** showing the classical squarewave performance into an eight ohm load in parallel with 2 μF. Overload recovery was also most impressive, the recovery from short tone bursts 10 dB into overload being absolutely clean with no visible distortion outside the overload burst. A less kind test is to drive the amplifier into overload with an asymmetrical waveform. **Fig. 6** shows the result of such a test where 1 kHz asymmetrical waveform as shown in the lower trace has been fed to the amplifier the output of which is shown in the upper trace.

Overall phase shift is small within the audio frequency band as shown in **fig. 7,** and as is to be expected the phase shift increases outside the audio band as a result of the intentional band limiting filters.

Interchannel cross talk was found to be extremely low and far better than specification —7 dB better at all frequencies. In fact, during all amplifier measurements it made virtually no difference if either or both channels were driven, so the power supply design must have been given considerable attention in the design process.

Summary

It is a reviewer's task to pick holes in equipment and also to mention its virtues: when a well respected manufacturer produces a new model every five or ten years it is for some good reason, as opposed to the 'this year's model' attitude of the less respected organisations who just change the colour of the knobs or add a couple of extra loudspeaker terminals for some gimmick which may have an equally gimmicky name.

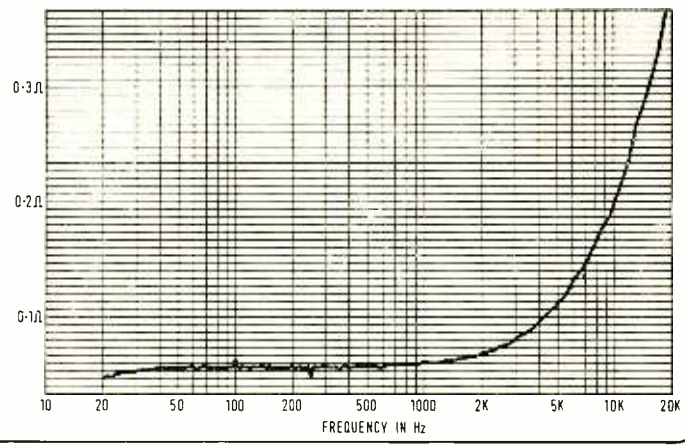
The Acoustical Manufacturing Company has an excellent track record for amplifier design (let alone loudspeaker design), and in spite of the few criticisms which I have of the Quad *405* there is no doubt that this new amplifier ranks amongst the world's best power amplifiers.

For once I will break my rule of excluding subjective comments on equipment (which I regard as highly controversial) and stick out my neck—using a well known high quality loudspeaker which has a peculiarly awkward impedance characteristic the Quad *405* sounds superb.

From a point of view of domestic applications and of monitoring classical material I do not have any reservations about the Quad *405* but I would not recommend the use of 4 ohm loudspeakers—particularly if rock music is to be reproduced at high levels.

On the other hand, an amplifier more suitable for the latter type of use will cost two or three times as much as the Quad if one looks for equivalent performance, and there are few amplifiers which fit in this slot.

FIG. 4
QUAD 405
OUTPUT IMPEDANCE



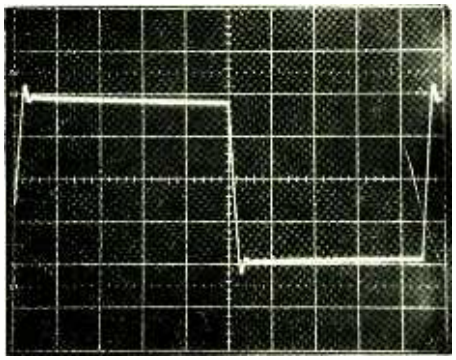


FIG. 5. 8Ω//2 μF, 1 kHz

FIG. 6. asymmetrical waveform, response 1 kHz

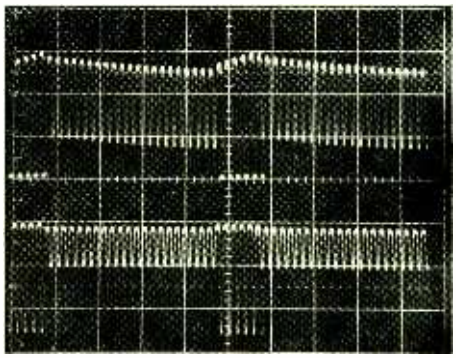


FIG. 7 QUAD 405 PHASE SHIFT