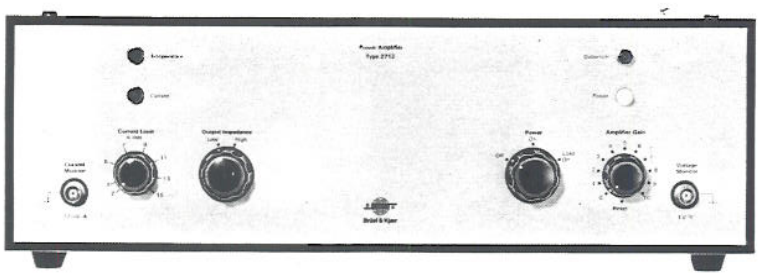
Instruction Manual

2712

Power Amplifier Type 2712



A 180 VA transistorized Power Amplifier for driving small vibration exciters having a permanent magnet field, particularly the Vibration Exciters Types 4808 and 4809 which have a force rating of 112 N (25 lbf) and 45 N (10 lbf) respectively. Its useful frequency range extends from DC up to 100 kHz with full power output available from 40 Hz up to 10 kHz. Extensive protective functions with adjustable output current limit from 2 to 15 A RMS, safeguard against overtesting and system component failures.

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Brüel & Kjær

POWER AMPLIFIER
TYPE 2712

Revision July 1977

CONTENTS

type 2712

180 VA Power Amplifier

FEATURES:

- Direct coupled solid state
- 180 VA power output
- Adjustable RMS output current limit
- Front panel control for Low or High output impedance
- Low distortion over wide frequency range
- Internally protected against current overload
- Extensive built-in protection with three indicator lights
- Front panel voltage and current monitor points

USES:

To drive

- Vibration Exciter Type 4808
- Vibration Exciter Type 4809 safely to full rating
- Vibration Exciter Type 4805 with associated heads at reduced rating

The Power Amplifier Type 2712 has been designed to drive small vibration exciters, particularly the 25 lbf (112 N) Vibration Exciter Type 4808. The RMS output current limit is adjustable, by a front panel control, and therefore this Power Amplifier will also drive the 10 lbf (45 N) Vibration Exciter Type 4809 safely to full rating. (The 2712 can also be used to drive the Vibration Exciter Type 4805 with associated heads at reduced rating.)

The Power Amplifier has a useable frequency range from DC to 100 kHz. The full AC output capability is 180 VA into a 0,8 Ω exciter or resistor load and is available in the frequency range 40 Hz to 10 kHz. The maximum voltage gain is 14 dB. Harmonic content of the output is very small as heavy negative feedback is used. A balanced preamplifier and the use of silicon transistors results in an instrument which can tolerate temperature and supply line variations while maintaining good stability.

Type 2712 can be used as a voltage generator with low output impedance and a flat voltage to frequency response, or as a current generator with high output impedance and a flat current to frequency response.

Description

A simplified block diagram of the Power Amplifier is shown in Fig.1. The instrument consists of an input stage, a preamplifier, a power amplifier and various warning and safety circuits with indication lamps.

Input

Both a capacitively coupled AC input and a direct coupled DC input are provided. Under normal working conditions the signal passes through a FET gate to the preamplifier stage. When the built-in protective circuitry is activated, however, the gate is triggered and disconnects the input signal from the preamplifier.

Preamplifier Section

The type of feedback from the output to the preamplifier stage is selected by the output impedance switch. Voltage feedback is used in the low impedance mode giving constant output voltage and very low output impedance. Feedback proportional to the current flowing in the load is used in the high impedance mode resulting in a constant output current and high output impedance.

Excessive signal levels will saturate the preamplifier and cause distortion of the output waveform. This will trigger the clipping detector which then lights the yellow DISTORTION warning lamp on the front panel. The instrument remains operative in this condition.

Power Output Section

From the preamplifier, the signal is fed to the power output stage. This is directly coupled to the output, and hence to a connected vibration exciter, to eliminate the need for a bulky output transformer. A current limiting circuit prevents instantaneous excessive positive and negative output current peaks.

As well as power amplification the 2712 provides system control and protection functions. During operation the voltage and current levels and waveforms can be inspected at the monitor points provided.

Protection

The Power Amplifier Type 2712 contains protection functions for the Power Amplifier itself and the connected vibration exciter. When triggered, they turn off the FET gate at the input thus disconnecting the input signal. Each triggered protective circuit also lights a red lamp which gives an indication of the reason for equipment shut-down.

Overload protection is provided for excessive coil drive current. This feature enables the 2712 to safely drive vibration exciters with different maximum current ratings. A front panel control is used to preset the true RMS output current at which the circuitry trips. The limit can be set anywhere between 2 A and 15 A RMS. The signal to the exciter is switched off if the preset driving coil current is exceeded, and the red CURRENT lamp will light.

The power output stage is protected by a temperature sensing safety device. Abnormal load conditions, high ambient temperatures or short circuited output can result in output transistor temperatures that exceed design limits and lead to transistor failure. To prevent such damage the temperature protective circuitry blocks the amplifier input signal, and the red TEMPERATURE lamp will light. Also excessive temperature of a power transistor triggers the protective circuitry and lights the lamp. Resetting after both current and temperature shutdown is made simply by turning the amplifier gain control fully counter-clockwise.

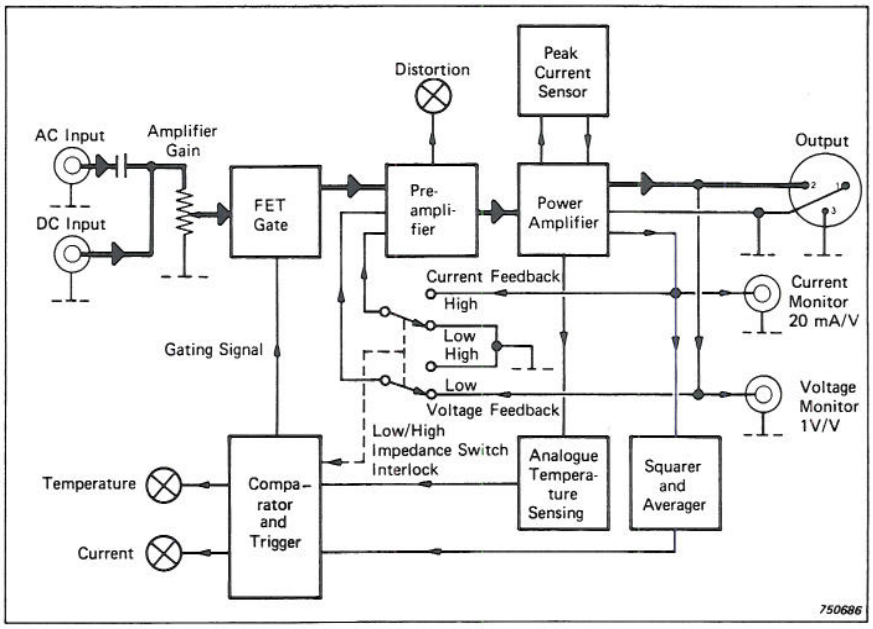

Fig. 1. Simplified block diagram of the Power Amplifier

Specifications 2712

Power Output Capacity:
180 VA into a 0,8 Ω exciter or resistor load at 25°C and nominal mains voltage
144 VA into a 1 Ω exciter or resistor load at 40°C or at 10% above nominal mains voltage
(3-pin Cannon socket at rear panel)

Output Voltage Capacity:
12 V RMS, DC to 15 kHz

Output Current Capacity:
7,5 A RMS at or below 5 Hz
15 A RMS, 40 Hz to 10 kHz
12 A RMS at 15 kHz

Frequency Range:
Full capacity: 40 Hz to 10 kHz
Reduced capacity: DC to 100 kHz

Frequency Response:
Typical small signal response in low impedance mode:
DC Input: DC to 15 kHz ± 0,5 dB
DC to 100 kHz ± 3 dB
AC Input: 15 Hz to 15 kHz ± 0,5 dB
(2 separate BNC sockets at rear panel)

Input Impedance:
> 10 kΩ

DC Stability:
Less than 50 mV drift from 0 V for ± 10% variation of mains supply from nominal, and for 10 to 40°C (50 to 104°F) variation in ambient temperature

Protection:
Input signal is removed and an indicator lamp is lit when the following parameters exceed preset limits:
Driver Coil Current — true RMS adjustable limit 2 to 15 A
Power Transistor Temperature
Heat Sink Temperature
Front panel indication is provided for Output Signal Distortion — no shut-down

Low and High Impedance:

	Low Impedance	High Impedance
Gain at 1 kHz	5 V/V ± 2 dB	8 A/V ± 2 dB
Output Impedance	< 0,02 Ω 5 Hz to 1 kHz < 0,05 Ω DC to 15 kHz	> 20 Ω 5 Hz to 1 kHz > 50 Ω 20 Hz to 300 Hz > 80 Ω 40 Hz to 100 Hz
Harmonic Distortion (full capacity)	< 0,2% 5 Hz to 5 kHz < 0,5% 5 kHz to 15 kHz	< 0,4% 5 Hz to 2 kHz < 1% 2 kHz to 15 kHz
Noise and Hum (below full output)	at least 80 dB	at least 70 dB

Other Features:
Electronic peak current limiting
Voltage and Current monitor points (front panel BNC sockets)

Temperature Range:
5 to 40°C (41 to 104°F)

Power Requirements:
Single phase 100, 115, 127, 150, 220, 240, V RMS, ± 10%
Complies with safety class I of IEC 348

Cabinet:
Supplied as model A (light-weight metal cabinet), B (model A in a mahogany cabinet) or C (as A but with flanges for standard 19" racks)

Dimensions: (model A)
(excluding feet, knobs etc.):
Height: 133 mm (5,2 in)
Width: 430 mm (16,9 in)
Depth: 200 mm (7,9 in)

Weight: (model A)
14,5 kg (32 lb)

Accessories Included:
1 3-pin Cannon Plug JP 0308
3 BNC Plugs JP 0035
1 Mains Cable AN 0010
Various fuses

2. CONTROLS

2.1. FRONT PANEL

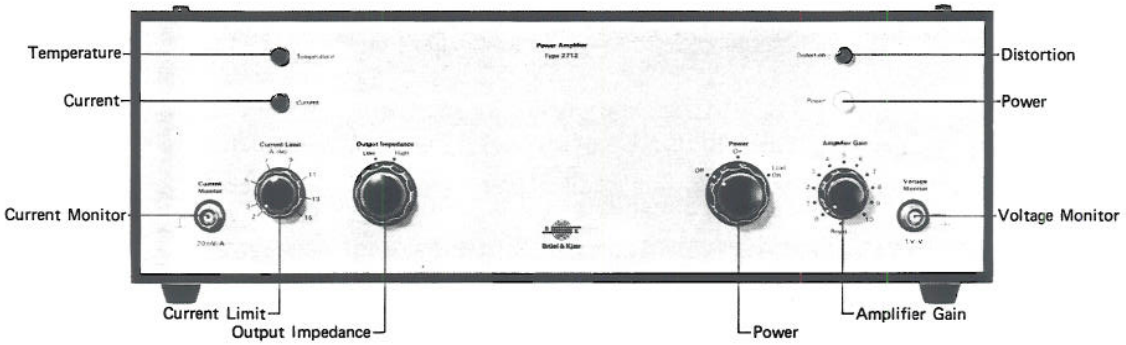

Fig.2.1. Front Panel of 2712

POWER: Three position switch for connection of power to the Amplifier and Vibration Exciter. The positions are:

"Off". Power off position. Mains supply and Exciter power lines are disconnected internally.

"Power On". Stand by position. Connects the mains supply leaving Exciter power lines disconnected. The white POWER lamp and Amplifier cooling fan should function.

"Load On". Exciter power lines are connected ready for operation.

Note: Never switch directly from "Power On" to "Load On". First wait a few seconds and ensure that the AMPLIFIER GAIN control is set to its "Reset" position. This will prevent a power surge which can cause automatic shut down of the Amplifier as well as a severe mechanical transient with the Exciter.

AMPLIFIER GAIN: Single turn potentiometer for adjustment of the Amplifier power output level to the Exciter. It has a click-stop "Reset" position for restoring operation of the Amplifier after automatic shut down when the red TEMPERATURE and CURRENT warning lamps are lit.

CURRENT LIMIT: Single turn potentiometer for adjustment of the Amplifier output current limit between 2 and 15 A RMS. Should be set to the maximum

drive current of the particular Exciter employed. Above the selected limit the Amplifier will be automatically shut down to protect the Exciter.

The CURRENT LIMIT protection circuitry employs a 60 s time constant matching the thermal-time constant of B & K Exciter moving coils.

OUTPUT IMPEDANCE: Two position switch for selection of feedback and output impedance mode. The positions are:

"Low". Provides constant voltage characteristics independent of test object changes on the Exciter. Gives best acceleration waveform and is therefore preferable for most vibration tests.

"High". Provides constant current characteristics, keeping generated force independent of test object changes.

VOLTAGE MONITOR: A BNC socket providing an output of the Amplifier voltage waveform (including DC component) for display on an Oscilloscope. It is direct coupled to the POWER OUTPUT socket on the rear panel and has an output sensitivity of 1 V/V.

CURRENT MONITOR: A BNC socket providing a phase inverted output of the Amplifier output current waveform (including DC component) for display on an oscilloscope. The output sensitivity is 20 mV/A.

Aside from the white POWER "On" lamp, there are three other indicator lamps on the front panel. These are:

TEMPERATURE: Red warning lamp indicating automatic shut down of the Amplifier when maximum operating temperature of power output transistors exceeded. To resume operation, see section 3.4.

CURRENT: Red warning lamp indicating automatic shut down of Amplifier due to excessive drive current. To resume operation, see section 3.4.

DISTORTION: Amber lamp indicating clipping of current and voltage output waveform to the Exciter. The Amplifier will continue to operate, but the input drive level must be reduced to resume normal operation.

2.2. REAR PANEL

SIGNAL INPUT DC: BNC socket providing a direct coupled input to the Amplifier. Enables a DC offset voltage to be applied for centring the vibration table of an Exciter when this is statically offset by heavy test specimens. The input impedance is 10 KΩ. Full output is produced by an input signal of 3,4 V peak.

SIGNAL INPUT AC: BNC socket providing a capacitive coupled input to the Amplifier. The —0,5 dB lower limiting frequency is between 10 and 15 Hz. Full output is produced by an input signal of 2,4 V RMS.

POWER OUTPUT: Power output socket accepting the 3 pin Cannon plug WK-C3-32C (B & K order no. JP 0308) provided, for connection of an Exciter as dis-

cussed in section 3.2.2. For full output power of 180 VA the moving coil of the Exciter should have a nominal load impedance of 0,8 Ω.

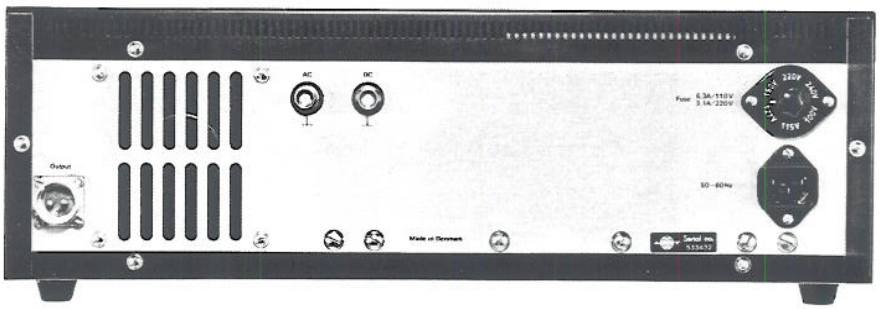

Fig.2.2. Rear Panel of 2712

MAINS VOLTAGE SELECTOR AND FUSE:

Voltage selector for operation of the Amplifier from a 100, 115, 127, 150, 220, 240 V (50 to 60 Hz) single phase AC mains supply. To select the correct voltage setting or change the fuse, see section 3.2.3.

MAINS INPUT:

Input socket accepting the power cable AN 0010 provided for connection of a mains supply as discussed in section 3.2.3.

3. OPERATION

3.1. PRELIMINARY

3.1.1. Rack Mounting

Power Amplifier Type 2712 may be used free standing on its four rubber feet or, with the addition of two Mounting Brackets KS 0023, may be mounted in a 19 inch instrumentation rack. The brackets are available on separate order and bolt into the slots at the front of the Amplifier side panels. The slots are hidden by a plastic cover strip which may be slid out after removing the bottom panel of the Amplifier and levering off the plastic clips at the bottom of each strip.

3.1.2. Ventilation

Forced air cooling of the 2712 enables it to be operated at ambient temperatures up to 40°C (104°F). At higher temperatures protective circuitry automatically shuts down the Amplifier to prevent overheating of its power output transistors.

With approximately 225 VA being dissipated as heat with the 2712 it is important that the flow of cooling air reaching the power output transistors is not interrupted. The ventilation grills on the side and rear panels of the Amplifier should therefore be kept free of obstructions.

3.2. SYSTEM CHECKS AND CONNECTIONS

Before connecting a mains supply the following system checks and connections should be carried out to ensure the correct function and safe operation of the apparatus.

3.2.1. Internal Supply Connections

The 2712 is delivered with the 21 V secondary taps of its mains transformer connected as shown in Fig.3.1. This is suitable for operation of the Amplifier with vibration exciters having a nominal load impedance greater than 0,76 Ω — namely the B & K Vibration Exciter Types 4808 and 4809. For operation with vibration exciters having a nominal load impedance equal to or less than 0,76 Ω — namely the B & K Exciter Body Type 4805 with interchangeable Exciter Heads Type 4811, 4812, 4813 and 4814 — the 19 V secondary tap connections shown in Fig.3.2 should be employed.

The secondary tap connections are a push fit type and are accessible on removing the Amplifier top panel which is fastened by two screws on the rear panel. The wrong secondary voltage will not harm the Amplifier, but will limit its maximum power output capability which depends on exciter load impedance as discussed in section 4.2.

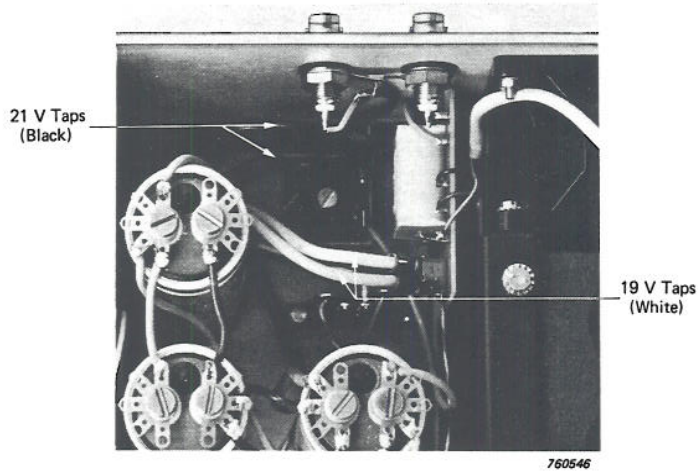

Fig.3.1. Internal connections for operation of the 2712 from its 21 V secondary taps

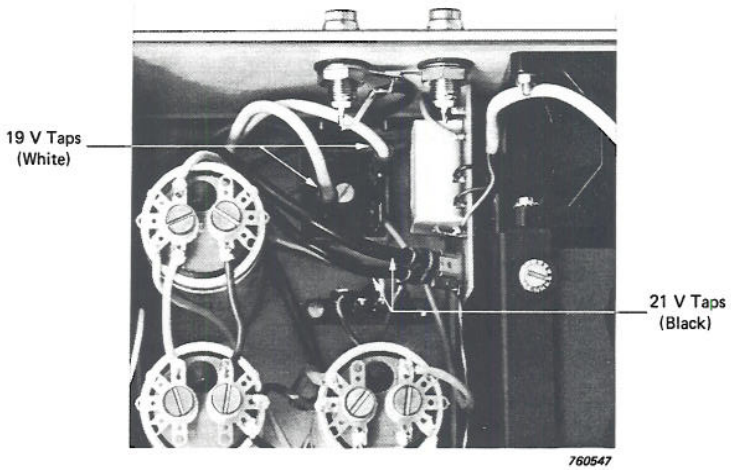

Fig.3.2. Internal connections for operation of the 2712 from its 19 V secondary taps

3.2.2. Exciter Connections

The POWER OUTPUT socket of the 2712 accepts the 3 pin Cannon plug WK-C3-32C (B & K no. JP 0308) provided, and has the pin identities shown in Fig.3.3.

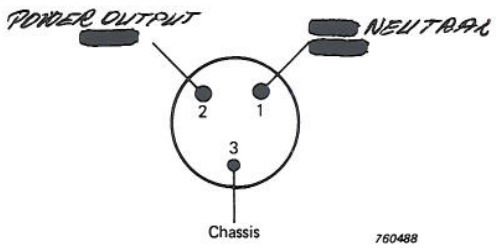

Fig.3.3. 2712 POWER OUTPUT socket (external view)

For connection to Vibration Exciter Type 4808 and to the interchangeable Exciter Heads Type 4811, 4812, 4813 and 4814 of Exciter Body Type 4805, the respective Drive Cable AQ 0095 and AQ 0026 should be used. These are supplied with the Exciters and have the plug connections shown in Figs.3.4 and 3.5 respectively.

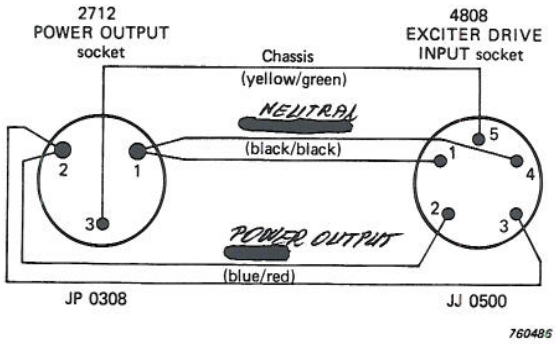

Fig.3.4. Drive Cable AQ 0095. Soldering side of plugs shown

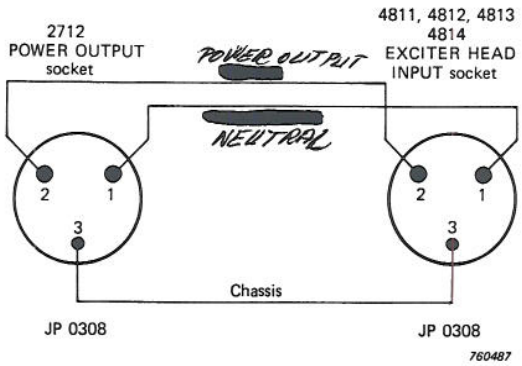

Fig.3.5. Drive Cable AQ 0026. Soldering side of plugs shown

For connection of the 4809 or other types of vibration exciter a suitable drive cable will have to be made up individually. For this purpose pin 1 (live) and pin 2 (neutral) of the POWER OUTPUT socket should be connected to the Exciter using the 3 pin Cannon plug provided.

3.2.3. Mains Supply Connections

The 2712 may be powered from a 100, 115, 127, 150, 220 or 240 V (50 to 60 Hz) single phase AC mains supply. Before connecting the supply the following checks and adjustments should be made.

Voltage setting

The mains voltage setting is displayed in the window of the VOLTAGE SELECTOR on the rear panel of the Amplifier. To select the correct mains voltage setting, press in the knob at the centre of the selector and turn it counter clockwise to release it. Behind the knob are some slots which with the aid of wide blade screwdriver may be used to turn the selector so that its white line points to the correct line voltage setting (± 10%).

Fuse check and replacement

The mains fuse is contained in the knob at the centre of the VOLTAGE SELECTOR. For 100 to 150 V mains supplies the fuse should be a 6,3 A slow blow (B & K order no. VF 0044), whilst for 220 and 240 V supplies it should be a 3,1 A slow blow (B & K order no. VF 0019). Both types of fuse are provided.

Note: Make sure that only fuses with the required rated current and of specified type are used for replacement. The use of mended fuses and of short circuiting of fuse holders should be avoided.

Supply connections

Once the voltage setting and fuse have been checked the mains supply may be connected to the MAINS INPUT socket of the Amplifier using the Power Cable AN 0010 provided. To fit a suitable plug to the cable, see Fig.3.6.

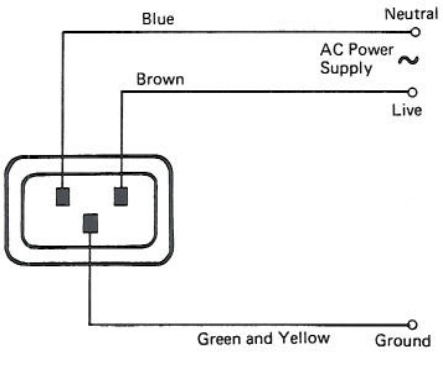

Fig.3.6. Connection of mains supply to MAINS INPUT socket of the 2712

For maximum operating safety it is recommended that the protective (green/yellow) conductor of the cable be connected to a suitable earth, such as the earth contact of a mains outlet socket. The use of an extension cable without protective conductor should be avoided.

3.2.4. Grounding Considerations

When using the 2712 together with other mains operated equipment in complex measurement set-ups, hum pick-up by ground loops may be produced. To prevent this it is necessary to ensure that the instrument set-up is properly grounded. This can be done as follows:

1. Connect the signal ground lines of all the instruments together. This is automatically done through the screens of the cables used to interconnect their input and output sockets.

2. Connect the signal ground line and chassis of the 2712 to the earth of a mains supply. This can be done using the MAINS INPUT socket connections shown in Fig.3.6.

3. Make the necessary adjustments such that the chassis of the other instruments are connected to one and only one of the following points a) mains ground, b) signal ground or c) chassis ground of an instrument which must eventually be returned to mains earth.

4. If a vibration exciter is employed, check that its housing is not grounded by the surface on which it is resting. Also isolate grounded test specimens and measurement transducers from the vibration table of the exciter.

3.3. OPERATING PROCEDURE

After making the system checks and connections given in section 3.2, apply the following setting up procedure to commence operation.

1. Set Power Amplifier controls:

POWER SWITCH	"Off"
AMPLIFIER GAIN:	"Reset" click-stop position
CURRENT LIMIT:	Maximum current limit of Exciter moving coil or of Amplifier, whichever is the smaller. Consult manufacturers data for particular Exciter employed and refer to Figs.4.3 and 4.4 of this Manual.
OUTPUT IMPEDANCE:	"Low" for the best acceleration waveform. "High" for force related tests. See section 4.2.

2. Connect the output of a Vibration Control Generator, such as B & K Type 1023, 1026, 1027 or 1047, to the AC or "DC" INPUT socket on the rear panel of the Power Amplifier. Adjust the output voltage controls of the generator for zero output.

3. On the POWER AMPLIFIER set:

POWER SWITCH:	"Power On" and then wait a few seconds before selecting "Load On" to connect the Amplifier output to the Exciter.
GAIN CONTROL:	Fully clockwise position "10".

4. Set the Vibration Control Generator to the required vibration test frequency and slowly turn up its output voltage level until the required vibration level is obtained on vibration table of the Exciter.

   If the amber DISTORTION lamp lights or the maximum displacement limit of the Exciter is exceeded causing the vibration table to knock against its end stops, then adjust Control Generator output voltage to a lower level in order to resume normal operation.

   For swept frequency vibration testing tune the Exciter Control Generator to the lowest frequency of interest so as to check that the Exciters low frequency displacement limit is not exceeded.

5. To set the Amplifier to Stand-by during the course of a test, return the GAIN CONTROL to "Reset" and the POWER SWITCH to "Power On". At the end of a test set the POWER SWITCH to "Off".

3.4. WARNING LAMPS AND FAULT DETECTION

If one of the red warning lamps light then a fault will have occurred in the system. Under such circumstances a vibration test will be automatically stopped in order to protect the Amplifier and Exciter. To help establish the cause of shut down a list of probable faults is given in Table 3.1.

Warning Lamp	Probable Fault
CURRENT	Input drive level too high for CURRENT LIMIT setting. OUTPUT IMPEDANCE switched before turning GAIN CONTROL to "Reset". Wrong output connections to Exciter.
TEMPERATURE	Overdrive at low frequencies. Wrong output connections to Exciter. Vibration laboratory temperature too high. Force cooling system of Amplifier blocked. Damaged power output transistor.

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Table 3.1. Fault detection

If incorrect Amplifier control settings or Exciter connection cause shut-down, turn the AMPLIFIER GAIN control to its "Reset" position and make the necessary adjustments. Normal operation may then be resumed by returning the AMPLIFIER GAIN control to the position used for test.

Should the shut-down occur as a result of an internal fault within the Amplifier or Exciter then the test must be discontinued by setting the AMPLIFIER GAIN control to "Reset" and the POWER switch to "Off". To remedy an internal fault the relevant service Instruction Manual for the Amplifier and Exciter should be consulted.

4. CHARACTERISTICS

4.1. SIGNAL INPUTS

The SIGNAL INPUTS of the 2712 have a minimum input impedance of 10 kΩ. The AC SIGNAL INPUT is for connection of an Exciter Control generator and is capacitive coupled giving a —0,5 dB lower limiting frequency of approximately 15 Hz. The DC SIGNAL INPUT is direct coupled enabling a DC offset voltage to be applied for centring Exciter tables which are statically displaced by heavy vibration test specimens.

The maximum input voltage with the AC and DC SIGNAL INPUTS is 3,4 V peak. With higher input levels the drive signal is clipped causing the DISTORTION lamp of the Amplifier to light.

4.2. POWER OUTPUT

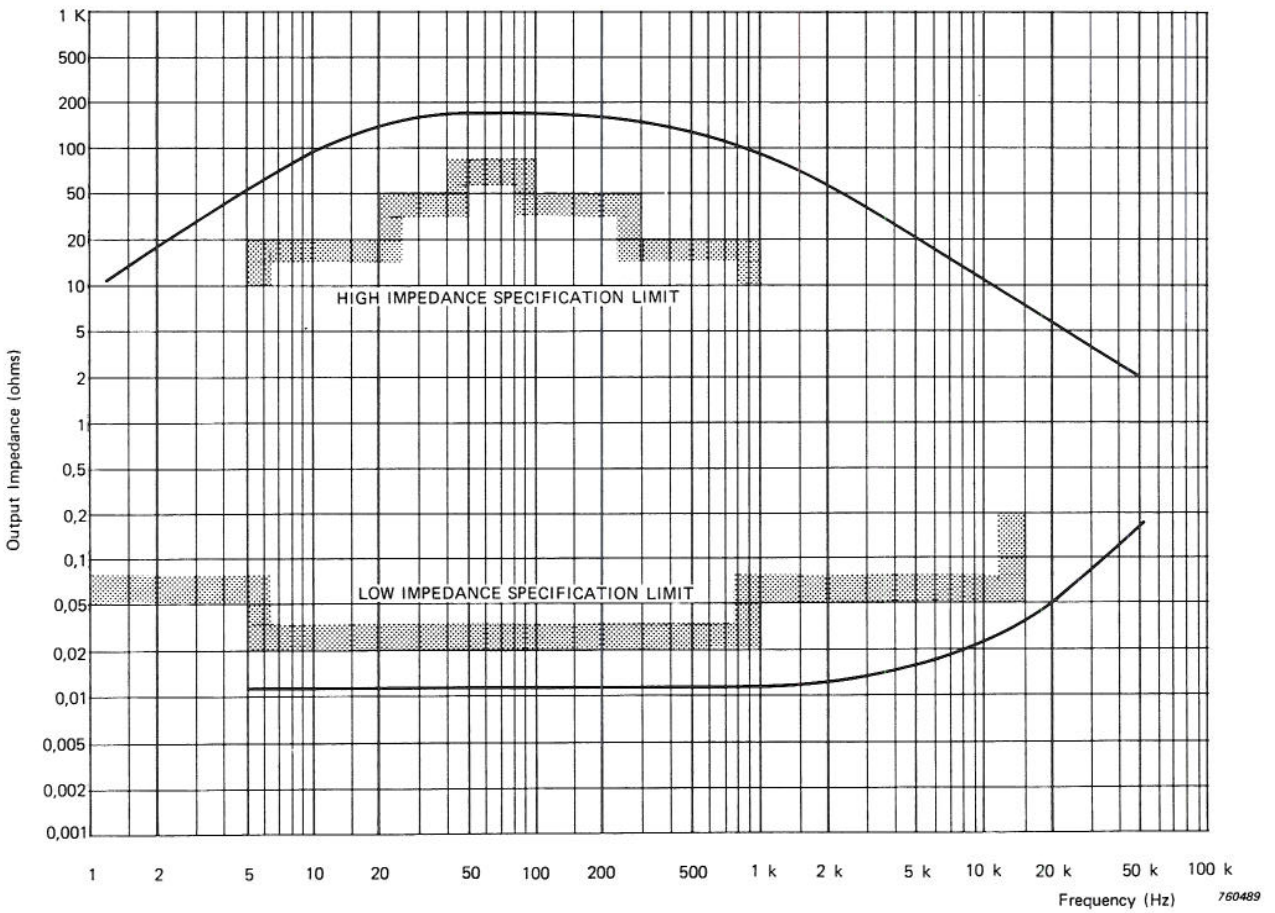

Fig. 4.1. Output impedance of the 2712 as a function frequency and OUTPUT IMPEDANCE switch mode

The POWER OUTPUT of the 2712 is direct coupled. Its output impedance depends on the type of feedback selected with the OUTPUT IMPEDANCE switch and is as shown in Fig.4.1.

With the "Low" impedance mode a fraction of the voltage developed across the moving coil of the Exciter is used as feedback. This gives the Amplifier voltage source characterstics — very low output impedance, constant output voltage with frequency — producing the best acceleration waveform. It is therefore suited for most single Exciter applications as well as for multiple Exciter applications at low frequencies where it is important that Exciters have the same motion.

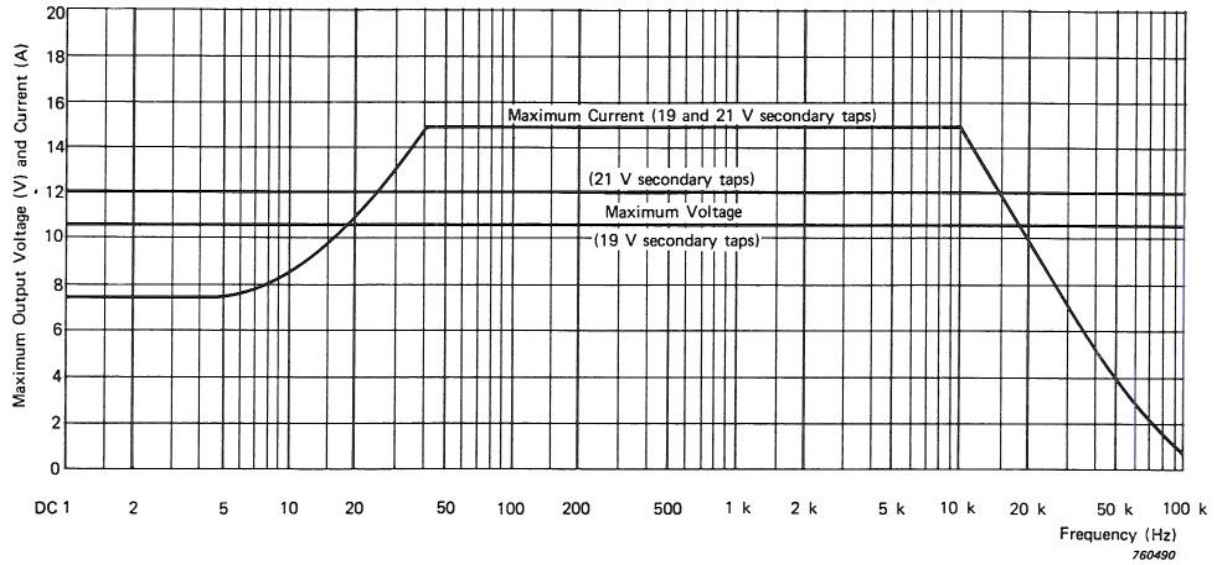

Fig.4.2. Maximum output current and voltage ratings of the 2712 as a function of frequency and mains transformer secondary tap connections

With the "High" impedance mode feedback is proportional to the current flowing in the Exciter moving coil. This gives the Amplifier constant current characteristics — high output impedance, constant output current with frequency — necessary to maintain a constant force with the Exciter despite changes in the vibration test specimen. This is useful for single Exciter fatigue tests and multiple Exciter resonant mode studies on vibration test specimens.

As shown in Fig.4.2 the maximum output voltage rating of the Amplifier depends on the connection of its mains transformer secondary taps (see section 3.2.1), whilst its maximum output current rating depends on frequency. With the 21 V secondary taps the maximum power output is 180 VA which is obtained with Exciters having a nominal load impedance of 0,8 Ω, whilst with the 19 V taps maximum power output is 165 VA which is obtained with Exciters having a nominal load impedance of 0,75 Ω. With other Exciter load impedances the maximum output rating is as shown in Figs.4.3 and 4.4. These are valid at frequencies ranging from 40 Hz up to 10 kHz. At other frequencies the Amplifier's output rating must be derated in accordance with Fig.4.2.

4.3. FREQUENCY RESPONSE

Full power output of 180 VA is available at frequencies beween 40 Hz and 10 kHz. At lower power levels the Amplifier has a useful frequency range extending from DC up to

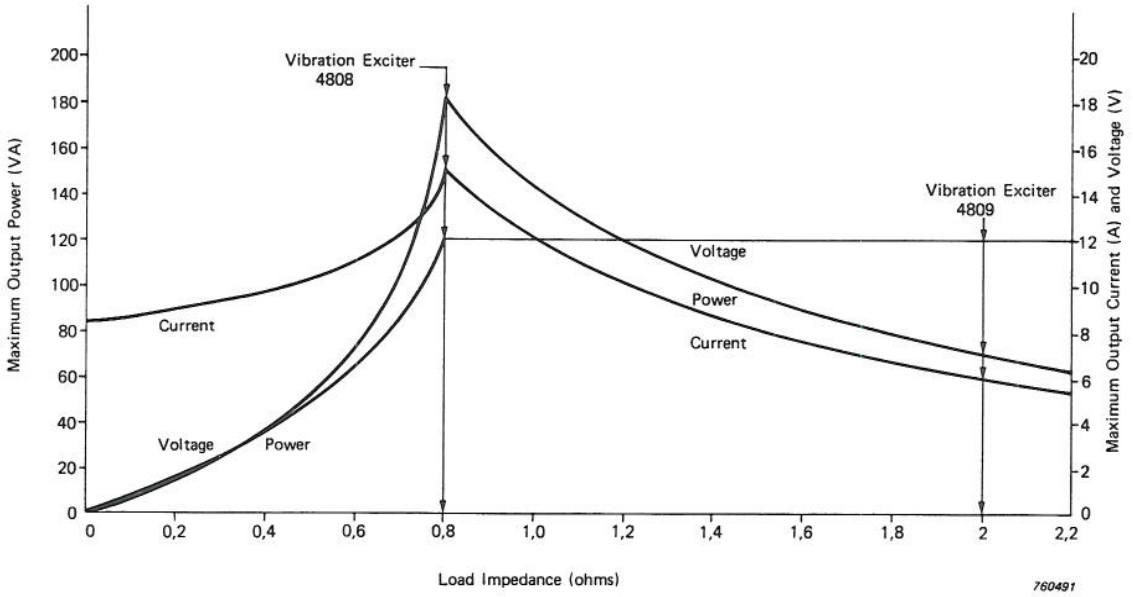

Fig.4.3. Maximum voltage, current and power output ratings of the 2712 as a function of Exciter load impedance, with the 21 V secondary taps of the Amplifiers mains transformer connected. Valid at frequencies ranging from 40 Hz up to 10 kHz

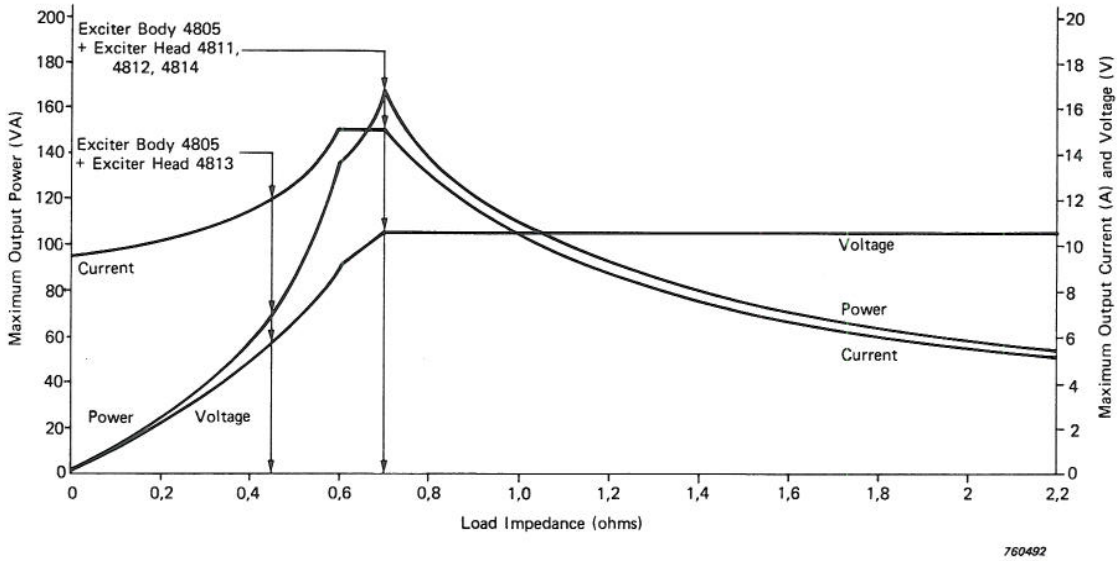

Fig.4.4. Maximum voltage, current and power output ratings of the 2712 as a function of Exciter load impedance with the 19 V secondary taps of the Amplifiers mains transformer connected. Valid of frequencies ranging from 40 Hz up to 10 kHz

100 kHz. This depends on the SIGNAL INPUT socket and OUTPUT IMPEDANCE switch setting as shown by the small signal response curves given in Fig.4.5.

4.4. DISTORTION

The percentage harmonic distortion produced by the 2712 is shown in Fig.4.6. Considering the 180 VA power output rating of the Amplifier the amount of distortion produced is very low. This can be attributed to the generous amount of feedback applied and the use of a direct coupled output.

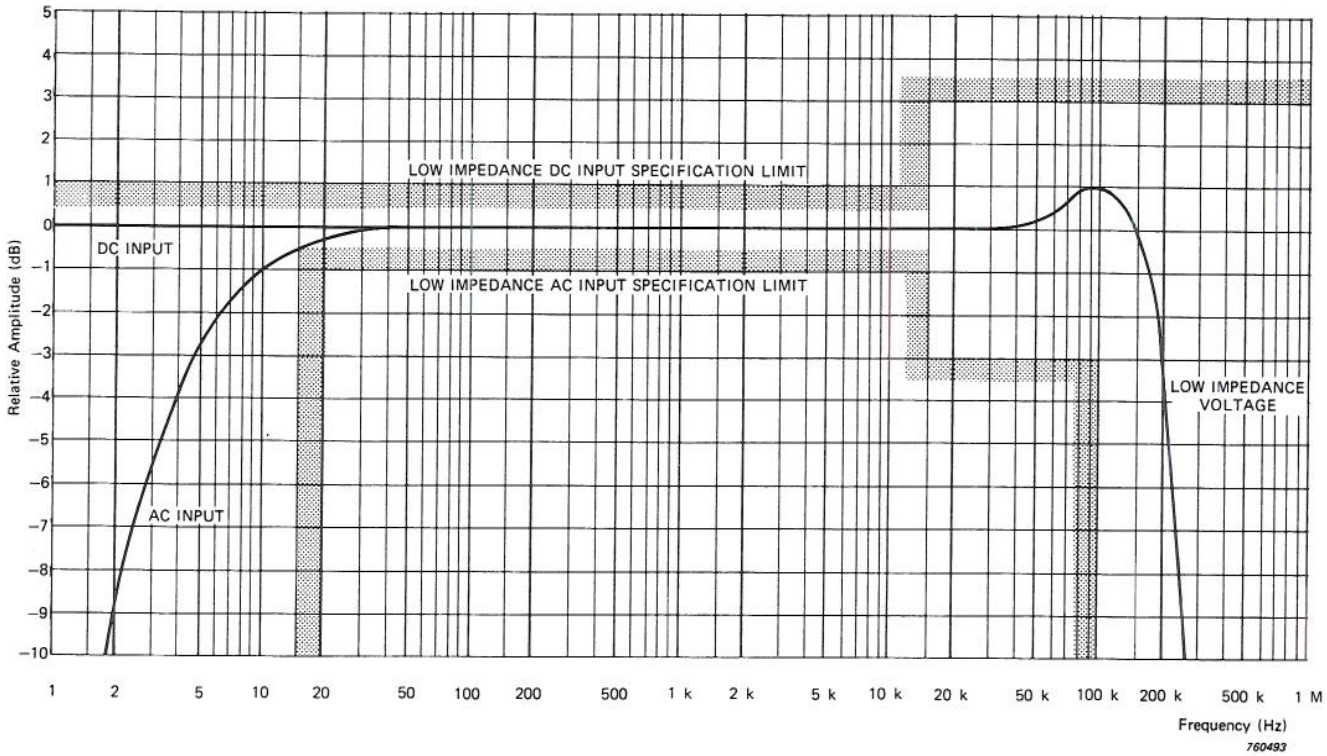

Fig.4.5. Small signal frequency response of the 2712 for power output levels up to 20 VA

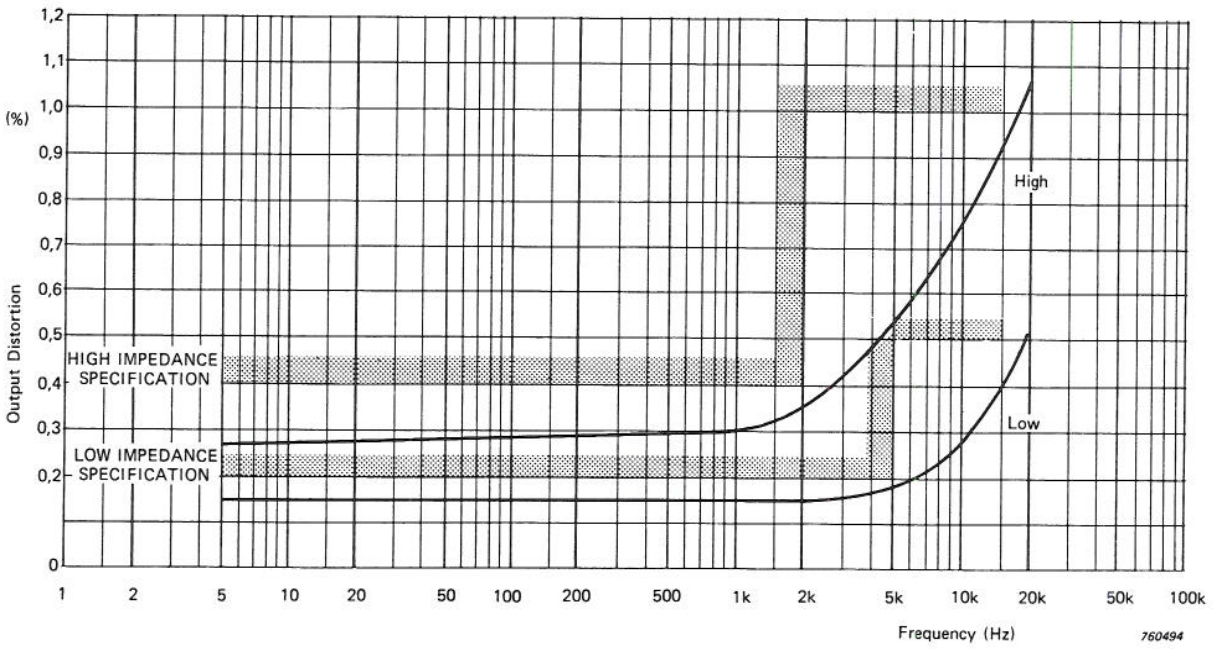

Fig.4.6. Typical percentage harmonic distortion curves for the "Low" and "High" OUTPUT IMPEDANCE modes of the 2712 with 180 VA into a 0,8 Ω load

5. ACCESSORIES

The range of B & K Exciter Control Generators and Vibration Exciters which may be used with the 2712 is shown in Fig.5.1. Full details on the equipment concerned can be obtained from the B & K Short and Main Catalogues which are available on request.

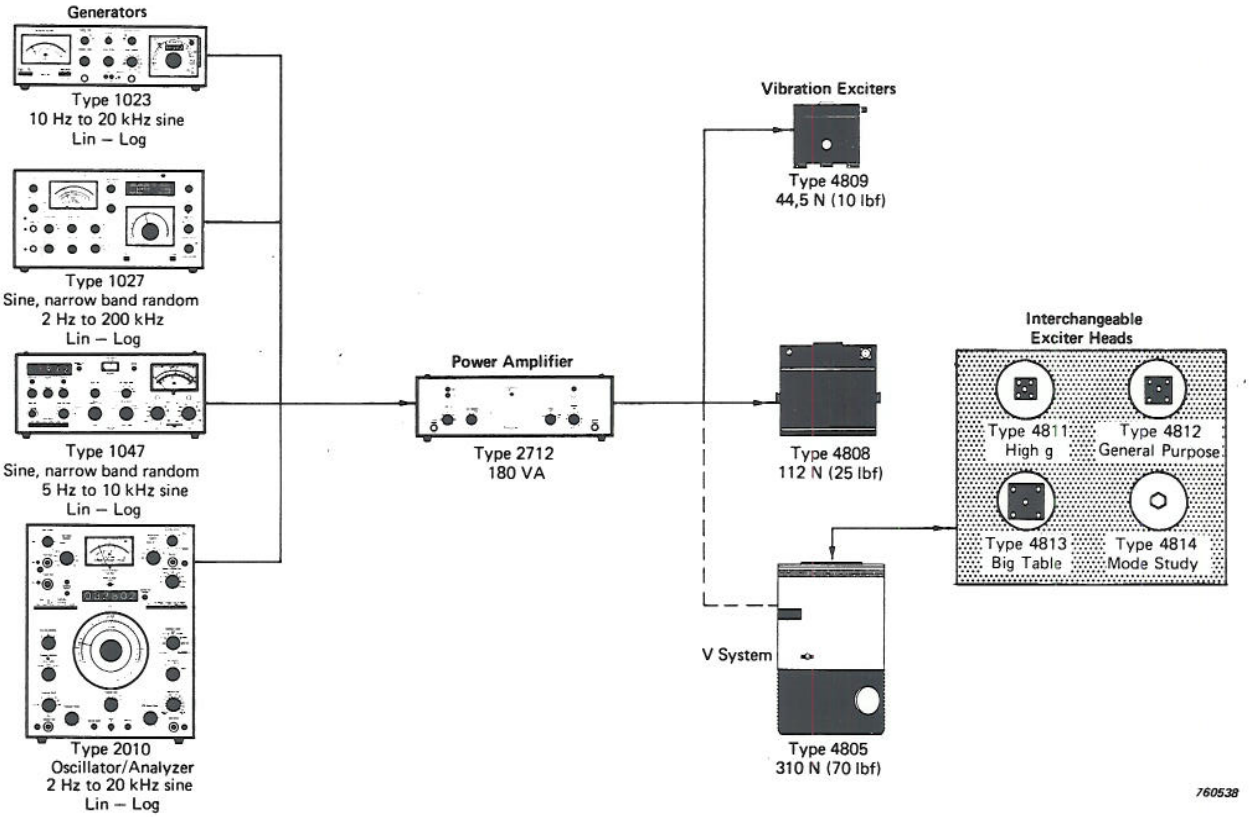

Fig.5.1. The range of B & K vibration test equipment for use with the 2712 Power Amplifier