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ACOUSTIC RECORDING SYSTEMS FOR USE IN MILITARY AIRCRAFT

by

K. Harpur

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Technical Memorandum MM 11

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ACOUSTIC RECORDING SYSTEMS FOR USE IN MILITARY AIRCRAFT

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SUMMARY

This Memorandum provides a description of the recording systems used for in-flight noise measurements inside military aircraft. This includes details of the equipment, its method of operation, possible measurement configurations and capabilities.

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1 INTRODUCTION

There is a continuing need to be able to conduct noise measurements inside the cockpits of military aircraft. The requirement is for in-flight recordings of cockpit noise as well as for measurements at the ear. The equipment must be easy to use once fitted and small enough not to prove a hinderance to the pilot. This Memorandum describes the equipment developed to achieve the measurements, the different ways in which it can be used and its associated characteristics.

2 EQUIPMENT USED

2.1 Nagra type SNN tape recorder

This miniature tape recorder is small enough to fit inside the pockets of the pilot's coverall and can be controlled remotely. It derives its power from two (1.5 V size AA) batteries giving it an average operating life of 8 hours. This exceeds the duration of the available tapes which range from 26 to 47 minutes.

When the SNN is running at a tape speed of 3 3/4 ips (its optimum value) the frequency response is quoted as 60:17000 Hz (±2 dB), which is more than adequate for recording typical fixed wing aircraft cockpit noise (Fig 1). Running a tape at the lower speed of 1 7/8 ips shows a degradation in the recorders performance (Fig 2).

The A-weighted signal/noise (s/n) ratio is greater than 60 dB which, as long as the input voltage is controlled, provides sufficient dynamic range for recording aircraft cabin noise. The maximum input signal specified is 160 mV rms although, in practice, it is advisable that the input signal be some 20 dB lower, of the order of 15 mV, to avoid any unexpected intense sounds saturating the tape. The heads should be clean and the tape be in good condition for maximum performance.

2.2 Knowles microphone type BT1759

The BT1759 (Fig 3) is an electret microphone having a flat frequency response from 50 Hz to 7 kHz ± 2 dB (Fig 4). It contains an integral FET amplifier giving a nominal output impedance of 3500 ohms at 1 kHz and the required battery voltage range is from 0.9 to 20 V DC. The microphone is virtually unaffected by normal temperature ranges and has a low sensitivity to vibration.

The main feature is its small size (7.92 × 5.59 × 2.28 mm) which allows it to be fitted underneath the flying helmet ear shell, when noise at-the-ear measurements are required, with minimum disturbance to the noise field. The lead assembly consists of copper strips embedded in a flat layer of melamine having an overall thickness of 0.03 mm which, when run under the ear bun seal, causes minimum leakage. The development of the early Knowles microphone assemblies for inflight recording is described in Ref 2.

2.3 Control boxes

A range of control boxes are used, to meet different needs; as they are generally knee mounted they are commonly referred to as 'knee boxes'.

2.3.1 Knowles microphone-intercom microphone box

This box allows recordings to be made using either a Knowles type miniature microphone under the earshell (noise at the ear) **or** on the outside of the helmet (cockpit noise). It also allows recording of the communication microphone output and both may be recorded simultaneously. The knee box performs three functions:

(i) To remotely switch the tape recorders on and off: where two recorders are used for simultaneous recordings, remote control of the recorders from one switch on the knee box will provide synchronised recordings.

(ii) To power the pre-amplifier in the miniature microphone and to attenuate the output signal if necessary: the miniature microphone positioned in a high noise field may produce a signal that requires some attenuation before the level is suitable for the SNN recorder. The knee box contains the necessary circuitry (Fig 5) and whilst the microphone assembly is actually powered from the tape recorder, to reduce the number of individual cables the power is supplied via the knee box.

(iii) To amplify the signal from the pilot's communication microphone: the intercom circuit amplifies the output signal from the pilot's communication microphone (boom or mask type) to a suitable level for recording on the SNN recorder. The gain is easily controlled using two sets of switches, located inside the box, which alter the input and output gain.

Where it is decided to record only a single Knowles microphone output using a single tape recorder then a knee box is not necessary, as a direct input to the Nagra SNN can be used with the microphone being powered from the SNN supply.

2.3.2 Knowles microphone-intercom telephones box

This unit (Fig 6) is similar to the one described in section 2.3.1 and only differs in that instead of recording communication microphone output it can be used to record the input signal to the telephones. This means that a recording can be made of the speech heard by the pilot, which includes the sidetone from the pilot's microphone. This can be useful, for example, if a recording is made when the pilot is unable to provide a full commentary during the noise recording period. The tape, which may include ground stations and other crew members talking, will provide a guide as to the aircraft's position, height, speed etc.

2.3.3 Alternative systems

Two alternative knee box systems were developed and produced by the RAF Institute of Aviation Medicine[1]. The first type can be used to measure in-flight helmet attenuation (IFA), by simultaneously recording the outputs from two Knowles microphones inside and outside the ear bun. The second type can be used to record speech alone from the pilot's communication microphone.

2.4 Break-in box

The adaptor (Fig 7) is designed to break into the Combined Communications System (CCS) and is placed between the helmet downlead plug and the socket on the Personal Equipment Connector (PEC). The microphone output or the input to the telephones can be monitored and recorded (via the appropriate knee box) without affecting the CCS. The break-in box allows both signals to be monitored simultaneously, but currently a knee box accommodating both microphone and telephone signals is not available. Simultaneous recording of both thus necessitates the use of two knee boxes.

A single type of box covers most aircraft since most use the standard NATO connector, however, a number of break-in boxes have been built specifically for use in the Tornado aircraft which uses 14 pin Lemo type connectors. The dimensions of the largest boxes are about 12 cm long and 2 cm square. The circuit diagrams are shown in Fig 8.

2.5 Connecting leads

There are six types of connecting lead, which are listed below:

(i) microphone break-in: feeds the communication microphone output signal from the break-in box to the knee box;

(ii) telephones break-in: feeds the telephones input signal from the break-in box to the knee box;

(iii) line input: feeds the output signals from the knee box to the line input on the SNN recorder and also carries the 5 V supply needed by the Knowles microphone;

(iv) remote: connects the knee box to the SNN so that the recorder can be switched on and off at the knee box;

(v) Knowles microphone/tape recorder: where a single tape recorder is used, feeds the output from the microphone directly into the recorder and supplies power to the microphone;

(vi) remote switch: used to remotely control the tape recorder when only one is being used.

The pin connections for all the leads are shown in Fig 9.

2.6 Active Noise Reduction (ANR) Power Supply Unit (PSU)

A relatively new development requiring in-flight assessment is the helmet mounted Active Noise Reduction system. Reduced noise levels at the pilot's ears are achieved by monitoring the noise under the ear bun with a sensing microphone, inverting the signal and replaying it back into the earshell in anti-phase. The sensing microphones and electronics of the system are mounted inside the ear bun assembly but to assess the degree of noise reduction achieved in flight, the system is powered by means of a man-mounted PSU. This provides 27 V DC from three PP3 batteries. The output from the sensing microphones in either the left or right earshells can be recorded directly onto the SNN via data output sockets on the PSU where miniature amplifiers providing 20 dB of gain are installed. The action of plugging the tape recorder/PSU lead (Fig 10) into either the left or right output socket enables the sensing microphone amplifier. This has been designed such that recordings can be made even when the ANR is switched off.

3 METHOD OF USE

3.1 Knowles microphone-intercom box (microphone or telephones)

The equipment used for simultaneous recordings of cockpit noise or noise at the ear and communication microphone output or telephones input is shown in Fig 11. During normal use the two tape recorders are stowed in the pilot's pockets with only the knee box accessible, strapped to the leg. All lead runs are secured so as not to present a snagging hazard.

Before flight the Knowles microphone/tape recorder integral system is calibrated using a Bruel and Kjaer type 4230 calibrator which provides a 94 dB, 1 kHz tone. If cockpit noise is being recorded, and the overall sound pressure level (OASPL) is greater than about 120 dB, the attenuator on the Knowles microphone channel is set to 10 dB. The frequency response curve of the Knowles microphone/recorder system is shown in Fig 12.

If a calibration tone is to be recorded on the intercom channel then generally an electrical calibration using a 1 kHz tone is used. If it is the communication microphone output that is to be recorded then the calibration tone should be at a level comparable in magnitude to the communication microphone signal. The typical output signal ranges from 0.5 to 5 mV and so the gain on this channel is set to 30 dB. The same principle applies when recording the telephones input signal which is typically about 1 V and thus is attenuated by 30 dB. The schematic layout of the complete system is shown in Fig 13.

3.2 Alternative systems (see section 2.3.3)

A detailed description of the operation of these can be found in Ref 1. The main advantage of using the IFA system is that a simultaneous recording is made of the internal and external noise. However, it should be noted that when the recorders are started the CCS is disabled and this would be unsuitable for single seat aircraft.

3.3 ANR recording

The PSU is worn by the pilot in the same way as a knee box and is connected to the helmet via a pigtail and an extension lead. The tape recorder/PSU lead is used to connect these two items directly and as only one recorder is in operation then a single remote switch, as described earlier, is mounted on the PSU on the knee so as to be easily accessible during flight. The tape recorder is stowed away as the remote switch is all that needs to be accessible.

There is, however, no way to calibrate the ANR sensing microphones as they are inaccessible under field conditions. If absolute rather than relative sound levels are required then a Knowles microphone/SNN recorder system can be used to measure the noise at the ear.

It is important that the batteries in the PSU are renewed before every flight or that a spare unit is carried and that all the various leads are disconnected when the system is not in use. The configuration of the ANR recording system is shown in Fig 14.

REFERENCES

No.	Author	Title, etc
1	R.L. Pratt S. Roberts	An in-flight acoustic recording system. RAF IAM Technical Memorandum 383 (1982)
2	D.C. Baines	Development in the use of Knowles miniature microphones to measure conditions inside the ear muffs. RAE Technical Memorandum FS 166 (1978)

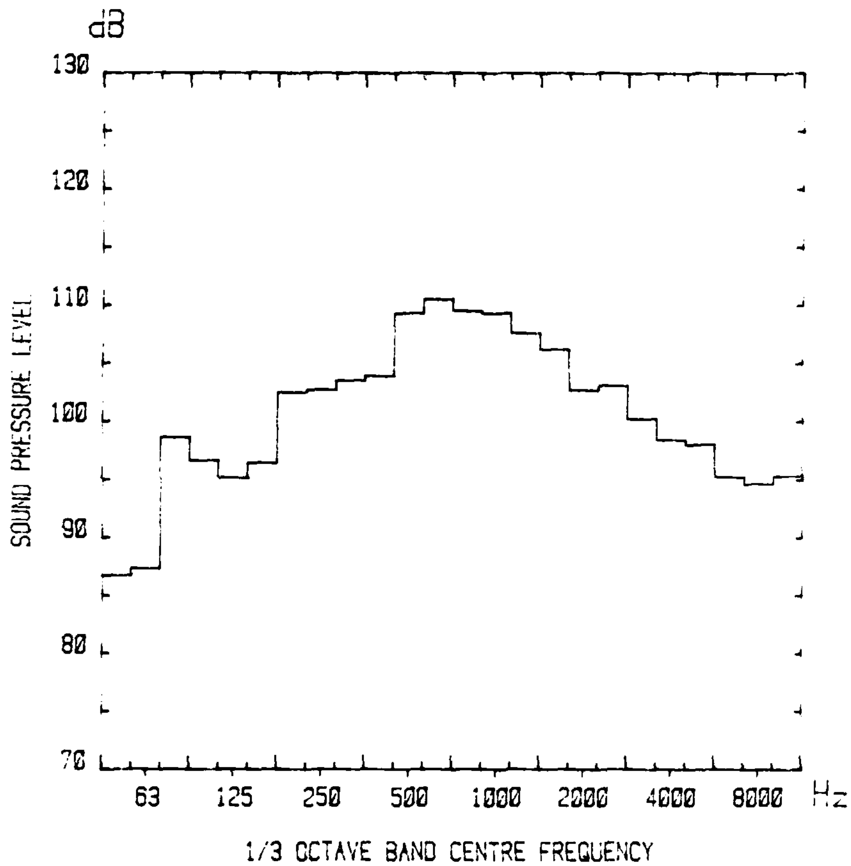

Fig 1 **A noise field typical of that found in the cockpit of modern strike aircraft during high-speed low-level flight**

Fig 2

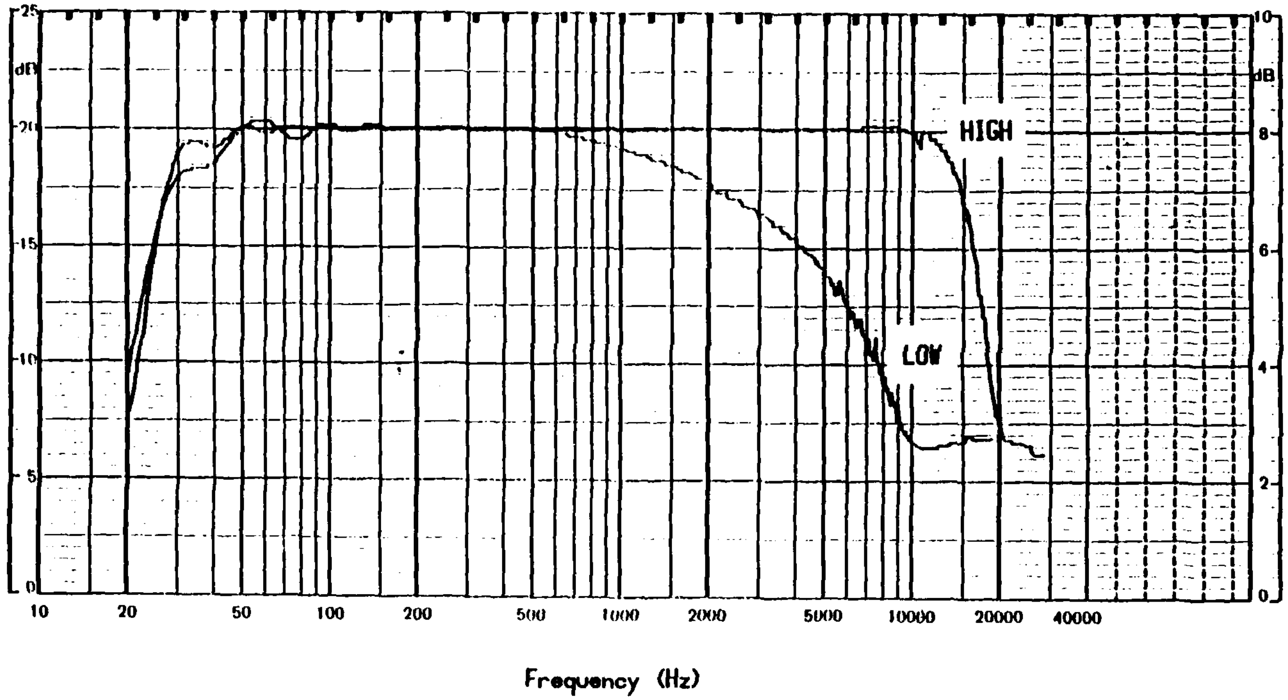

Fig 2 Frequency response of the Nagra SNN type tape recorder at high and low running speeds (15 mV input signal)

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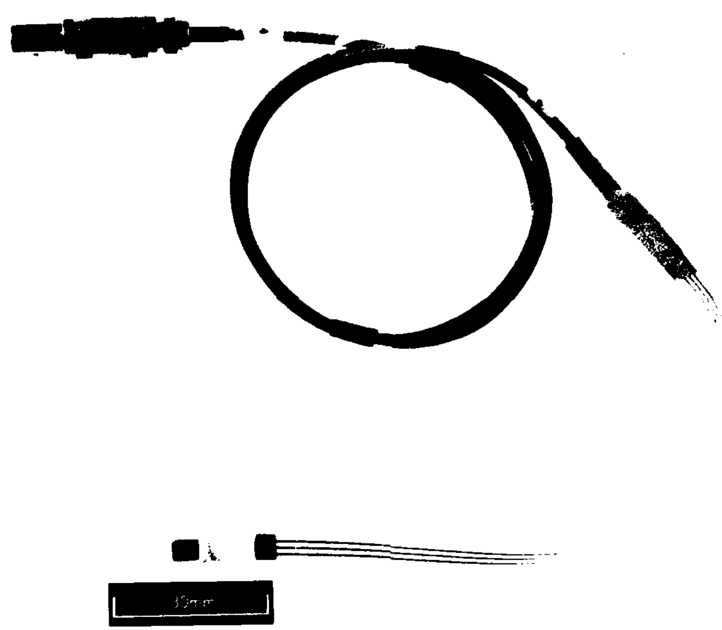


Fig 3 Knowles microphone type BT1759

Fig 3

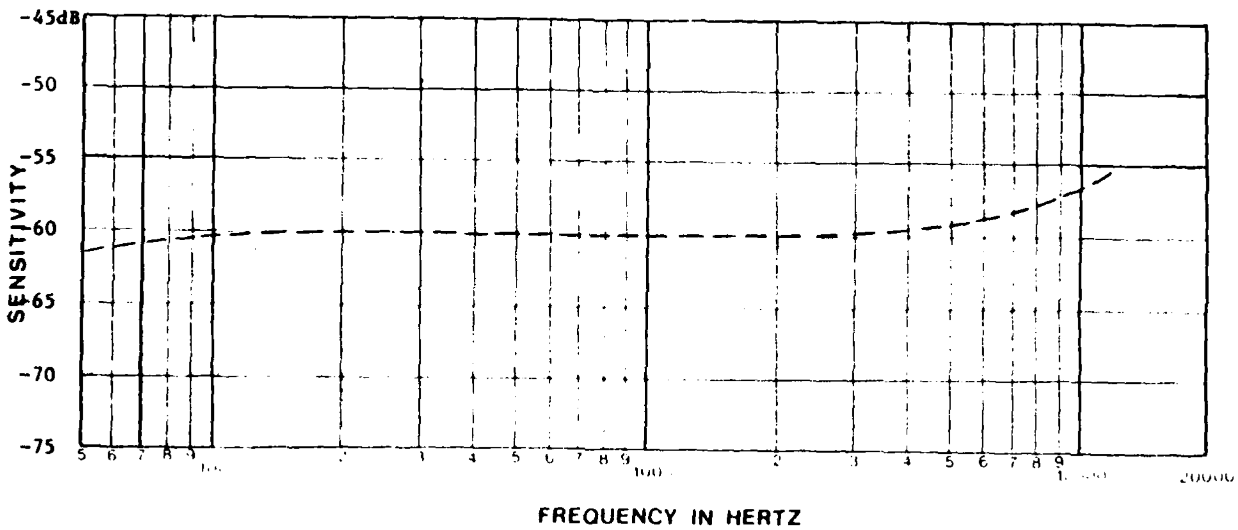


Fig 4 **Frequency response of the Knowles microphone type *BT1759* in a 0.1 pascal (74 dB) sound field**

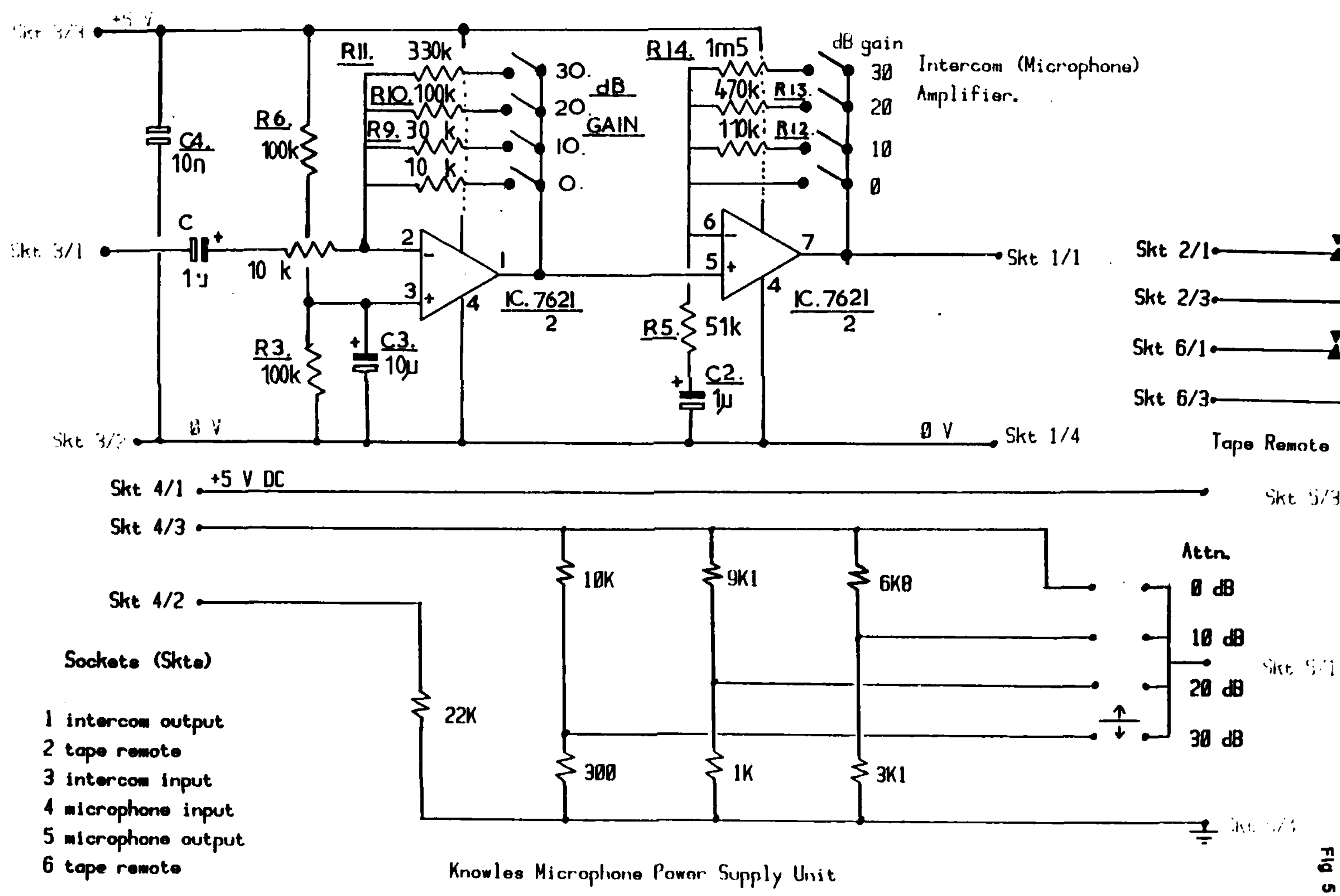


Fig 5 Knowles microphones-intercom (microphone) box

Fig 5

Fig 6

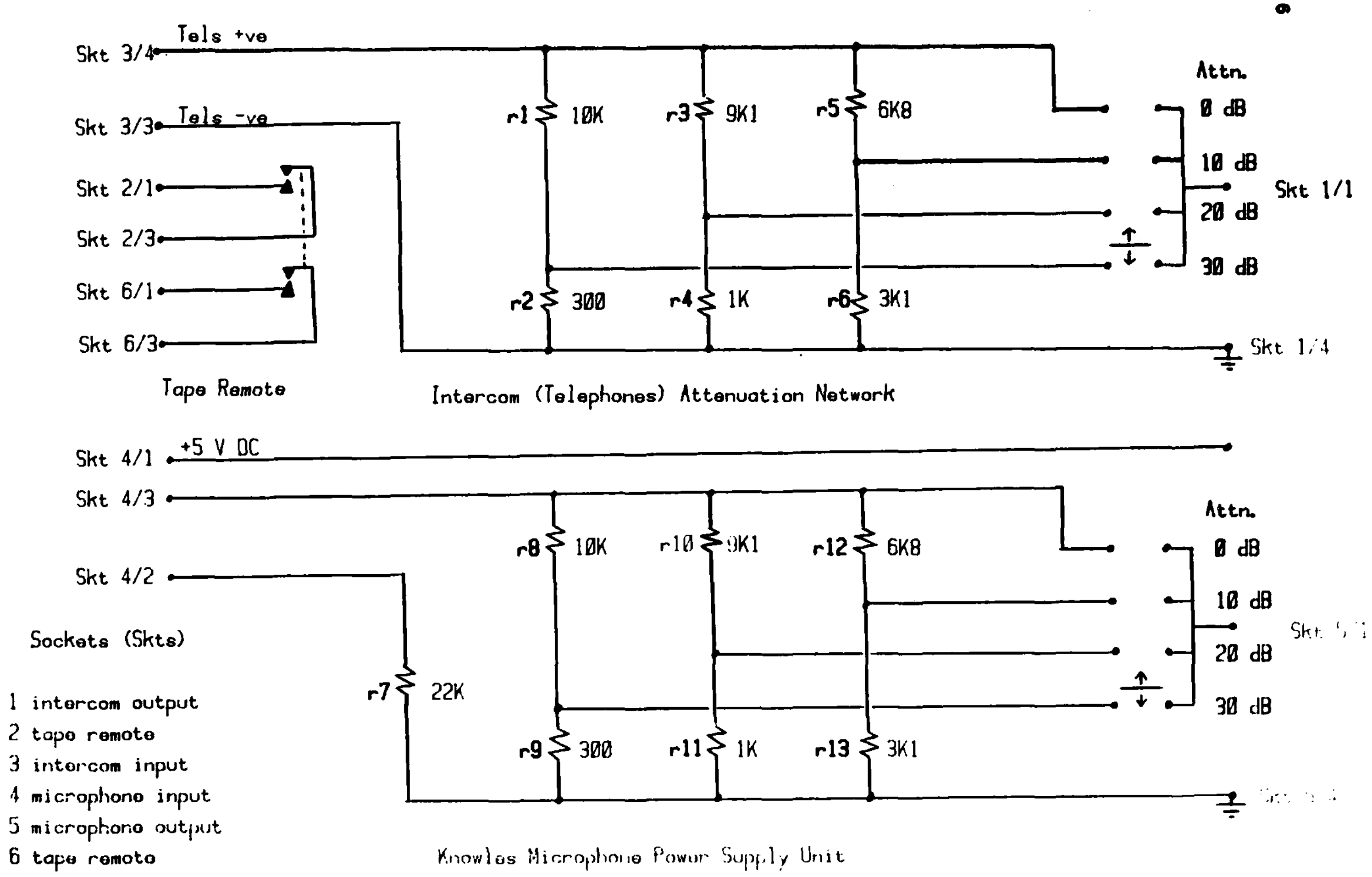


Fig 6 Knowles microphone-intercom telephones box

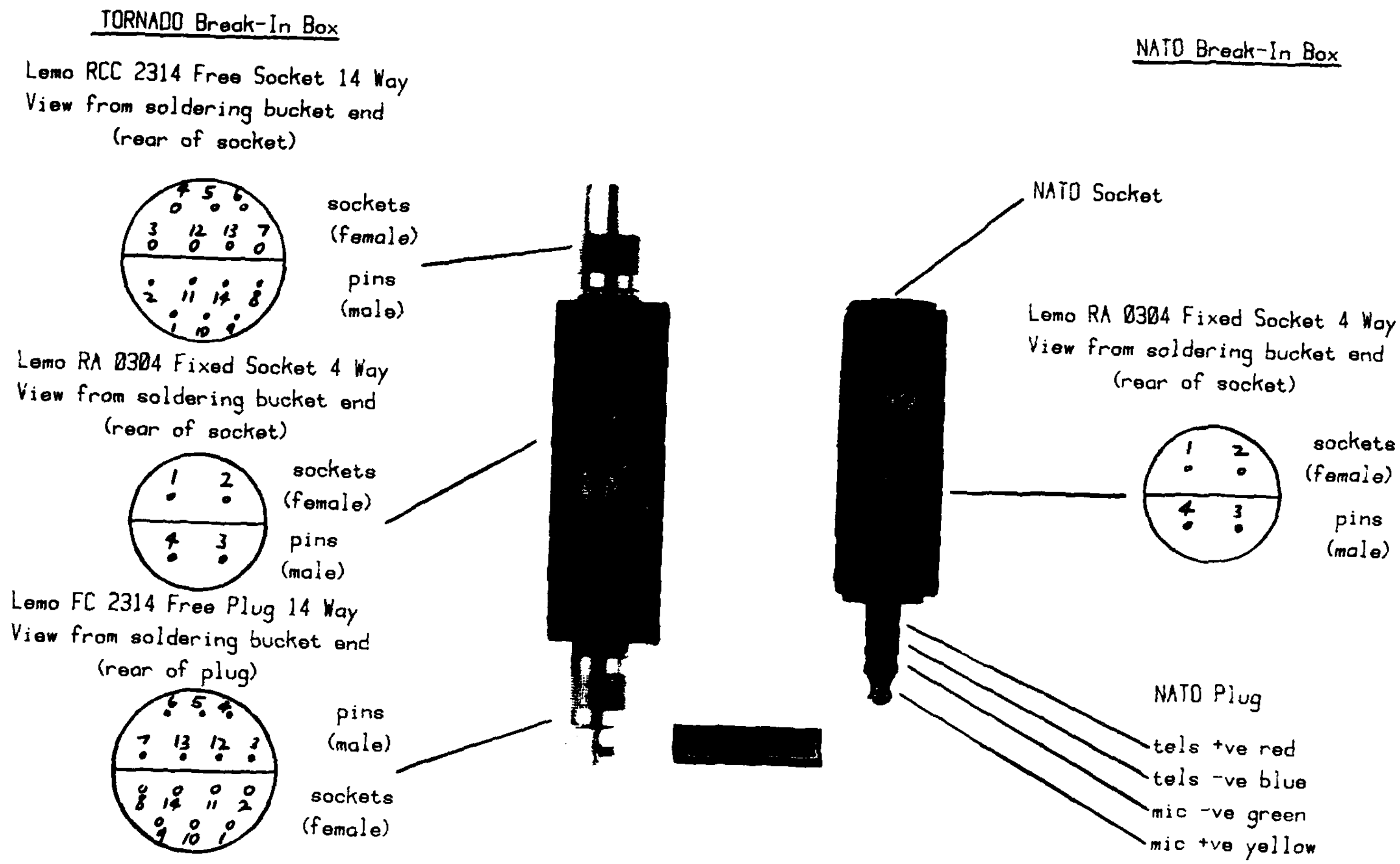


Fig 7 Break-in boxes

NB.
In all cases the pin/socket mates with the same pin number on the socket and vice versa.

Fig 8a&8b

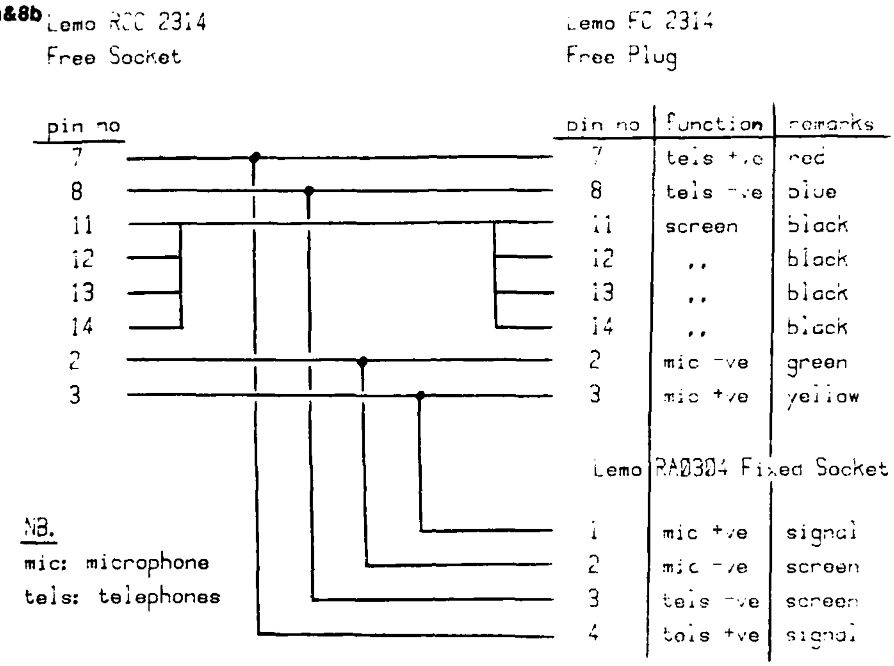


Fig 8a TORNADO break-in box circuit diagram

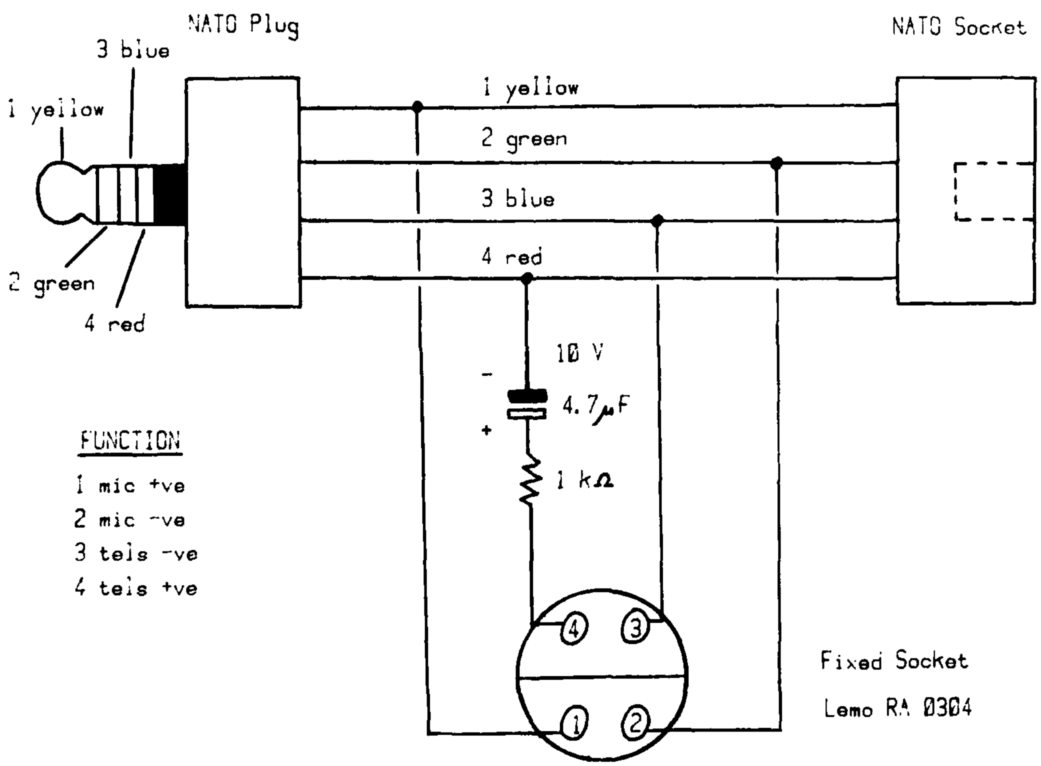


Fig 8b NATO break-in box circuit diagram

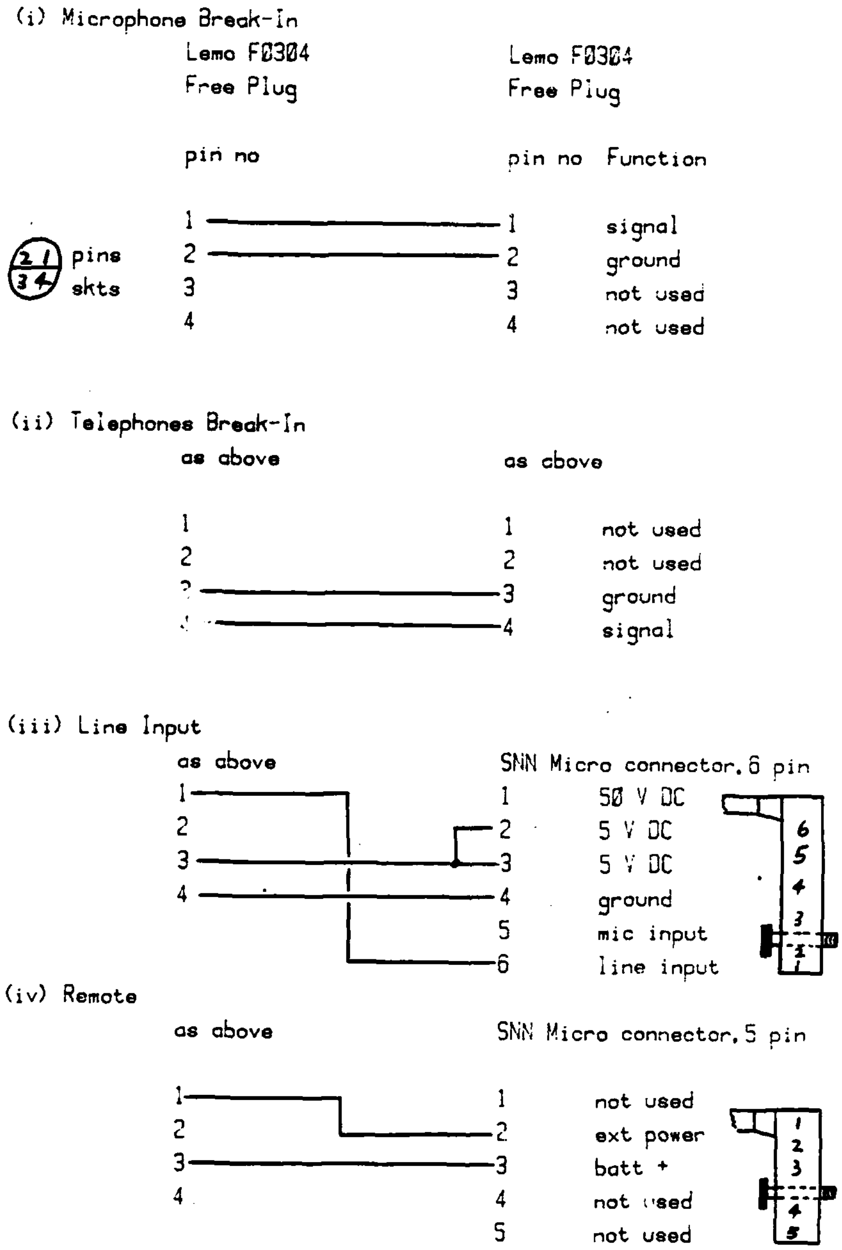
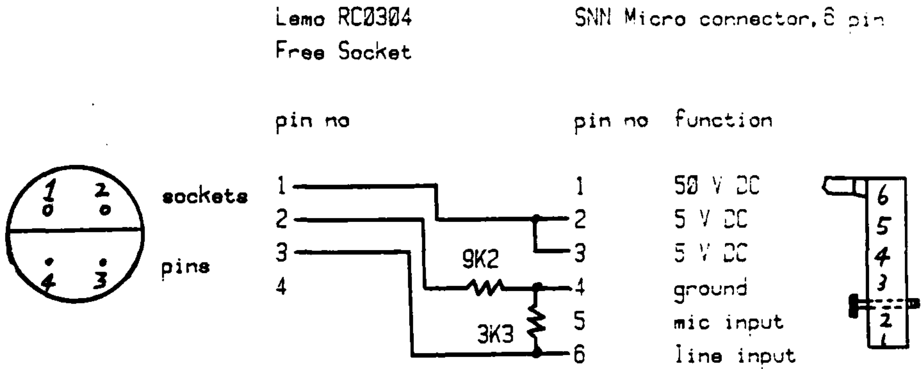


Fig 9 Connecting leads (i) to (iv) only

Figs 9&10

(v) Knowles Microphone/Tape Recorder



(vi) Tape Remote Switch

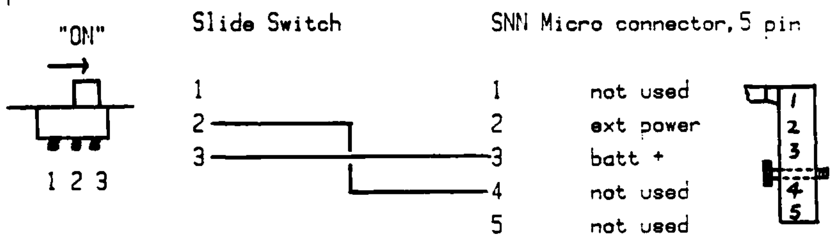


Fig 9 Connecting leads (v) and (vi)

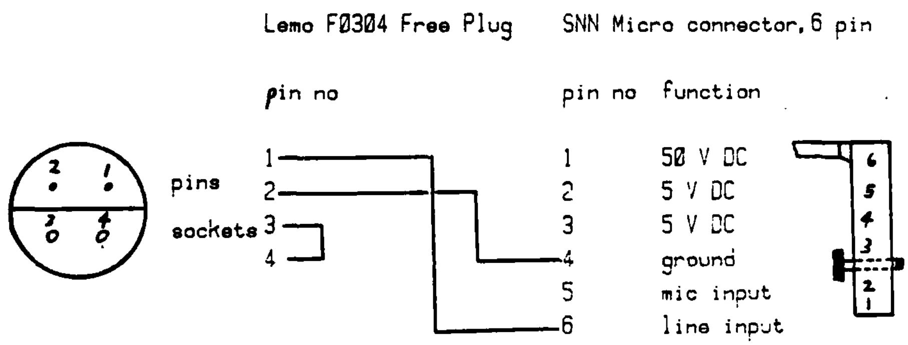


Fig 10 Tape recorder/power supply unit connecting lead

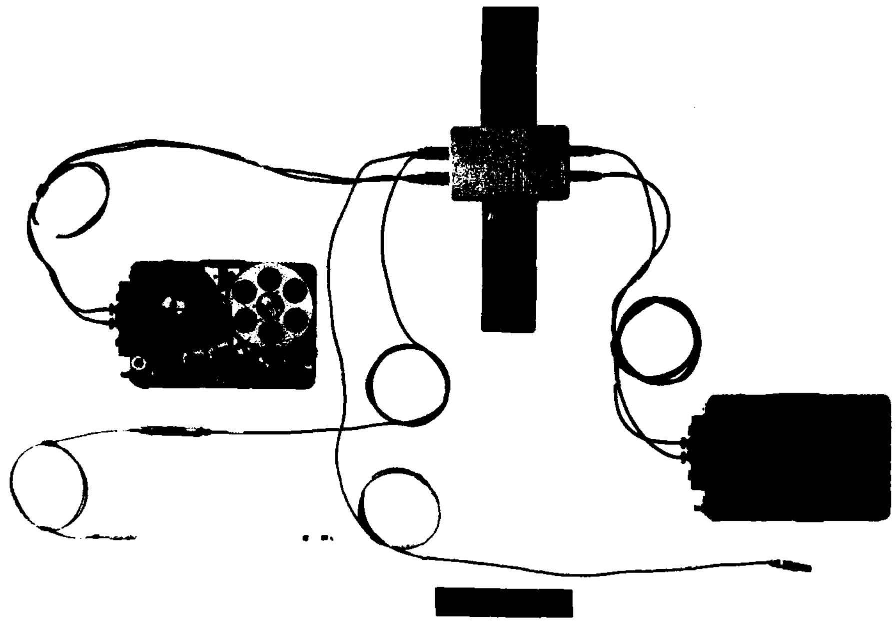


Fig 11 The complete Knowles microphone-intercom acoustic recording system

Fig 12

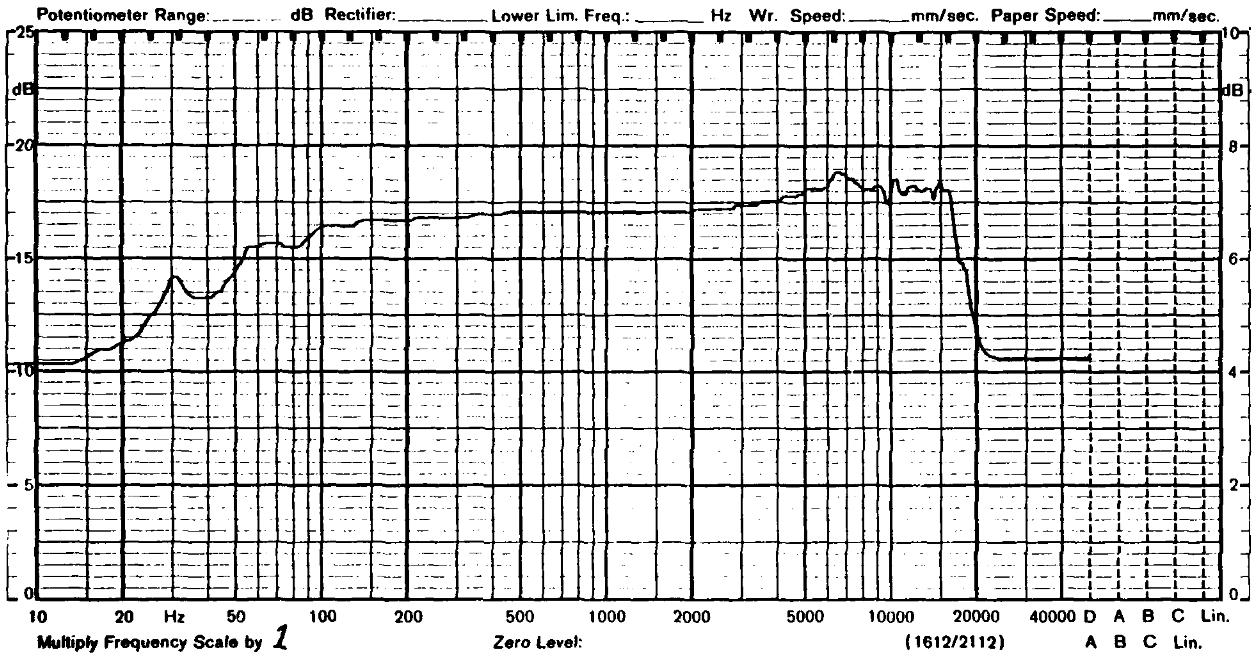


Fig 12 Frequency response of the Knowles microphone/tape recorder system in a 1 pascal (94 dB) sound field

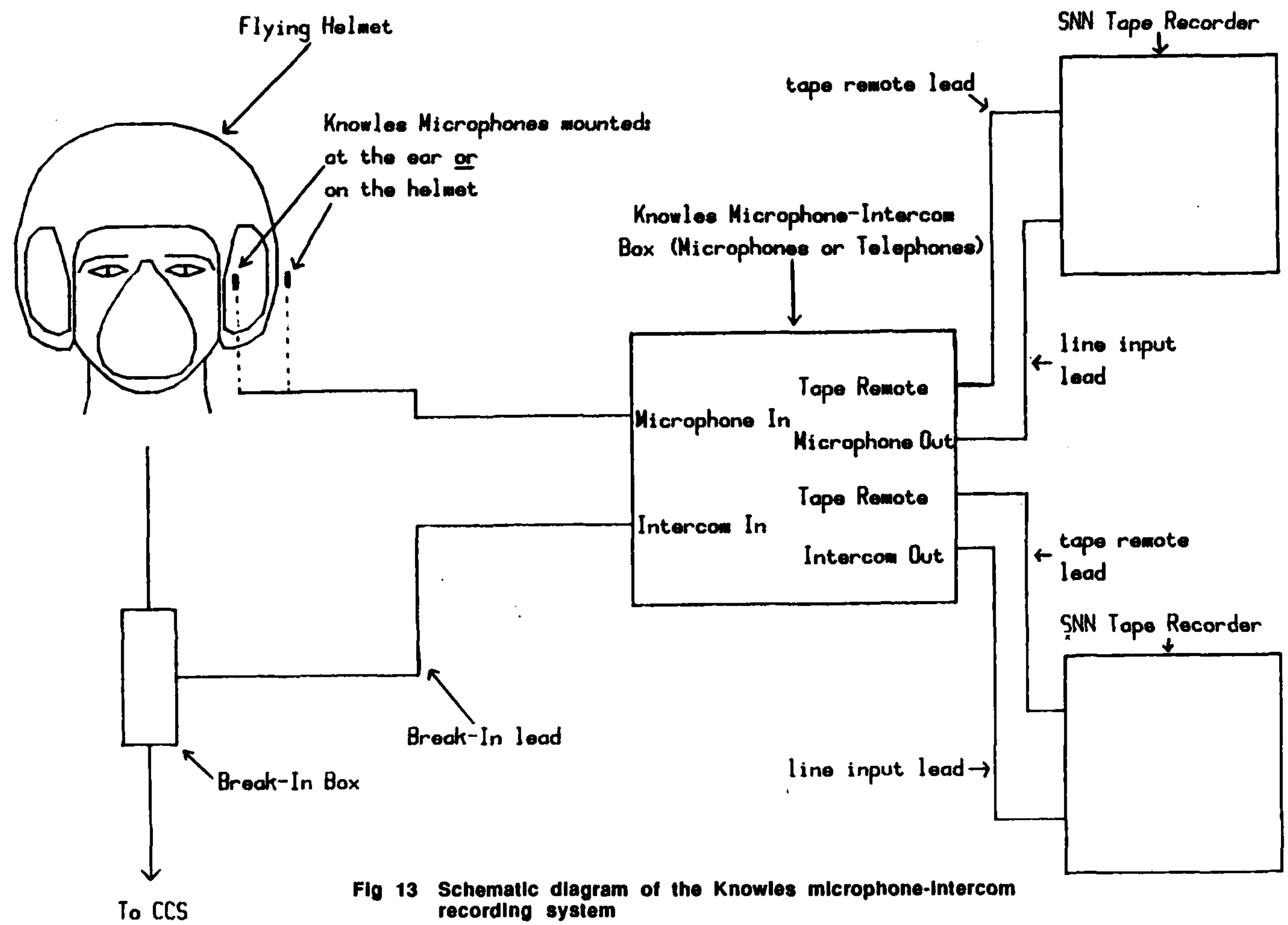


Fig 13 Schematic diagram of the Knowles microphone-intercom recording system

Fig 14

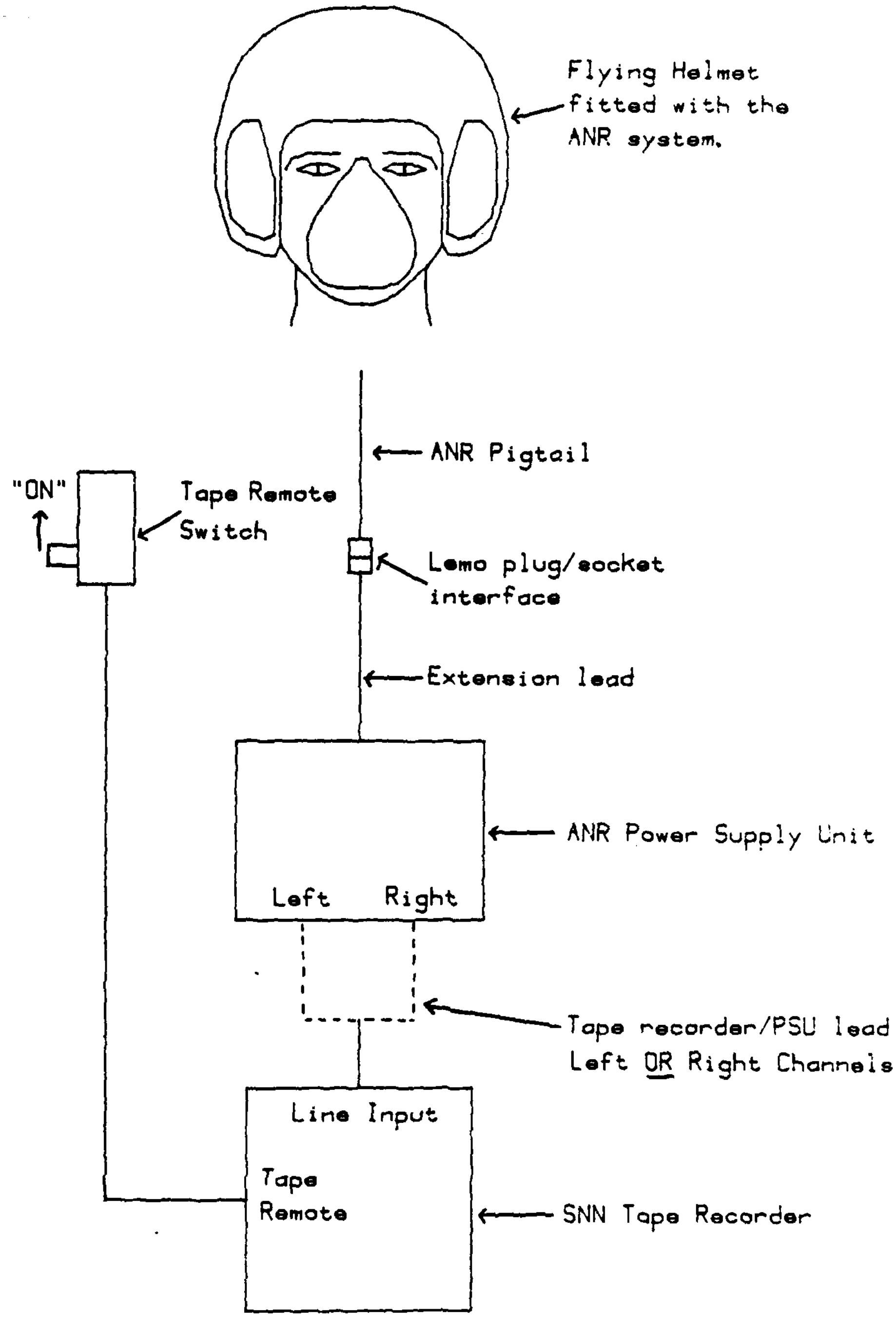


Fig 14 Schematic diagram of the ANR recording system

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17. Abstract

This Memorandum provides a description of the recording systems used for in-flight noise measurements inside military aircraft. This includes details of the equipment, its method of operation, possible measurement configurations and capabilities. Keywords: Acoustic recording systems, Great Britain, Cockpits, Noise reduction, Microphones, Pilots, Aircraft noise. (SDW)

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