



NAGRA

NAGRA IV D and NAGRA IV L Portable Tape Recorders

INTRODUCTION

The NAGRA IV D and NAGRA IV L are self-contained high performance sound recorders of exceptional reliability. They will operate in any position. They can be powered either by internal batteries, or an external A.C. supply using an ATN Power Unit. The weight and size is slightly reduced as compared to the NAGRA III.

They are built to Military and Aeronautical Standards, thus giving the recorders a reliability which has not been available heretofore in the electro-acoustical field. The NAGRA IV D AND IV L are single track monaural recorders. The NAGRA IV D replaces the previous NAGRA III BHO non-sync recorder, and the NAGRA IV L replaces the NAGRA III PHO synchronous recorder.

DESCRIPTION

The case for the new recorder is similar in shape, but slightly smaller than the NAGRA III. The tape deck is shock-mounted to the case. The principle controls are on the front panel, with connectors and accessory controls mounted on the sides.

The electronic circuits are modular on plug-in boards. This provides:

- (a) Recorders can be equipped to meet specific requirements.
- (b) At sometime in the future, recorders will be available with minimum facilities and cost to meet limited requirements.
- (c) Recorders can be easily changed from one type to another as discussed in subsequent paragraphs.
- (d) Pre-amplifier modules to meet special microphone requirements will be available in addition to the standardized pre-amplifiers used in most professional work.
- (e) Modular replacement will be used for most repair thus providing a rapid and economic service.

1. RECORDER CASE

The NAGRA IV has a corrosion-resistant light metal alloy hardened case which provides increased shock-resistance despite it's reduced weight.

The batteries are mounted in a glass fibre loaded polyester resin container located in the base of the recorder case. The battery compartment lid is of stainless steel construction. This gives a reasonable protection against corrosion due to battery leaking.

The reels and tape deck are covered and protected by a shock-resistant, vacuum formed lid of a transparent plastic.

The recorder can be carried by a new hand handle or the regular shoulder strap, both of which are removable. The handle can be folded under the recorder, giving a convenient angle for operation on a table.

2. TAPE DECK

The tape deck is machined from a plate of hard light metal alloy, and is mounted on the case with a three point suspension. This reduces the risk of misalignment of the tape deck even though the case may be sprung by careless handling.

The capstan, the magnetic heads, the guides and puck wheel assembly are all mounted on the tape deck. The capstan, which is just under 1/2" diameter, is an integral part of the motor, and is situated between the bearings. This gives a better speed stability than would exist if the capstan overhung the bearings, as in the majority of magnetic tape recorders. The motor, which is especially conceived for this application, is manufactured by Kudelski, and is servo speed stabilized. The stabilizer circuit, which uses 31 transistors, also gives a stabilized voltage source for the rest of the electronic circuits, rendering the latter proof against supply voltage variations, within prescribed limits. It should be noted that the motor is fed with the unstabilized voltage during fast re-winding of the tape, thus the re-wind speed will vary slightly depending on the battery voltage.

In addition, the stabilizer circuits have several self-checking and safety features. An accidental short-circuit of the stabilized voltage or any possible overload of the motor cannot cause damage to any part of the NAGRA.

On the front panel, there is an electromagnetic indicator "AR" which will show a white cross during normal operation. If the white cross does not show, it indicates the existance of one of the following troubles:

- (a) The motor is overloaded.
- (b) The main function selector is in the position "Fading".
- (c) The power supply voltage reserve is too low.

If the "AR" indicator does not show because of an insufficient voltage as in (C) above, it is still possible that the recorder may function correctly because this feature is designed to give a warning, slightly in advance, as the batteries are approaching the end of their useful life.

Normally, the motor can operate at three different stabilized speeds. Namely 15 inches per second, 7.5 inches per second or 3.75 inches per second. The selection is made by a switch situated between the tape reels. For certain applications, a fourth slower speed of $1 \frac{7}{8}$ inches per second will be available on special order and at a slight increase in cost. The non-sync NAGRA IV D is equipped with three magnetic heads: The erase, record and playback heads respectively. The synchronous NAGRA IV L has a fourth magnetic head, namely the sync head. All of these heads are plug-in mounted. The position and azimuth of the heads is adjustable by means of a cam and pinion assembly, with great stability and a resistance to vibration, mechanical and thermal shock.

A dampening and filter roller is located just in front of the record head. This filter roller dampens longitudinal vibrations of the tape, thus further reducing the flutter of the new NAGRA IV. A 60 Hz stroboscopic disc is mounted on the filter roller, thus providing a check of tape speed.

The tape tension on the reels is controlled by means of two mechanical servo systems.

The puck and tape guide control lever, which is fixed on the tape deck, is used during re-winding or when changing the tape. The puck pressure is applied by the main function selector on the front panel. This ensures that, once the tape has been threaded, the recorder may be used or stored for an indefinite period with the lid closed, without risk of creating a flat spot on the puck.

The risk of accidental erasure is reduced by automatically switching off the erase and bias signals when the puck and tape guide control lever is in the re-wind position.

3. SIGNAL INPUTS

The NAGRA IV D and IV L recorders have four possible signal inputs, which are:

- (a) Two microphone inputs
- (b) The availability of a line input
- (c) The availability of a fixed level input for a remote mixer

The two microphone inputs are internally connected to two plug-in modular preamplifiers. Normally, the recorders will be furnished with preamplifiers similar to the NAGRA III, however, modular preamplifiers will be available to meet special microphone requirements. They are:

(1) QPM-1-200. This is the standard preamplifier for dynamic microphones of 200 ohms impedance. Its performance is excellent from all points of view. Nevertheless, it would be advisable to use the QPM-2 series preamplifiers for microphones whose impedance/frequency characteristic is variable.

(2) QPM-1-50. This is identical to the QPM-1-200, except that it is designed for use with microphones of 50 ohms impedance.

(3) QPM-2-200. This is a voltage preamplifier for dynamic microphones of 200 ohms impedance. It is designed for microphones in which the impedance varies considerably with frequency. Generally, the manufacturers of such microphones publish the fact that the terminal load should be greater than 1,000 ohms. The QPM-2 series preamplifiers have a slightly poorer frequency response than the QPM-1 series, particularly at the extremes of temperature. Also, if the gain control of a channel equipped with this preamplifier is advanced accidentally when the input is not connected, a background noise will be introduced into the system. This is not the case with the QPM-1 series.

(4) QPM-2-50. This is identical to the QPM-2-200 except that it is designed for use with microphones of 50 ohms impedance.

(5) QPM-3-4. This is a preamplifier/power supply for Sennheiser transistorized condenser microphones types MKH 104, 404, 804.

(6) QPM-3-5. This is identical to the QPM-3-4, except that it is designed for use with Sennheiser microphones types MKH 105, 405, 805.

(7) QPM-5. This is a special dynamic microphone preamplifier for use with certain low noise microphones which have been developed for Kudelski. Normally, these preamplifiers are delivered only with the microphones for which they are intended.

(8) QPM-6. This is a line preamplifier designed to convert a microphone input into a balanced line input.

(9) QPM-7. This is a preamplifier designed to accept the signal from a phonograph pickup cartridge, and to correct it according to R.I.A.A. Standards.

4. EQUALIZATION, AUTOMATIC LEVEL CONTROL, OVERLOAD PROTECTION AND FADING DEVICE

The separate input signals are combined after their respective mixing controls, thence amplified for recording. Several different signal handling circuits are available and can be used between the combining network and the record head. They are:

(A) Low Frequency Roll-off Attenuator.

The signal coming from the two microphone inputs can be passed through a speech filter which attenuates the very low frequencies. This filter is not the type that produces the effect of speaking into a barrel. More precisely, it is a system which compensates for resonances due to the room in which the recording is made, and at the same time, it re-establishes the correct phase relationships at low frequencies. It can also be used to compensate for boominess produced when speaking too close to certain microphones.

This filter can be switched into the circuit by means of the "VLF" control on the front panel. There is a choice of four different values of equalization, plus a linear position.

This switch also has a sixth position marked "REF". In this position a 400 Hz reference generator is turned on. This gives a signal with a fixed level of -8db or 0 vu, as a reference level. A recording of this 400 Hz reference signal should be made on every roll of tape. It will be used as a reference level during transfer.

(B) Automatic Level Control (ALC).

A switch marked "LEVEL" is located at the top left hand corner of the front panel which provides the following choices:

- (a) Manual level control of the two microphone channels, by means of their respective gain controls.
- (b) Automatic level control on microphone channel No. 1, and manual control on channel No. 2.
- (c) Automatic level control on both microphone channels.

The automatic level control of the NAGRA IV series must not be confused with that of the NAGRA III series. The latter used only one transistor and three diodes, and was a simple device with limitations.

The new automatic level control uses 27 transistors and 12 diodes. It is capable of regulating the sensitivity without introducing parasitic components of the control voltage into the signal. The third harmonic distortion which is most noticeable, is normally less than 0.25% over the entire compression range of 30 db. The major innovation of this circuit is that the control voltage is derived from two independent timing circuits. The first has an ultra-rapid response time and is designed to attenuate transients that are higher in level than the signal. The second timing

circuit is designed to operate after a signal has lasted for a short time. It operates on a signal that can no longer be treated as a transient which is the basic signal to be controlled. It modifies the gain according to the level of this signal, and stores the control signal voltage in a memory device which allows the gain to remain unaltered during brief pauses in the speech; thereby avoiding the rise and fall of background noise which normally exists with the conventional type circuit. If the pause exceeds a predetermined time, normally three seconds, the controller assumes that the signal to which it was adjusted has finished, and thus erases its memory and seeks a new level of adjustment. The timing and level of the circuit is adjustable, and can be used to compensate for the different rhythms of various languages and/or individual speakers.

(C) New Recording Process

The new recording amplifier reduces the overall distortion of the recording signal in such a manner as to permit the recording level to be increased by 4 db., still maintaining less distortion than would normally exist. As an example, a conventional tape recorder produces 1.8% distortion at 0 db., whereas the NAGRA IV produces only 0.8% distortion at +4 db at 1 KHz.

In addition, the increased permissible level produces a direct and favorable influence on the signal to noise ratio. In professional recording, the tape is frequently duplicated several times before it reaches the listeners ear, and consequently the distortion at each stage must be reduced to produce an acceptable end result. The NAGRA IV thus presents a new advance in the technique of duplicating.

The noise level and distortion are additive effects so any reduction in either can be used to improve either or both. If the standard recording level of 200 mMax is to be used, the gain should be adjusted so that the modulometer peaks to 0 db. Under this condition there will be a lesser improvement in signal to noise, but there will be a 4 db gain in latitude before overload.

The NAGRA IV is equipped with a double limiter, which reduces the gain of the recording amplifier in the event of a signal which would overload the tape. It is noted that this limiter is independent of the automatic level control and serves a different purpose. It prevents the bad distortion that is normally encountered from an accidental overload, whereas the automatic level controller, as its name implies, regulates the level to an optimum.

The limiter is divided into two separate circuits. The first limits signals in the low and middle frequency ranges and operates in a time less than 1 mSec, with 0.5 Sec. recovery. This limitation produces a signal distortion which is only slightly in excess of the theoretical value.

The second circuit limits in the high frequency range, and it is of a different type which takes into account the high frequency boost of the equalization circuits. In subjective tests, sibilants remain clear.

(D) "F" Device (Fade-in and Fade-out - Mickey Mouse Eliminator)

In order to obtain clean starts and stops in recorded sequences, an intermediate position has been incorporated in the main function selector, between "TEST" and "RECORD". In this position, the functions are identical with those of the "RECORD" position, with the exception that the input signals are attenuated 30 db. On passing from this position to "RECORD", the signal level increases progressively over one second to its normal level, giving a sound fade-in. Conversely, there is a sound fade-out in passing from "RECORD" to "F". After the signal has faded out, the selector can be passed to "TEST" to stop the motor and tape transport. If this effect is not required, it can be annulled by passing directly from "TEST" to "RECORD" and vice versa, without stopping at the intermediate position.

When the function selector is in the "F" position, the white cross in the "AR" indicator disappears, diminishing the risk of accidentally leaving the function selector in this position during a recording.

It should be noted that the devices in this Section 4 are distinctive to the NAGRA IV D and IV L, and similar devices are not found in any other recorders.

5. RECORDING LEVEL MEASUREMENT

In electro-acoustic techniques, there are two methods of measuring signal levels, namely the modulometer and the volume unit meter (VU meter). The latter is a simple voltmeter which responds to the average level of the signal and which has a fairly slow ballistic characteristic standardized at 300 mSec. If the signal is transient in nature, the meter does not have time to respond, and thus shows a level much below the real value. With ordinary speech, a VU meter indicates approximately 8 db. less than the true peak value. The VU meter indication more or less corresponds with the subjective impression of the human ear, but for sounds other than speech, its indications may be very inaccurate.

The modulometer, on the other hand, measures the peak instantaneous value of the signal, and incorporates an integrating or memory circuit to keep the meter circuit voltage constant for a sufficient time to allow the meter to respond. Previous to the utilization of transistors, the modulometer was bulky, and consequently, rarely used. However, with transistors there is no difficulty in incorporating one even in a recorder as compact as the NAGRA. The NAGRA IV is fitted with a modulometer as standard equipment. The modulometer is semi-logarithmic. It is full wave operated to minimize errors due to asymmetrical waveforms.

A VU meter can be installed on special order at an increased cost.

6. BIAS AND ERASE OSCILLATOR

The bias and erase oscillator power has been increased so as to fully erase certain modern tapes that are hard to erase.

The bias level is adjustable by means of a screwdriver control, operating in such a manner that the power consumption is in proportion to the energy requirement, thereby conserving the battery life as much as possible. The oscillator gives an extremely pure signal which contributes towards the reduction of recorded noise.

7. PLAYBACK

The record and playback circuits are completely separate and independent, enabling the operator to playback simultaneously with the recording.

The playback circuit is new and gives an improvement in signal to noise.

The signal leaves the playback amplifier at 560 mV, corresponding to a recording level of 200 mMax. If the original recording level was +4 db., the output will thus be 888 mV. At this level, the signal is available for external use at the mixer socket, and, after further amplification, at the line output and headphone connectors.

The NAGRA IV has a small monitoring loudspeaker. It is adequate for checking for overloads, signal to noise, etc., but it is not intended as a quality check. A volume control for the loudspeaker is mounted on the left hand side of the recorder case.

The line amplifier can operate from both the playback signal and the microphone input signal which can be mixed as required. This facility permits the addition of a commentary to a playback signal, the commentator only hearing the latter. The synchronization of the commentary with the previously recorded sound is thus simplified.

8. LINE AMPLIFIER

The NAGRA IV line amplifier with transformer output gives a balanced floating signal which is satisfactory for direct connection to telephone lines.

A simpler, cheaper and lighter amplifier will be available for situations where a single ended output is acceptable. The lighter amplifier is available on special order.

9. MODELS TO BE AVAILABLE

Several different models of the NAGRA IV will be offered as soon as they are available.

NAGRA IV D

The features described in the preceeding sections of this memorandum are included in the NAGRA IV D non-sync recorder.

NAGRA IV L

This is the Neopilot synchronous version of the NAGRA IV D. The printed circuit miniaturization has made it possible to incorporate within the NAGRA IV L many of the accessories which heretofore have been external. They are:

- (a) Crystal Frequency Standard for synchronization without cables.
- (b) V.H.F. Receiver and Decoder for the start mark and camera identification signals.
- (c) Frequency Meter for checking the camera speed when using synchronization cable between the camera and the NAGRA.
- (d) Synchronizer for slaving a NAGRA with another source of pilot signal, during playback. The second source may be either from a camera or a Crystal Frequency Standard.

All of these accessories are optional and are mounted on plug-in printed circuit boards. It is thus possible to obtain a NAGRA with the complete basic wiring, but without the pilot circuits and without the Neopilot head, all of which may be added at a later date.

NAGRA IV DE AND NAGRA IV LE

These are identical to the NAGRAS IV D and IV L respectfully, but operating at only one speed, namely 7 1/2 in/sec.

NAGRA IV B

This model is also single speed and does not have the automatic level control, low frequency attenuator, "F" Device, Limiter and certain measuring facilities. It is designed to be simple in operation.

NAGRA IV A

This is the automatic model for reporting. It has one microphone input only, with automatic Level Control. It is a single speed machine without the "F" Device or the Limiter. The meter measures the degree of compression. Playback is made at a fixed level, which corresponds to a line output at nominal level for a correctly recorded tape. The loudspeaker volume is controllable.

NAGRA IV M

This model is designed to operate exclusively with the AR IV Mixer. It has only those fixtures that are necessary when working with a mixer. It does have the Limiter and three speeds, but not the second microphone input, line input, gain controls or modulometer.

TECHNICAL CHARACTERISTICS OF THE NAGRA IV

The values given below are typical at ambient temperature, except where otherwise stated, and are for recorders with a complete set of class 1 electronics.

1) Dimensions and Weight		Units
Dimensions of case alone, without knobs, feet, handle, etc., but with lid.	12 1/2 x 8 3/4 x 4 1/4	in.
Overall dimensions, but without carrying handle	13 x 9 1/2 x 4 1/2	in.
Thickness of case	0.079	in.
Thickness of tape deck	0.118	in.
Weight without batteries, tape or reels	11 - 9	lb/oz
Weight with dry batteries and 5" reel of tape	14 - 2	lb/oz
2) Power supply		
Required Voltage supply, D.C., positive to chassis	10.5 to 30	V
Current Consumption:		
"TEST"	85	mA
"PLAYBACK LINE"	175	mA
"PLAYBACK LOUDSPEAKER" (average level)	225	mA
"RECORD"	225	mA
"RAPID REWIND"	320	mA
Battery type-ASA Standard (12 cells)	D or L 90	
Battery life for Eveready (U.S.) type 950-duty cycle 2 hr/24 hr	18	hr

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As above but continuous duty	8 1/2	hr
Battery life for Eveready (U.S.) type 95 Alkaline Battery - continuous duty	32	hr
3) Magnetic Tape		
Nominal tape width	0.246	in
Admissible tape thickness	0.0005 - 0.0021	in
Max. reel diameter (lid open)	7	in
Recording time for tape of 0.0014" thickness at 7.5"/sec.	45	min
Max. reel diameter (lid closed)	5	in
Recording time under same conditions	22	min
4) Tape Advance		
Switched speeds	15. 7.5 3.75	in/s
Speed stability as a function of temperature over the permitted range	0.1	%
Speed stability as a function of position voltage supply, quantity of tape, etc.	0.1	%
Wow and flutter according to DIN Std 45 507:		
15"/sec	± 0.04	%
7.5"/sec	± 0.06	%
3.75"/sec	± 0.12	%

5) Amplifier Characteristics

Values given for NAGRA IV equipped with QPM-1-200 Microphone
Preamplifier.

Overall Frequency response 30-20,000 Hz, 200 ohm microphone, unloaded line output	± 0.5	db
Total harmonic distortion at 0 db level, input 10 mV, output loaded 600 ohms	0.15	%
Minimum input voltage to cause 1% distortion at 1 KHz	35	mV
Noise level with ASA "A" filter	- 126	dbm
6) Modulometer		
Integration time for -1 db	4	msec
Usable scale	- 30 to + 5	db
Frequency response:		
40 - 10,000 Hz	± 0.25	db
20 - 20,000 Hz	± 1	db
7) Erase Characteristic		
Residue of 800 Hz signal recorded at maximum level and erased	- 80	db
8) Record/Playback Characteristic		
Frequency response by standard tape or by record/playback, on Scotch tape No. 203, recorded at -20db:		
Speed:		
15"/sec	30-20,000 (± 2 db)	Hz
7.5"/sec	30-15,000 (± 2 db)	Hz
3.75"/sec	30-7,000 (± 3 db)	Hz

Maximum recording level compared with standard level of 200 mMax.	+4	db
3rd Harmonic distortion 0.8 at this level on Scotch tape No. 102	0.8	%
Noise level of playback system without tape, but motor loaded with tape simulator. Measured with ASA "A" filter, referred to maximum level	-79	db
Signal to noise ratio record/playback - Scotch tape No. 102, speed 7.5"/sec referred to maximum level	70	db
Signal to noise ratio as above, but with Scotch tape No. 203	73	db

9) Inputs

Values are for Nagra IV fitted with two QPM-1-200 Microphone Preamplifiers.

Number of incorporated microphone inputs	2	
Input level for 200 ohm microphone	0.2 - 30	mV
Input level for asymmetric line input. Z = 100 k.ohms	.037-120	V
As above, but at accessory socket	3.7 - 1,200	mA
Mixer input level Fixed level corresponding to 0 db. Z = 9 k.ohms	560	mV

10) Automatic Level Control

Input level for recording at nominal level	0.6 - 20	mV
Average distortion in this range	0.25	%

Frequency response	55 - 16,000	Hz
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11) Speech Filter and Reference Generator

Number of speech filter positions	4	
Reference generator frequency	400	Hz
Reference generator level	- 8 db = 0	vu

12) Outputs

Output level of line amplifier with 600 ohm load for signal level of 0 db	4.4	V
Internal output impedance	60	Ohms
Output level at different frequencies to give 1% distortion into 600 ohm load		
1,000 Hz	9.6	V
5,000 Hz	9.6	V
30 Hz	9.2	V
Maximum output level at headphone jack, no load	880	mV
Output level at headphone jack, with 50 ohm load	20 - 800 variable	mV
Mixer output level for Odb signal, load = 100 k.ohms	560	mV

13) Incorporated Loudspeaker

Electrical power output (with external power supply)	1.6	W
Frequency response \pm 6 db	200 - 15,000	Hz

14) Temperature Range, Position, Etc.

Operating temperature range with special belts and external power supply	-67 to +160	F
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Operating temperature range with normal belts and internal manganese batteries	-4 to +160	F
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Operating position	any
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Vibration, shock, etc., according to Aeronautical Specifications.

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April 4, 1968