

N A G R A 4.2

PORTABLE ANALOGUE AUDIO

TAPE RECORDER



INSTRUCTION MANUAL

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We reserve the right to modify the product, and / or the specifications without notice.

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1.1 INTRODUCTION

The NAGRA 4.2 was introduced originally in 1971. It is a portable 6.35mm (1/4") mono analogue audio tape recorder designed for high quality recording having radio, cinema and television applications.

Many mechanical and electronic modifications have been made to the machine since its release, to adapt it according to modern day requirements. Despite all these modifications, the machine remains remarkably similar to the original.

The Nagra 4.2 can be delivered in two different versions both of which are available in either NAB or CCIR equalization. These versions are as follows:

NQ-LSP	Non pilot
NQS-L	Pilot

Each version has three speeds: 38 cm/s, 19 cm/s and 9.5 cm/s (15, 7½ and 3 ¾ ips) with the following standards: NAB and CCIR.

The Nagra 4.2 is a mono recorder recording full track audio on 6.35mm tape, and the Neopilot synchronization system.

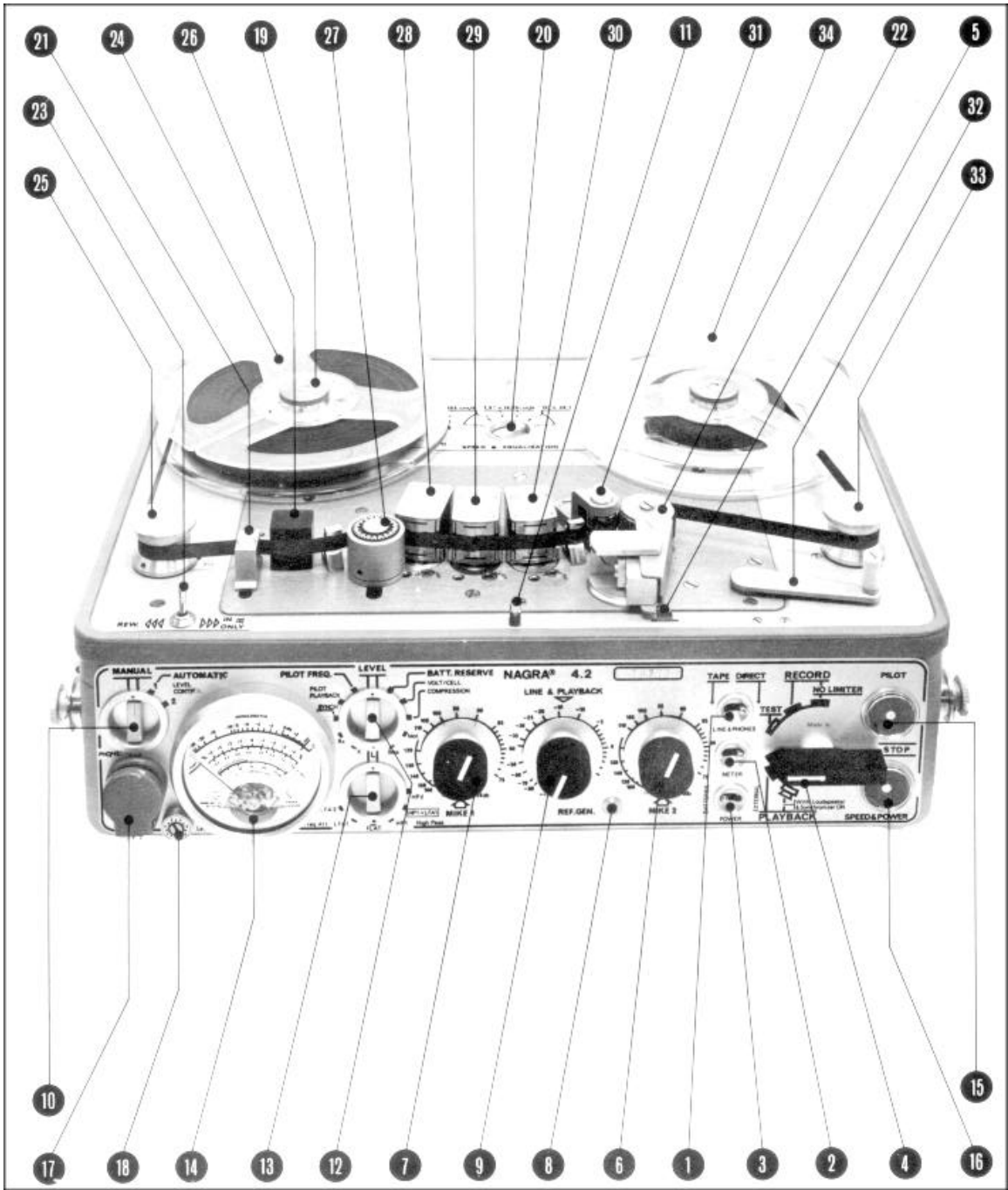
The audio inputs may be used with either the two internal microphone pre-amplifiers (switchable between Dynamic, T power and Phantom power depending on the microphone pre-amplifier which is fitted) or as a line input, via the QCE cable.

The NAGRA 4.2 also contains a switchable limiter, a built-in loudspeaker, and an internal reference generator for line up, and calibration purposes.

Optionally the machine may be fitted with the NEOPILOT pilot option.

The machine may also be powered from either an external supply ATN-3 or internal batteries.

The 4.2 may also be used with the QGB 10" reel adaptor, to allow the use of larger reels for longer recording and playback.



1. TAPE / DIRECT SWITCH (line and phones)
2. TAPE / DIRECT (snap switch)
3. POWER SELECTION SWITCH (external / batteries)
4. MAIN FUNCTION SELECTOR (six position rotary)
5. PINCHWHEEL LIFTER (stop + test only)
6. LEVEL CONTROL mic input 2
7. LEVEL CONTROL mic input 1
8. REFERENCE OSCILLATOR (push button)
9. LINE & PLAYBACK POTENTIOMETER
10. MANUAL/AUTOMATIC SELECTOR
11. LID CATCH
12. MODULOMETER MODE SELECTION SWITCH
13. FILTER SWITCH
14. MODULOMETER
15. PILOT INDICATOR
16. SPEED AND POWER INDICATOR
17. HEADPHONES OUTPUT
18. HEADPHONES VOLUME CONTROL
19. REEL FIXING NUT
20. SPEED AND EQUALIZATION SELECTOR
21. MOBILE TAPE GUIDE
22. PINCH ROLLER
23. REWIND AND FAST FORWARD SWITCH
24. TAPE REELS
25. TENSION ROLLERS
26. ERASE HEAD
27. STROBOSCOPE ROLLER
28. RECORDING HEAD
29. PILOT HEAD
30. PLAYBACK HEAD
31. CAPSTAN SHAFT
32. PINCHWHEEL AND TAPE GUIDE CONTROL LEVER
33. TAPE TENSION ROLLER (OR TIMER)
34. TAKE-UP REEL

1.2 CONTROLS: DESCRIPTION AND USE

FRONT PANEL

1. TAPE / DIRECT SWITCH (line and phones)

When in "TAPE" position, the signal is reproduced directly from the tape.

When in "DIRECT" position, there are two possibilities:

- A. When recording, the signal is available before arriving on the tape.
- B. When playing back, the signal may be adjusted by means of the level control and corrected by filter switch (13).

2. TAPE / DIRECT (snap switch)

This switch affects the meter in the same way that the previous switch affects the output. Thus when it is held to the left, the meter will display the "OFF TAPE" signal whereas normally it displays the "DIRECT" (EE) signal.

3. POWER SELECTION SWITCH (EXTERNAL / BATTERIES)

The NAGRA 4.2 may be powered by either internal batteries or by an external source which may be selected using this switch. See also the "POWER SUPPLY" section of this manual.

4. MAIN FUNCTION SELECTOR (six position rotary)

STOP	Stops the machine completely from any function, and will slightly move the pinch wheel away from the capstan to prevent a "flat" being caused on the pinch roller. In this mode no circuits are powered.
TEST	Will power all circuits and allow level adjustment by means of level controls (6), (7) and (9). In this mode the motor is not powered. All indications of the modulometer will be of the DIRECT input, irrespective of the position of tape / direct switch (1).
RECORD	Is the first of the two RECORD positions and corresponds to RECORD WITH LIMITER where the recording level is limited to +4 dB. This level remains constant when the input level is between +4 dB and +10 dB. Thus in this position tape saturation cannot occur and distortion is avoided.
RECORD	The limiter is inactivated in this position so that recordings that should be saturated can be made. (e.g. gun shots or explosions).
PLAYBACK	Is the first of the two playback possibilities and corresponds to playback of the tape to the headphones and line output only.
PLAYBACK	This position is exactly as above, only it allows (with monitoring via the internal loudspeaker at the same speaker) time. This is also the only position of the main function selector that permits the FAST FORWARD function to be performed.

5. PINCHWHEEL LIFTER (stop + test only)

6. LEVEL CONTROL (right) mic input 2

7. LEVEL CONTROL (left) mic input 1

These are the main level controls for the two microphone inputs.

8. REFERENCE OSCILLATOR (push button)

On the lower edge of the front panel, between the line and playback potentiometer and the mic 2 potentiometer, there is the reference generator push button. When this button is pressed, a composite 1.1 kHz signal with a 10 kHz 9th harmonic at a level of approximately -8 dB is injected into the "DIRECT" chain of the recorder.

The modulometer will show -8 dB. It is useful to record a short burst of this signal at the beginning of each reel of tape so as to enable the level of the playback chain to be accurately calibrated before the real recording is made. This also permits adjustment of the record head azimuth in the field without test equipment. At this point the subject of print-through should be mentioned. After a certain period of time, a recording may be copied (at reduced level) onto adjacent turns of a tape on a reel. This produces a perceptible echo during the silences preceding or following a strong sound. It is thus recommended to leave a pause of two or three turns of tape after recording the "REF" signal.

9. LINE & PLAYBACK POTENTIOMETER

This potentiometer is used to adjust the line input level when using the machine to record a signal from the line input (41).

10. MANUAL/AUTOMATIC SELECTOR

This switch allows selection of the sensitivity adjustment of the microphone inputs. In the MANUAL position the sensitivity is adjusted by means of the potentiometers (6) and (7). In the AUTOMATIC position 1 this gives ALC (automatic level control) to mic input 1 only and for both mic inputs in the position 2.

11. LID CATCH

12. MODULOMETER MODE SELECTION SWITCH

This is an eleven position rotary switch allowing different information to be displayed on the modulometer.

Each position is described below:

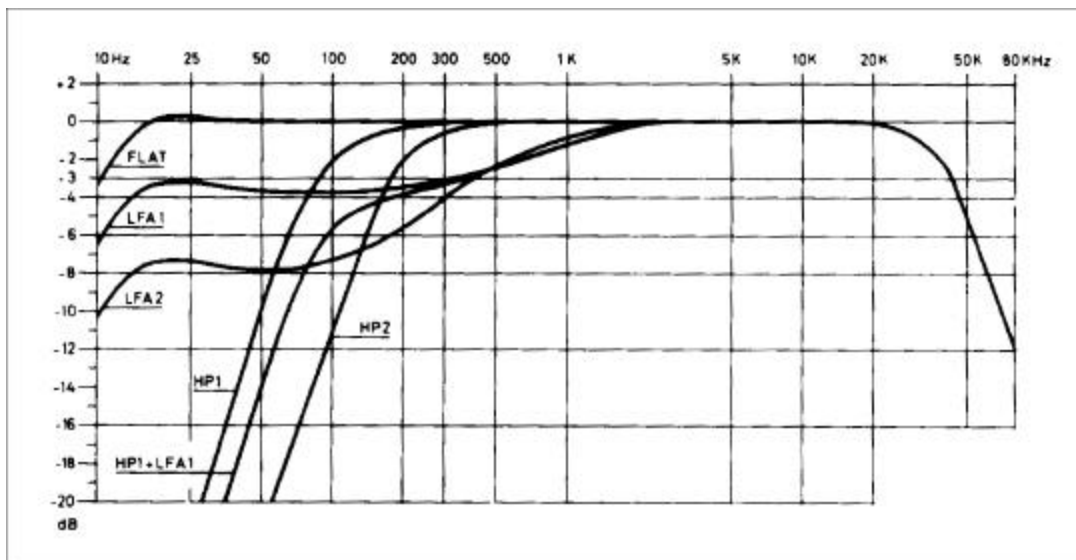
X	Position not used.
RX	Indicates the level of the RF signal picked up by the antenna of the QRR receiver. (see note)
SYNCH	This indicates the phase shift between the pilot playback signal from the tape and the reference signal. Synchronism is correct when the needle is stationary.

- PILOT PLAYBACK** This indicates the level of the pilot signal played back from the tape.
- PILOT FREQ** This indicates on the +4 to -4% scale of the modulometer, the frequency deviation as determined by the QFM frequency meter circuit (if fitted), between the pilot signal being recorded or played back and the 50/60 Hz reference.
- LEVEL** The modulometer will indicate the level of the direct or the recorded signal on the decibel scale.
- BATT. RESERVE** Indicates on the lower scale, the bold line shows the supply voltage reserve; the lower limit at the extreme left of the bold line represents 11 V.
- VOLT/CELL** This is a battery check indicating on the V/CELL scale of the meter and indicates the Volts per cell of the batteries.
- COMPRESSION** Compression reading in decibels on the ALC compression scale when switch (10) is in the AUTOMATIC position.
- MOT** This indicates the motor current. Maximum deviation = 250 mA.
- BIAS** This indicates the record bias level on the V/CELL scale.
- NOTE :** The QRT / QRR radio transmitter and receiver accessories are no longer manufactured.

13. FILTER SWITCH

This is a six position rotary switch, allowing different filter possibilities to be switched in or out.

- LFA 2** Low frequency attenuation, -8 dB at 50 Hz.
- LFA 1** Low frequency attenuation, -4 dB at 50 Hz.
- FLAT** The machine has a linear response.
- HP 1** High pass filter, -10 dB at 50 Hz.
- HP1+LFA1** Combination of high pass and low frequency attenuation, -14 dB at 50 Hz and -3 dB at 400 Hz.
- HP2** High pass filter, -20 dB at 50 Hz.



14. MODULOMETER

This meter is the visual indication of many functions and levels of the machine. The modulometer displays information according to the position of mode selector switch (12).

The modulometer has 4 scales:

1. Recording level in dB
2. Frequency deviation in %
3. Battery voltage (volts / cell)
4. Compression

15. PILOT INDICATOR

This rotary "SASS" type indicator shows a white segment when the frequency (if the machine is fitted with the pilot system) of the pilot signal are correct.

NOTE: This only indicates the presence of a correct signal being fed to, or coming from the head, and does not guarantee correct recording of the signal. This should be checked by switching the modulometer to PILOT playback (this does not function in the RECORD mode).

16. SPEED AND POWER INDICATOR

This rotary "SASS" type indicator gives a quick visual indication that the machine is functioning correctly and will indicate a white segment when this is the case. It will turn black whenever any of the following conditions occur:

- a.) The power supply voltage (batteries or external) becomes insufficient for correct operation of the machine.
- b.) The motor current reaches its maximum limit, in this case voltage and speed stabilizer circuit A22 requires the motor to run faster, but this is not possible because the automatic current limiter circuit has been activated. (If this occurs during normal operation, then contact your nearest NAGRA agent.)
- c.) WOW & FLUTTER is out of tolerance. (Contact NAGRA agent).

Thus, when a white segment is indicated, the operator can be absolutely sure that the power supply is sufficient, that the motor current is correct, and that the tape speed is within tolerance.

17. HEADPHONES OUTPUT

This 1/4" jack type socket (type 297) is the headphones output socket accepting headphones with an impedance of anything from 50 Ohm to 600 Ohm. (Optimum value is 200 Ohm).

18. HEADPHONES VOLUME CONTROL

This small potentiometer is adjustable using a screwdriver and adjusts the level fed to headphones output connector (17).

Position 1 is the minimum and position 6 is the maximum.

19. REEL FIXING NUT

TAPE DECK

20. SPEED AND EQUALIZATION SELECTOR

This is a six position rotary switch permitting the selection of the speed and equalization of the 4.2 in both record and playback.

Possible settings are:

3 3/4	ips	(9.525 cm/s)
7½	ips	(19.05 cm/s)
15	ips	(38.10 cm/s)

For each of these speed selections there are two possible positions labeled I (STD) and II (LN) these correspond to different tape types.

For best quality recordings the 15 ips speed is recommended.

For normal recordings, the 7½ ips speed is available. The 3 3/4 ips speed is available for those cases where the length of recording time of the tape is more critical than the actual quality of the recording.

21. MOBILE TAPE GUIDE

22. PINCHROLLER

23. REWIND AND FAST FORWARD SWITCH

REWIND is possible with main selector (4) in any position other than STOP, assuming pinch roller lever (32) is in the fully open position.

FAST FORWARD is possible only with main function selector (4) in the playback (with loudspeaker) position and pinch roller lever (32) fully engaged.

The central position of this switch is OFF and this is the position that the switch should be in whenever the machine is not required to spool. Keeping it in this position will prevent accidental spooling of the tape when opening the pinch roller gate or playing back a recorded tape through the internal loudspeaker.

24. & 34. TAPE REELS

The 4.2 can be used with reels up to a maximum diameter of 5" (127 mm) with the plexi-glass lid closed, or up to 7" (178 mm) with the lid open. However, if the QSET option is fitted to the machine the 7" (178 mm) reels may be used with the lid closed.

If it is necessary to use reels of up to 10" (254 mm), then the QGB large reel adapter may be used. See Accessories.

25. & 33. TENSION ROLLERS

These two rollers keep the tape tension constant and ensure correct tape handling and positioning. During normal use neither of these two rollers should be at either end of its travel. If this is the case refer to the MECHANICAL CALIBRATION section of the service manual.

The two rollers can be replaced by either the QTIM or QLEN tape measuring rollers. The QTIM is supplied in the place of the take-up reel tension roller as standard equipment. QLEN instead of QTIM is optional. (To be stated when ordering).

26. ERASE HEAD

This is a full track erase head.

27. STROBOSCOPE ROLLER

This roller comes in two versions: 50 Hz (CCIR machines) and 60 Hz (NAB machines). Using this roller, it is possible to check that the machine is running at the correct speed, either in record or playback. This works at all speeds and uses the stroboscopic effect whenever a mains powered lamp is shone upon it. When at the correct speed, the bars on the roller should appear stationary.

28. RECORDING HEAD

Audio recording head.

29. PILOT HEAD

Neopilot head used for both recording and playback of pilot signals.

30. PLAYBACK HEAD

Audio playback head.

31. CAPSTAN SHAFT

Tape main drive.

32. PINCH WHEEL AND TAPE GUIDE CONTROL LEVER

This lever engages and disengages the tape from the heads and motor capstan shaft. It also moves the stroboscope roller and mobile tape guide in and out, to allow easy loading of the tape.

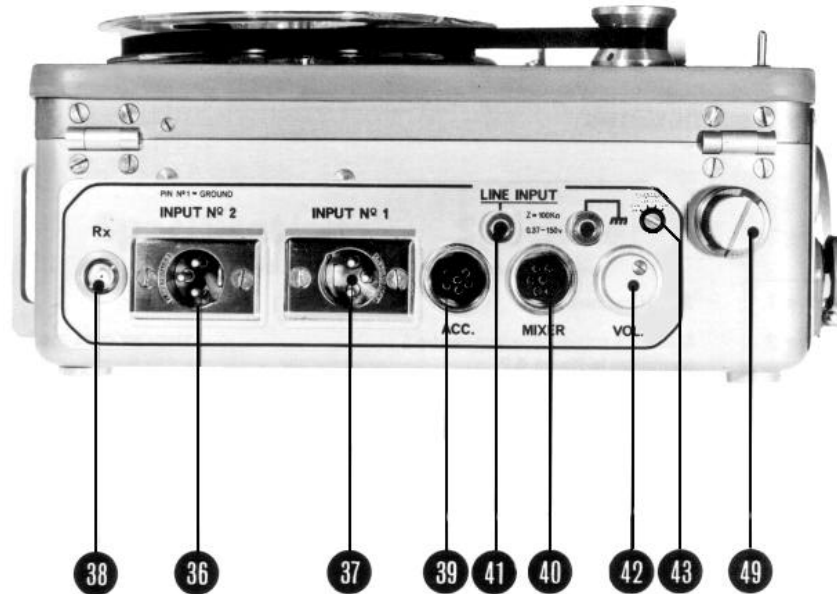
When it is in the open position, rapid rewinding is possible. (This lever should never be left in the open position for long periods of time as this may cause a "FLAT" on the capstan shaft "O" ring).

33. TAPE TENSION ROLLER (OR TIMER) (see 25)

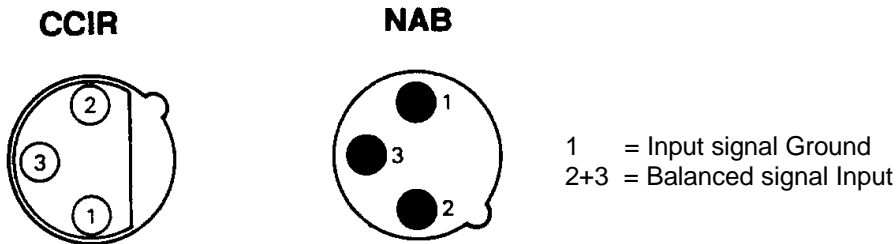
34. TAKE-UP REEL (see 24)

Positions 36 To 49 see CONNECTORS

1.3 CONNECTORS



36. MIKE 2 input



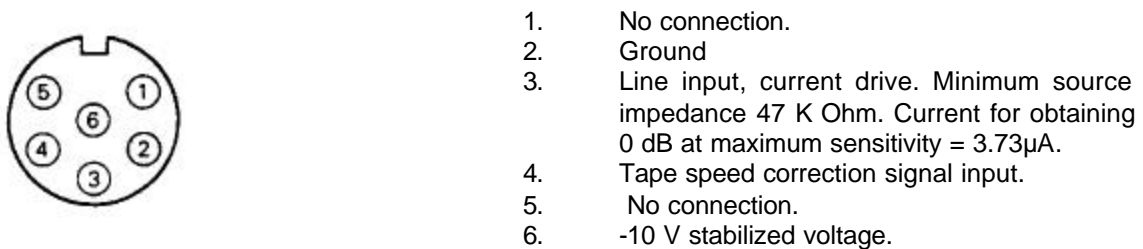
37. MIKE 1 input

Identical to No 36 above.

NOTE: The microphone inputs are convertible into symmetrical and floating line inputs by installing, in place of the microphone preamplifiers, preamplifiers type QPM-6 and using the corresponding potentiometer to control the input level.

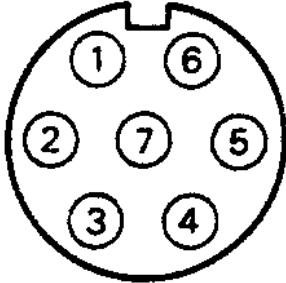
38. RX Antenna input for QRR receiver.

39. ACC (accessories)



40 MIXER

For connection to external mixing console. (connector type: T 3478 corresponding plug T 3475/1).



1. Input with fixed sensitivity, 560 mV to obtain 0 dB, input impedance 9 k Ohm. (2.5 Vpp to obtain +4 dB)
2. -10 V stabilized voltage, Maximum current 50 mA. Noise level < 5 V rms.
3. Direct amplifier output, minimum load impedance 10 k Ohm, output voltage 560 mV at 0 dB. This is a monitoring signal to be fed back to the mixer.
4. Unstabilized negative supply voltage. Available in all positions of the main function selector. Current drawn should not exceed 2 A as this may blow the internal fuse with internal batteries.
5. Playback amplifier output minimum load impedance 100 k Ohm, output voltage 560 mV at 0 dB.
6. Motor stop control terminal. (connect to -10 V to stop motor). Operational in all modes except REWIND. it is not recommended to use this remote method in REC as this will magnetize the recording head and reduce performance.
7. Ground (chassis)

41 LINE INPUT

Banana jack line input connector. Input impedance 100 k Ohm, input voltage to obtain 0 db on maximum sensitivity 370 mV. Maximum voltage, up to 150 V. This is the value supported by the input resistance, but it is not recommended to exceed 10 V as crosstalk might be produced. Up to 150 V has been foreseen is to allow for connection to a sound distribution system at 100 V nominal.

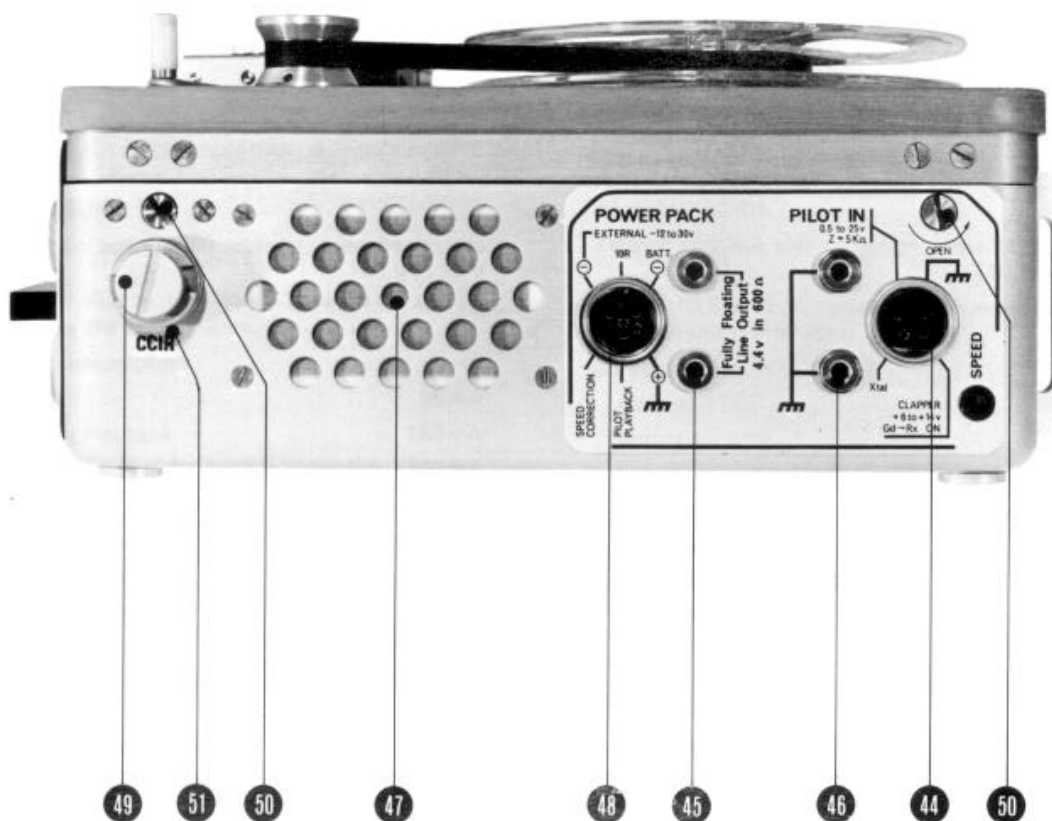
42 VOL

Loudspeaker volume control.

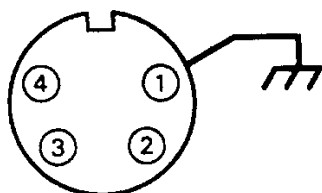
43 MICROPHONE INPUT SELECTOR

This is a four position microphone input selector:

DYN 200	=	Dynamic microphone impedance 200 Ohm 0.2 mV / bar (2mV/Pa) sensitivity.
+48	=	Condenser microphone, 1,5 mV/ibar (15mV/pa) sensitivity +48 V phantom powering.
+12	=	Condenser microphone, 1.5 mV/ibar (15mV/pa) sensitivity +12 V phantom powering.
T	=	Condenser microphone, 1.5 mV/ibar (15mV/pa) sensitivity +12 V T powering.



44. PILOT AND CLAPPER INPUTS



1. Ground
2. CLAPPER: Clapper oscillator control input (control voltage + 4 to 14 V) or switching on of QRR receiver by connecting to ground.
3. XTAL: Internal crystal pilot generator out, 50/60Hz.
4. PILOT IN: Pilot signal input, impedance 5 k Ohm. Input level 0.5 – 25 V.

45. LINE OUTPUT

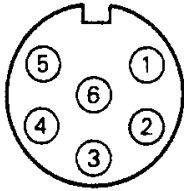
The line output of the Nagra 4.2 is on the right-hand side of the recorder. The load impedance should be equal to or greater than 600 Ohm. When the "Line and Phones" switch is in the position "Tape", the line output voltage is 4.4 V into 600 Ohm while playing back a tape recorded at 0 dB. The Nagra 4.2 can record at a level 4 dB higher than this, thus the maximum line output voltage will be 7 V. Unloaded, these voltages will be 10% greater. The line output uses two 4mm banana sockets. It is made up of by the secondary of a transformer and is floating. A banana socket connected to the chassis is available beside the line output sockets.

46. GROUND (banana socket)

47. LOUDSPEAKER

48. POWER PACK

6 pole connector for external power supply and pilot signal output.



1. - BATT: Negative pole of battery compartment.
2. + BATT: Positive pole of battery compartment.
3. PILOT PLAYBACK: Pilot playback output.
4. SPEED CORRECTION: Tape speed correction input.
5. EXTERNAL -12 to -30: Input for external power supply -12 to -30 V negative pole.
6. -10 R: -10 V stabilized voltage output during record, I max 100 mA

49. FIXTURE FOR CARRYING STRAP/HANDLE

50. CASE FIXING SCREW

51. PLATE SHOWING RECORDING AND PLAYBACK EQUALIZATION.

2.1. POWER SUPPLY

All models of the NAGRA 4.2 may be powered either by an external power supply (ATN-3) or alternatively by internal batteries. The 4.2 will accept voltages ranging from -11 V to -30 V with peaks of up to -35 V. The batteries are placed in the bottom of the machine and the polarity is marked inside the battery compartment. Turning the two fasteners with a screwdriver or a small coin opens it. All the batteries MUST be orientated in the same direction as indicated on the base of the battery compartment.

The NAGRA 4.2 houses twelve "D" type 1.5 V cells having a maximum diameter of 33.5 mm and a length of between 59.5 and 62.5 mm. It is important to remember that corrosive material can leak out of flat batteries, causing severe damage to the recorder, and therefore it is recommended not to leave batteries in the machine during periods of storage.

If leakage occurs as a result of leaving flat batteries in the machine, then wash the affected area with fresh water. The machine will suffer much less from the water than the electrolyte from the batteries. The external supply is fed into the machine via connector marked POWER PACK (48) on the right-hand side of the machine. Rechargeable batteries may also be used and can be charged using the ATN-3C (order no 14376), which includes the charger circuitry.

The 4.2 will function when the power is as low as 12 V (at 15 ips - 38 cm/s) and down to as low as 10.5 V at the lower speeds. (These figures correspond to a machine in perfect condition and working at room temperature).

When using an external supply, selector switch (3) must be in the "EXTERNAL" position. It must be in the "BATTERIES" position when internal batteries are in use. It is not necessary to remove the batteries when working with an external supply (and vice versa).

DANGER OF REVERSED POLARIZATION

A reversed polarized power supply (negative to the chassis) WILL damage the machine. To reduce the risk of serious damage a diode is placed in parallel with the supply, which will be short-circuited in the event of, reversed polarization. If such an event occurs with normal "dry cells", they will be rapidly exhausted and no further damage will occur.

On the other hand, certain accumulators are capable of supplying sufficient current (in excess of 8 amperes) such that the internal wiring of the machine will become hot enough to cause its insulation to decompose. This will then liberate gas, which causes considerable corrosion. If this happens, contact your nearest NAGRA agent immediately.

MEASURING BATTERY CONDITION AND POWER SUPPLY VOLTAGE

BATTERY RESERVE

When the Meter Switch is put into the "Batt. Reserve" position the meter will indicate the difference between the power voltage available and the power, which the Nagra needs. Often the two voltages will fluctuate. The device will take into consideration the lowest instantaneous voltage and memorize this. This detail is important, for the average voltage of a power supply can be sufficient but momentary drops in the voltage can happen and drop lower than the required minimum.

New batteries will give about 18 V whereas the Nagra can be powered by up to 30 V. This explains why, with new batteries, the needle of the meter will only indicate about 40% full scale, when it is switched to "Batt. Reserve".

VOLT / CELL

The meter switch in this position works as a simple voltmeter. The centre scale is graduated from 0 to 1.6 V, it indicates 1/12 of the total voltage or the average voltage of 1 cell.

The position Volt/Cell is essentially designed to monitor the voltage of some accumulators, which would be damaged if they were allowed to discharge below a certain value. This value is 1 V /Cell for certain manganese dioxide alkaline accumulators.

It is also possible to monitor the external power supply voltage. If when in the position "Batt. Reserve" position the indication is that the Nagra is not receiving sufficient voltage, but the Volt/Cell indicates that the power supply voltage is correct, this means that the Nagra requires an abnormally high voltage. Under these conditions the motor and motor collector should be examined.

MEASURING THE MOTOR CURRENT

The meter will measure the motor current when the meter switch is in the position "Mot". There is no corresponding scale on the meter but the "Volt/Cell" scale can be used.

Full scale deflection corresponds to a motor current of approximately 250 mA. In "no load" running, i.e. without tape and with the pinch wheel separated from the capstan (but not in the rewind mode), the needle should indicate between 0.2 and 0.3 V. If this value is exceeded, see paragraph 6.2.

"SPEED & POWER" INDICATOR

At the lower right-hand side of the front panel there is a rotary indicator marked "SPEED & POWER". Under normal circumstances a white cross should appear, but it will disappear when:

- a.) the power supply voltage becomes insufficient.
- b.) the motor current reaches its maximum value. In this case, the speed stabilizer requires the motor to \varnothing faster, but this is not possible as the current limiter has already reacted. Thus there is a strong probability that the speed will not be correct.
- c.) tachometric WOW is out of tolerance.

In summary, if a white cross appears on the indicator the operator may be sure that the power supply is sufficient, that the motor turns at the correct speed, and that the tape speed is correct.

EXTERNAL POWER SUPPLY

On the right-hand side of the machine there is a 6 pin Tuchel-type T 3403 connector marked "POWER PACK". The corresponding plug is the T 3400/1.

The connections are as follows:

pin 1	Battery negative
pin 2	Chassis (positive)
pin 3	Pilot playback output
pin 4	Speed correction signal input
pin 5	Negative external supply
pin 6	-10 V stabilized output.

3.0 OPERATION

On the right-hand side of the front panel is the main function selector, which determines the mode in which the Nagra works. By putting it into the position "Test", all the circuits are powered, but not the motor. If the meter switch, on the upper right-hand side of the modulometer, is switched to the "BATT. RESERVE" position, the needle of the modulometer indicates that the Nagra is powered. (if this is not the case see POWER SUPPLY in this manual).

With fresh batteries, the needle will not advance to more than half way up the scale. It only reaches the extreme right of the scale with an external power supply.

After checking the power supply, put the meter switch to the "LEVEL" position (recording or modulation level). A microphone can receive sounds of a very variable intensity. The tape must be recorded as fully as possible, but without the high frequencies passing a level called the "saturation" level. The modulometer indicates the level of modulation. The needle can deflect up to the mark "Max" on the right of the scale, but should not pass this limit. If the needle is deflected less, the recording will be of a lower level.

The sensitivity, that is to say, the level of recording for a given sound, can be controlled either manually or automatically. The choice is made by means of the AUTOMATIC/MANUAL switch on the upper left of the front panel. In the position "MANUAL" the level can be controlled by means of potentiometers (6) and (7). In the position "AUTOMATIC" an Automatic Level Controller controls the level. The modulometer deflects with respect to the incoming signal without reaching the extreme right-hand end of the scale.

3.2 TAPE SPEED AND STANDARD SELECTION

The NAGRA 4.2 is capable of running at three different speeds, which can be selected by changing the position of "SPEED AND EQUALIZATION" selector (20) on the top deck of the recorder between the two spools.

The speeds available are :

3¾ ips (9.525 cm/s)

7½ ips (19.05 cm/s)

15 ips (38.10 cm/s)

Each position of this selector automatically selects the correct equalization of the machine according to the chosen speed. There are two different positions available for each speed and they are marked "I" and "II" which represent Standard and Low noise respectively.

For adjustments of equalization and checking of tape speed refer to the 4.2 SERVICE MANUAL.

NOTE: The NAGRA 4.2 is only equipped with one recording bias oscillator and it is therefore only possible to bias the recorder for one specific tape type at any one time. However, it is possible to optimize the equalization in the second position (LN) for a different tape.

2.3 LOADING A TAPE ON THE RECORDER

Select "STOP", then release the tape path from the heads, guides and capstan shaft by pulling lever (32) forward, until it comes to a complete stop. Remove the spool retaining nuts and place a reel of tape on the left-hand turntable, with the loose end of the tape coming from the left-hand side of the spool. Pass the tape around the left-hand guide roller and across in front of the heads, and around the right-hand guide roller. Attach the end of the tape to the empty spool on the right-hand turntable. Replace the two spool retaining nuts, and close lever (32) until it reaches its original position, thus putting the tape into contact with the heads.

NOTE: It is important to lower the head-shield before loading a tape, otherwise the tape may pass behind it, and thus not be in contact with any of the heads. When the tape has been loaded and lever (32) has been restored to its original position, the shield may be lifted in front of the heads.

RECORDING

The NAGRA 4.2 can make a recording using either microphones or a "DIRECT" line input signal.

RECORDING WITH MICROPHONES

When using microphones, connect a microphone to one or both of the two XLR type connectors on the left-hand side of the recorder. If the QPUT/QPAUT microphone pre-amplifiers are installed in the recorder, check that the switches corresponding to each of the microphone inputs are in the correct position corresponding to the type of microphone to be used. The possible selections are T-power, +12 V and +48 V phantom, powering or 200 Ohm dynamic.

The level of the signal coming from the microphones may now be observed by putting the machine into the "TEST" position and switching modulometer switch (12) to the "LEVEL" position. The gain may now be adjusted using potentiometers (6) and (7) on the front panel.

Turn the main function selector to either of the two RECORD positions, depending upon whether the limiter is required or not. Observe the modulometer to see that the levels remain correct throughout the recording. The modulometer indicates in both RECORD modes the "Direct" signal. It is possible to show the "off tape" signal during the recording by moving the LINE AND PHONES snap switch to the left.

Depending on the position of "TAPE / DIRECT" switch (1) it is possible to monitor either the input signal, or the "off tape" signal on the headphones output during the recording. This is possible because the NAGRA 4.2 is a three head machine. (Moving this switch will not affect the recording).

RECORDING A LINE SIGNAL

Recording a line input signal rather than a microphone signal is very similar to working with microphones. Firstly set the microphone potentiometers (6) and (7) to their fully anti-clockwise positions. (this is to prevent any noise being amplified by the high gain microphone pre-amplifiers, being recorded on the tape).

Connect the line input signal to the line input connector (41) on the left-hand side of the recorder. Set the main function selector (4) to the "TEST" position and adjust the level of the incoming signal on the modulometer by means of the level potentiometer (9) marked "LINE AND PLAYBACK". Finally switch the main function selector to one of the two "RECORD" positions to start the recording. When the recording is completed, select "STOP".

FAST FORWARD / REWIND

To rewind a tape put the main function selector in the "STOP" position, and open the pinch wheel gate by using operating lever (32) then select "TEST" and rewind the tape by means of toggle switch (23) located on the top left-hand front corner of the top deck.

When the tape is fully rewound always place operating lever (32) back in the fully closed position (this will prevent a "flat" portion being made on the capstan "O" ring).

To wind a tape fast forward use switch (23) as for rewind. However, it is not necessary to open the pinch roller gate. The FAST FORWARD position of the toggle switch is only active when the main

function selector is in the PLAYBACK (with loudspeaker) position. This is done to prevent accidental winding of the tape during RECORDING.

While fast forwarding the tape, the audio on the tape will be heard through the internal loudspeaker. To avoid damage to the loudspeaker, use the volume control (42) to decrease the level.

PLAYING BACK A RECORDED TAPE

Rewind the tape as explained above, then set main function selector (4) to one of the two possible "PLAYBACK" positions (either with, or without loudspeaker). The signal from the tape is now available on line output banana output connectors (45/46) on the right-hand side of the recorder. If line and phones switch (1) is in the "TAPE" position, the signal is fed directly to the line outputs with no possibility for adjustment. However, if it is in the "DIRECT" position then the output may be adjusted with the "LINE AND PLAYBACK" potentiometer.

The frequency response may also be modified using "FILTER" switch (13).

WORKING WITH HEADPHONES

If headphones are to be used, they can be plugged into the jack socket (17) on the lower left-hand front side of the machine.

The level of the headphones may be adjusted using potentiometer (18). In record, the signals can be monitored either off tape or directly, depending on the position of the line and phones switch.

NOTE: When the machine is in the "TEST" position, the headphones output is always fed with the "DIRECT" signal.

The headphones output will accept a 1/4" stereo "JACK" connector (type 297) and can be used with headphones having an impedance from 50 Ohm to 600 Ohm. (Optimum value is 200 Ohm).

During playback, the headphones may be used for monitoring. In the position "Tape" the signal coming from the tape can be heard. In the position "Direct" a mixing of the signals coming from the microphones and from the tape can be heard. The mixing of these signals can be controlled by means of the potentiometers "Mike 1", "Mike 2" and "Line and Playback".

To listen to the recording on an external amplifier/loudspeaker installation, connect it to the Line Output on the right of the recorder. This output receives the same signal as is transmitted to the headphones. Loudspeaker signals should not be allowed to feed a microphone. Under these conditions, the signal passes from the loudspeaker to the microphone, which retransmits it, producing a howling known as the Larsen effect (acoustic feedback).

To avoid this effect, the "Line and Phones" switch should be placed in the position "Tape", or the potentiometers "Mike 1" and "Mike 2" turned down.

To playback in the headphones or to an external installation, the position "Playback" of the Main Function Selector should be chosen. The internal loudspeaker is thus disconnected.

2.8 PRECAUTIONS

The pinch wheel is automatically disengaged in the position "Stop" of the Main Function Selector. This enables the Nagra to be stored with the Pinch Wheel and Tape Guide Control Lever in the closed position. If this lever is in the disengaged position, the lid of the recorder can not be closed.

Do not store the recorder with the Main Function Selector in any position other than "Stop", as this will cause a "flat" to be formed on the pinch roller and this will cause Wow and Flutter problems during future uses. To avoid the accidental discharge of the batteries, put the "Power" switch into "External", thereby disconnecting the internal batteries (if installed).

If the recorder has to be stored for a long period of time, remove the batteries, as a corrosive liquid can leak from discharged batteries.

4.1. DIRECT AND TAPE CHAINS

GENERAL

Signals coming from the microphone(s), line and mixer inputs, once they are amplified, filtered, controlled and mixed, form the "Direct" signal, which will be recorded on the tape.

The signal played back from the tape gives, after amplification and equalization, the "Tape" signal. During recording, the "Tape" signal is that which has already been recorded on the tape, and therefore is not that which is being recorded.

The modulometer measures the level of the "Direct" signal. It is operational even in the absence of a tape. On the other hand, there will be no "Tape" signal in this case. When the Nagra is in playback, the level control potentiometer "Line and Playback" is used to adjust the "Tape" signal. The "Direct" signal is therefore made up not only of the input signals, but also by the playback signal. This allows for example, the superimposition of a commentary to the signal being played back from a tape. On the other hand, the "Tape" signal will always be exclusively the playback signal from the tape.

The line output amplifier, which also feeds the headphones, can be connected either to the "Tape" signal or to the "Direct" signal, the choice being made by the "Line and Phones" switch on the front panel. The loudspeaker amplifier is only fed from the "Tape" signal. Acoustic feedback therefore cannot be produced, even if the microphones are in service, unless, of course, this takes place from the headphones.

The Line and Phones snap switch allows meter readings of the playback signal while recording. It always snaps back into the "DIRECT" position.

AUDIO INPUTS

The Nagra 4.2 has 4 inputs:

- a.) two microphone inputs
- b.) one asymmetrical line input transformable into 3rd microphone input with the aid of an external preamplifier.
- c.) one mixer input at fixed level

MANUAL LEVEL CONTROL

When using manual level control the position of the microphone potentiometers, which are in use, adjust the input in such a way that the loudest sounds to be recorded do not exceed the maximum level. The potentiometers corresponding to the unused inputs should be kept in their anti-clockwise position.

The active potentiometers can be equally used to give a compression, by increasing the sensitivity during the soft passages, and vice versa.

LIMITER

The Nagra 4.2 is equipped with a safety limiter, which instantaneously reduces the gain of the recording amplifier when the signal exceeds the maximum level providing that the RECORD with limiter position of the Main Function Selector has been selected. This limiting evidently causes distortion, but it is less objectionable than that caused by saturation of the tape. Normally, the limiter will only be brought into action when accidents occur. It is possible that, in the middle of a dialogue, for example, a short but high power sounds exceeding the maximum level can occur. Under these conditions it is preferable to saturate rather than to limit because the saturation will be practically unnoticeable due to the short duration of the sound. On the other hand, the limiter requires a certain recovery time before the normal sensitivity of the chain is re-established. This sensitivity variation

can affect the ambient sound and can be a greater nuisance than saturation by a brief sound. To avoid this phenomenon, it is necessary to reduce the recovery time of the limiter. Detailed instructions as to how this can be done will be sent on request. The limiter can be switched off by setting the Main Function selector to position RECORD - NO LIMITER. This may be advantageous for certain recordings, e.g. gunshots, explosions, where tape saturation is desired.

AUTOMATIC LEVEL CONTROL (ALC)

The Nagra 4.2 is fitted with an Automatic Level Control. It replaces the manual potentiometer when the selector switch placed on the left of the meter is on the position "Automatic". In the position "1-Automatic", only microphone No 1 has its sensitivity controlled automatically. Microphone No 2 is controlled by its respective potentiometer. In "2-Automatic", the ALC circuit controls both microphone inputs. The operation of the ALC is complex. It is useful to place the meter switch in the position "Compression" as needle will indicate by how much the sensitivity of the amplifier chain has been reduced. The extreme left position corresponds to a maximum gain; the extreme right to a reduction of gain or compression of approximately 30 dB.

When a signal, whose amplitude is sufficient for the maximum recording level to be exceeded, arrives from the microphone, the Automatic Level Control will instantaneously reduce the gain to avoid over-modulation (similar to the limiter). If the signal is short, the Automatic Level Control concludes that it is accidental, and forgets it rapidly, i.e. it returns to its previous sensitivity. On the other hand, a longer signal is considered useful.

The sensitivity is therefore memorized and maintained. This avoids the increase of background sound level between words. It can happen, however, that an interfering signal is long. This will therefore produce a long reduction of sensitivity. To avoid that, the Automatic Level Control has a circuit of rapid recovery, which enters into action if the level remains less than -10 dB for about 1.5 seconds. Therefore, if a long and loud noise upsets the recording, the recorder can be reset to its normal sensitivity by keeping quiet for 1½ seconds.

Experience has shown that the Automatic Level Control allows an absolutely automatic recording to be made for reporting interviews etc. and of a quality, which is difficult to attain with manual control.

MEASUREMENT OF SIGNAL LEVEL

The Nagra 4.2 is equipped with a device for measuring the signal level. Normally, this is a modulometer, but a v.u. meter is available on special request.

The meter is connected to the "Direct" signal. During recording it measures this level. If the line amplifier is connected to the "Direct" signal ("Line and Phones" switch in "Direct"), the measurement will thus be of the signal sent along the line. On the other hand, if the "Line and Phones" switch is in "Tape", the level sent along the line will be independent of the "Direct" signal and will consequently not be measured. In any case, the level of this signal cannot be altered. A signal recorded at nominal level will give a line signal of nominal level.

5.0 PILOT

INTRODUCTION

The NAGRA 4.2 (NQ-L version) is equipped with a Neopilot system. This system developed by KSA, records a synchronization signal simultaneously with the audio, of 50 Hz (60 Hz in NTSC countries). Two signals are recorded in phase opposition so as to avoid any interference with the audio replay chain. The pilot signal serves as a speed reference to ensure that when the tape is replayed, it is always replayed at the same speed at which it was recorded. The pilot signal can either be supplied from an external source (a film camera for example) or can be generated by the internal crystal generator (QGX-3) if fitted.

If a recording is made with a pilot version of the NAGRA 4.2 it is later possible, during playback, to lock the speed of the NAGRA by means of the pilot synchronizer (QSLI) to an external reference signal. This means that providing the "start" point of the recording is known for both the film camera and the NAGRA then the two can remain in perfect synchronization throughout the tape.

To obtain a film with a synchronous sound it is necessary to keep the image and the sound continually slaved to one another. The acceptable tolerance is in the region of 40 msec.

RECORDING A PILOT SIGNAL.

A pilot signal can be recorded when recording either a line input signal or with microphones.

RECORDING THE INTERNAL CRYSTAL

For the 4.2 to record its internal crystal the QGX-3 crystal generator must be fitted to the machine. This is a circuit that is located on the left-hand end of the battery compartment inside the machine. There are two operating frequencies for this circuit 50 or 60 Hz. Check by means of the switches on the circuit that the correct frequency has been selected. Once this is done then switch the main function selector to the "TEST" position. The pilot indicator (15) on the top right-hand side of the front panel should show a white segment. If this is not the case then check that the pilot crystal shorting plug is located in the pilot socket (44).

This shorting plug is like a blank screw in jumper with the letters "XTAL" marked on it. If this is installed and the rotary indicator does not show a white segment then check that the machine is correctly powered and that the power selector (3) is in the correct position with respect to the supplied source. If this is all correct but the indicator remains black then consult your nearest NAGRA agent.

Once the indicator shows a white segment then the recording is made in exactly the same way as described for recording the audio, the pilot signal will be recorded automatically. No further manipulation of the pilot system is needed.

RECORDING AN EXTERNAL PILOT SIGNAL.

Remove the crystal shorting plug in the connector (44) and feed the Pilot input socket (44) by means of the QCP cable. The other end of the cable must then be connected to the source (either an ATN-3, camera...). Check that the external pilot signal is present by switching the machine to the TEST position as above. While making a recording the cable must always be left connected. Make the recording as above.

SYNCHRONIZING A RECORDED TAPE.

Check that the machine is fitted with the QSLI synchronizer circuit. This circuit is located at the right-hand end of the battery compartment inside the machine. The circuit faces downwards, and has its front right corner cut away.

Feed the pilot input connector (44) with the reference signal either from the pilot out socket on the ATN-3 (for synchronization to mains) or from the machine to which the 4.2 is to be synchronized. Turn the main function selector to the playback WITH loudspeaker position, and after a short period (typically 1.5 secs) the pilot indicator (15) should once again show a white segment. Check the level of the pilot signal from the tape by switching the modulometer switch (12) to the position "PILOT PLAYBACK" The needle should deflect about half way. If the modulometer selector is switched to the position "SYNCH" the meter will indicate the deviation between the external pilot reference and the pilot signal from the tape.

FREQUENCY METER (OPTIONAL ACCESSORY QFM)

This device measures the frequency of the pilot signal. If the meter switch is in the "Pilot Frequency" position, the meter will indicate the frequency. The scale is from +4% on the left hand side to -4% on the right. The accuracy is about $\pm 0.1\%$ on the centre of the scale. In addition, the frequency meter circuit gives a warning if the frequency is more than 5% out from its nominal value. If this is the case then the rotary "Pilot" indicator turns black. The QFM exists in two version for 50 Hz and 60 Hz (QFM 50 and QFM 60).

QUARTZ CRYSTAL PILOT GENERATOR (OPTIONAL ACCESSORY QGX-3)

This accessory is designed for synchronous filming without a cable between the camera and the Nagra. It supplies a signal whose frequency is 50 Hz $\pm 0.001\%$, and is very stable within a wide temperature range.

The output signal of the generator is connected to pin No 3 of the pilot socket. To record it, it must be re-introduced into the Nagra by bridging pin No 3 to pin No 4. This is done with the aid of a dummy plug, which is supplied with the generator, or by a standard plug with the two pins connected. The solution of using a dummy plug rather than a switch has been adopted in order to reduce the risk of human error. The QGX-3 is switchable and gives a 50 Hz or 60 Hz signal.

PILOT INDICATOR

This device is found on the upper right of the front panel. It shows a white cross when the Nagra is in operation and if a pilot signal of sufficient amplitude is provided, and if there is no "Alarm" signal in the pilot system. The "Alarm" signal will appear and turn the indicator black if the following conditions occur:

- A)** if the frequency of the pilot signal is incorrect (on condition that the QFM frequency meter circuit is installed)
- B)** if the pilot signal does not reach the pilot head (on condition that the QSLI synchronizer circuit is installed)

This is indicated in the position "Test" of the main function selector. When the Nagra is in playback, this indicator will only show a white segment when a pilot signal is being played back from the tape and another pilot signal is being fed from outside. If one of these two signals is missing, the indicator will remain black. This is very important when using the QSLI.

INTERNAL SYNCHRONIZER (OPTIONAL ACCESSORY QSLI)

This device has two functions:

- A) It measures the amplitude of the playback pilot signal on the tape. With the meter switch in the position "Pilot Playback" the meter indicates the amplitude. The normal value should be between 1 and 2 V on the lower middle scale.
- B) It can modify the tape speed of the Nagra in order to render the playback pilot signal synchronous with a pilot signal coming in on the "Pilot" socket on the right side. For this speed correction to take place, the Nagra must be switched to "Loudspeaker Playback" and the "Pilot" indicator should show a white cross. The white cross is only shown if the external pilot reference signal is correct and a pilot signal is played back from the tape.

When the meter switch (12) is in the "SYNCH" position, the meter is connected to the QSLI, and shows the difference of phase between the external pilot signal and the playback pilot signal from the tape. Thus, if the signals do not have exactly the same frequency and phase the needle will oscillate. This can be seen on "Playback" (without the loudspeaker). One complete oscillation left, right, left, every 2 seconds corresponds to a speed error of 1%, which can be corrected by the QSLI.

By putting the main function selector in the (Loudspeaker Playback) position the QSLI is switched on, and the needle should be stationary. If it continues to oscillate, then the frequency exceeds the synchronizing capacity of the QSLI. If the Nagra is equipped with frequency meter circuit QFM, and the needle is stationary and if the pilot indicator shows a white cross, synchronization is practically certain.

There is one exception, however, if the playback frequency from the tape is grossly incorrect (e.g. 100 Hz instead of 50), the needle will not be able to follow the beat and will remain stationary in the center of the dial.

If this is suspected, switch to Playback. The needle should oscillate. If need be, upset the tape speed by blocking the left hand tension roller momentarily. If the needle remains in the center, the recorded pilot signal is incorrect.

The speed variator QSV-2 is very useful in these cases. In attempting to adjust the speed (on slaved playback) the QSLI has to adjust itself in order to prevent the speed variator from operating. The needle of the meter will show this adjustment and will prove that synchronization is correct.

SPEED VARIER QSV-2

This is an external accessory for the Nagra 4.2. It is plugged into the ACC socket (39) on the left hand side of the recorder. It enables the speed to be varied manually up to $\pm 12\%$. The QSV-2 is used for the following applications:

- A) To transfer a tape whose pilot signal originated from a camera whose speed was out of tolerance.
The QSLI synchronizer allows the automatic correction of speed errors up to $\pm 2\%$. It is not unknown for cameras to have a speed error greater than this tolerance. The speed Variator allows the offsetting of the average speed, which will then be corrected by the Synchronizer in the normal manner. Naturally, under these conditions, the tone of the sound will be altered, but this is inevitable.
- B) Transfer of a tape whose pilot signal is interrupted. A very convenient method of indicating the start marks (or end of takes) as well as the take identification is by short interruptions of the pilot signal. During these interruptions, the slaving between the Nagra 4.2 and the film recorder is suppressed. It is important that the speed change during the suppression is not brutal, otherwise audible wow will be heard. To avoid this, it is sufficient to make approximate correction with the aid of

the Speed Varier and to allow the Synchronizer to make a final adjustment to ensure the slaving.

This can be done as follows:

Method A

1. Play back the tape to be transferred without slaving. When using the QSLI internal synchronizer, put the Nagra into "Playback" without loudspeaker.
2. Adjust the speed with the aid of the Speed Varier QSV-2 in such a manner that the playback pilot signal and the mains are approximately synchronized. The needle of the Nagra meter (switch on "SYNC") will not swing.
3. Rewind the tape and make the transfer in the usual manner. Under these conditions, the speed correction achieved by the Synchronizer will be very small.

Method B

Make the transfer in the classic manner and adjust the Speed Varier so that the needle (in the position SYNC) remains at the center of the scale (QSLI). This method is less precise, but it is sufficient in practice. It should be noted, however, that the interruptions of the pilot signal happen at the beginning of a sequence, and it is almost always necessary to make a trial playback, adjust the speed, rewind and then make the transfer.

USE OF SPEED VARIER WHILST FILMING ON PLAYBACK

Whilst filming on playback, it is possible that the camera may run at an incorrect speed. It will therefore be necessary to adjust the camera, if possible, to avoid any change in the tone of the final sound. If this is not possible, correction can be made with the Speed Varier (see above).

RECORDING OF FACSIMILE AND SIMILAR SIGNALS

A Nagra equipped with a Quartz Crystal Pilot Generator and a QSLI Synchronizer can reproduce, on playback, frequencies with a precision of the order of 0.001%, as any slipping or stretching of the tape is automatically compensated for. This applies to average frequencies for, inevitably, mechanical tolerances and longitudinal vibrations of the tape will affect the instantaneous speed (wow and flutter).

Experience has shown that this precision is more than sufficient for the recording and reproduction of facsimile signals. Other telemetering applications are, of course possible.

PILOT PLAYBACK USING A NAGRA 4.2 L NOT EQUIPPED WITH QSLI SYNCHRONIZER

Output impedance: 47k Ohm $\pm 20\%$

Load impedance: from zero to infinity.

Output voltage from tape recorded on Nagra 4.2 L: 330mV ± 3 dB.

PILOT PLAYBACK MADE BY NAGRA 4.2 L FITTED WITH QSLI SYNCHRONIZER

Output impedance: 10 k Ohm $\pm 20\%$

Load impedance: from zero to infinity

Output voltage from tape recorded on Nagra 4.2 L: 0.85 V nominal ± 3 dB.

The Nagra 4.2 fitted with a QSLI can be used to measure the playback pilot signal. 0.85 V corresponds to a meter deflection of 1 V on the scale calibrated from 0 to 2 V and normally used to measure the voltage per cell of the batteries. 1.7 V corresponds to full scale deflection.

PILOT CONNECTORS

On the Nagra 4.2, the pilot playback signal is to be found on the Power Pack connector (48), which is a 6 pin Tuchel socket, located on the right-hand side of the recorder.

Pin No 2 is connected to the chassis and the output pilot signal is connected to pin No 3.

6.0 BASIC THEORY

CONTROL OF THE INPUT SENSITIVITY (MODULATION), DYNAMIC RANGE, SIGNAL-TO-NOISE RATIO, DECIBELS

The dynamic range is the ratio between the loudest and softest sound levels. The dynamic range is large for a symphony orchestra compared to that of an announcer reading a news bulletin.

The signal-to-noise ratio is related to the dynamic range. It is important that the softest sound level to be recorded is still considerably stronger than the noise. Thus, sound with a large dynamic range requires a high signal-to-noise ratio. However, this ratio can be practically equal to the dynamic range in the case where the noise level is close to the threshold of audibility. The subjective perception of the sound level follows a law, which is approximately logarithmic. It is for this reason that it is customary to measure sound level as a logarithmic unit. This is the decibel (dB). Each time the sound power is multiplied by 10, the number of decibels, which that represents is increased by 10. Thus an increase of 100 times equals 20 dB, a 1000 times equals 30 dB etc. It should be remembered that the power is proportional to the square of the amplitude. The voltage, which a microphone gives, is proportional to the amplitude. In other words if the voltage increases 10 times, the power increases 100 times and corresponds to 20 dB.

The decibel is a measure of power ratio and not an absolute value. In taking as a reference, a sound corresponding to a variation of pressure of 2×10^{-4} μ bar (value considered as the threshold of audibility at 1 kHz) a scale in absolute value will be obtained. A sound of 90 dB will therefore mean 90 dB above 2×10^{-4} μ bar. The frequency response of the human ear varies with frequency. In order to compensate for this, the sound level should be measured with filters simulating the variations of sensitivity of the ear. Thus the decibels become the phon referred to 2×10^{-4} μ bar. The potentiometer scales of the Nagra 4.2 are graduated in decibels referred to 2×10^{-4} μ bar. At 1 kHz, these decibels are the same as phons but as the Nagra does not have psophometric filters, it cannot be considered as a phon meter. With a potentiometer control placed on X dB, a sound of X dB, captured by a normal microphone (0.2 mV/ μ bar into 200 Ω) and attacking a normal sensitivity preamplifier, produces a recording at nominal level. The modulometer will indicate 0 dB.

COMPRESSION OF THE DYNAMIC RANGE

The ideal installation for recording and reproduction should reconstitute exactly the sound levels, which have been recorded.

The listener should hear exactly what the microphone heard. The human ear has a dynamic range of more than 120 dB. The Nagra 4.2 has a signal-to-noise ratio, which is exceptionally high. However, this ratio can only just reach 70 dB. An amateur tape recorder should, according to the DIN standard, reach 45 dB. It is clear that the ideal installation is not possible without compressing the recording and expanding it again on playback.

Listening to a signal with a dynamic range of 120 dB poses some practical problems. The ambient noise of an apartment or a cinema auditorium is considerably greater than 0 phon. 120 phons becomes painful to listen to. Therefore, apart from exceptional cases, the listening dynamic range should be reduced. The choice of this dynamic range and, in consequence, the degree of compression is one of the essential tasks of the sound engineer.

Classical music discs designed to be listened to on a Hi Fi chain can have a very high dynamic range. A chamber orchestra can be recorded practically without compression. A symphony orchestra should be slightly compressed, and this is done with the music score, and requires a good musical culture.

A transmission designed to be listened to on a Hi Fi chain can have a very high dynamic range. Practically, everything should be at maximum level. On television, the dynamic range can be fairly high. At least in those countries where habitation in individual houses is dominant. Apartment blocks limit the maximum power. In any case, evening transmissions should have a lower dynamic range, the listening level being considerably reduced, but the pianissimo should still be audible. It is true that the ambient noise level is also reduced during the evening.

In cinema work, the dynamic range depends upon the public for which the film has been made. In certain countries the cinemas are very noisy. A comedy film provokes laughter, and this should be taken into account. The dialogue following a joke should always be at a high level otherwise it will

be drowned in the noise of the auditorium. On the other hand, a suspense scene permits the use of very low sound levels.

Generally, for dialogue an effect can be obtained not by the absolute level of the sound but by the contrast. A burst of sound will be much more effective if it is preceded by a passage at a moderate level. This trick is well known amongst cinema "mixers" -the level is lowered before a forte.

WHEN SHOULD COMPRESSION BE DONE?

- A)** Recordings intended to be transferred on to a disc. The signal-to-noise ratio of the modern disc is excellent, but it is important that the noise level of the tape should not be transferred. If a compression is decided upon, it should be done at the time of the original recording, otherwise an increase of the pianissimo will also increase the sound level of the tape noise. It is difficult to use the complete dynamic range of the recorder without the risk of exceeding the maximum level when a fortissimo is produced. For this reason, it is prudent to work simultaneously with two or three tape recorders in parallel, but whose input sensitivities are varied by a few decibels. The tape which has been recorded at the highest level, but without the maximum level having been exceeded, will be the one used for playback. Also, it will be possible to choose, during editing, certain passages from tape No 1 and others from tape No 2 etc.
- B)** Recordings intended for radio transmission. The compression should be done at the time of recording. For reporting ect., the use of an automatic level control can be of interest. It gives a tendency to always obtain the maximum level, that is, it compresses to a large degree.
- C)** Recording intended for radio transmission to be reworked in a studio. In this case, two methods are possible. The signal-to-noise ratio of the Nagra 4.2 is greater than that of the radio transmission; therefore it is not essential to use the complete dynamic range of the Nagra. It is possible, to adjust the sensitivity in such a way that the fortissimo reaches 0 dB. As the maximum level of the Nagra is +4 dB, there is, therefore, a safety margin. The compression can be done according to the needs in the studio whilst working on the final recording.
- D)** Cinema and Television, where the sound is always edited during the final mixing. The important thing is to preserve the maximum amount of sound information. The very large dynamic range of the Nagra 4.2 allows the fortissimo to be recorded at a level below the maximum, avoiding accidental distortion due to a burst of sound. In many cases, it may even be desirable to work on automatic level control, but this decision depends on the circumstances, and those who have to make the decision need no advice. The problem of microphone and preamplifier noise should be considered. Very often, the background noise of the recording is not dominated by that of the tape, but by that of the microphone. In these cases, it is useless to increase the sensitivity during recording. The general level will be greater but so will that of the noise level. Nothing is gained in information, but the risk of saturation by a loud sound will be uselessly increased.

The "point above which it is useless to go" is around the 80 dB mark on the potentiometer scales. This can be easily verified: replace the microphone by a resistance equal to the nominal impedance of the microphone to ensure that ambient noise does not upset the measurement. Record and playback simultaneously ("Line and Phones" switch on "Tape"), listen with good headphones and increase the microphone sensitivity. Even with the potentiometer in the extreme left hand position a noise will be heard. Turn the potentiometer clockwise. Up to 90 dB on the scale, the noise level will hardly vary. As from 80 dB, the noise of the resistance replacing the microphone and of the preamplifier becomes dominant. This point varies according to the quality of the tape used. With a poor tape it can be 78 dB, whereas with an excellent tape 82 dB. It is also to be supposed that the playback will be made on a Nagra 4.2 or on a machine with similar performance. If an ordinary machine should be

used, not having a sufficiently quiet playback chain, it may be desirable to increase the input sensitivity above 80 dB. On the other hand, the problem is completely different if the tape produced should be used without reworking. In this case, it is necessary to compress according to the needs even if the noise level of the microphone considerably exceeds that of the tape. For these applications, there is a special range of high gain amplifiers available (see section 5).

5.3. INTERFERENCE

To obtain a good signal-to-noise ratio, it is not sufficient to place the microphone well, it is equally important that no interference can be introduced into the system. An explanation showing how this interference occurs will be given and also the means to eliminate it.

ELECTROSTATIC INDUCTION

The microphone and the cable, which connects it to the Nagra and the plugs, should all be well shielded. If these conditions are respected, no electrostatic induction can occur.

However, certain parts of some microphones are grounded by a simple contact, which is not protected against corrosion. Often the plug shielding is similar, and certain cables have only a symbolic shielding.

In these cases any electrostatic field can induce interference voltages into the system, in particular if the Nagra is not grounded but is connected to a camera, which is not interference suppressed and the entire system is at a voltage above ground. Hence, the ground itself, as seen by a cable, is a potential source of interference. In other words, interference is introduced at the slightest defect of the shielding. The induced interference can be at an audio frequency or a high frequency, which can be detected within the recorder.

ACTION TO BE TAKEN AGAINST ELECTROSTATIC INDUCTION

1. Good shielding. Above all, check the plugs.
2. Avoid the conditions where the Nagra is floating above ground with an interference voltage. One possibility is to use a photoelectric coupler between the camera and the Nagra. Obviously, no trouble can arise if quartz crystal synchronization is used.
3. If, for any reason, it is not possible to follow the advice given, it is possible to reduce the interference level by:
 - a) Using shielded input transformers, which attenuate the passage of indirect interference.
 - b) Using symmetrical input (with the middle point grounded, which will attenuate the passage of direct interference.
 - c) In the most hopeless cases (such as with a radio transmitter close by) add external filters.

It should be noted that the microphone preamplifiers of the Nagra 4.2 are already fitted with filters, but their action only begins at around 500 kHz, because they are, above all, designed to reduce very high frequency interference for which the usual shielding is ineffective.

MAGNETIC INDUCTION

Certain microphones are sensitive to magnetic fields and they should never be placed close to any motor, or transformer etc. The cables being double and twisted, means that voltages induced should cancel one another, whether the input is symmetrical or not. It is essential, of course, that the microphone should be floating, that is to say, that neither of its output wires should be grounded (except in the case where the shielding should be connected to the shielding of the cable).

The only case where a magnetic induction can be dangerous is where a microphone cable runs along-side a power cable. The latter radiates a magnetic field, which is not homogeneous, and any irregularities in the twisting can suffice to induce interference voltages.

CABLE PREAMPLIFIERS

It would seem somewhat illogical to have to take great precautions to transmit a signal as weak as that given by a microphone when it would be easy to amplify the signal close to the microphone, and thereby transmit a higher voltage. This can be done with a cable preamplifier. This accessory is placed close to a dynamic microphone and gives an output voltage similar to that of a condenser microphone. The power supply requirements are also similar, so that it is possible to interchange a condenser microphone with a dynamic microphone fitted with a cable preamplifier. Under these conditions the Nagra should also be fitted with a plug-in preamplifier designed for a condenser microphone. As the power supply requirements vary according to the type of condenser microphone, so there exists a corresponding range of cable preamplifiers, to be fed from each type of preamplifier.

5.4. VOLTAGE OR CURRENT FEED

By altering the negative feedback, it is possible to adjust the input impedance of any preamplifier to practically any value. If the input impedance is high, the microphone will not supply any current, and only the voltage will be used to transmit the signal. This is called a voltage feed. If the impedance seen by the microphone is very low, the voltage at the microphone terminals will remain negligible, but the microphone will supply a current, which will transmit the signal. This is called a current feed.

A dynamic microphone whose impedance is constant as a function of frequency can be used indifferently for current or voltage feed. Current feed offers certain advantages: the performance of the input transformer has much less influence on the overall result, the noise level is minimum when the input is open etc. This last point ensures that a recording will not be spoilt if an unused channel is left with the level control open. Therefore, when there is a possible choice, current feed would seem to be preferable. Unfortunately, microphones with a cardioid characteristic possess an internal impedance which varies greatly with frequency and they can be used only for voltage feed.

Thus the standard pre-amplifiers for the Nagra 4.2 use the voltage feed method, but current feed preamplifiers are available for special cases, where desired.

FILTERING PREAMPLIFIERS

In a large number of cases, it is desirable to attenuate very low frequency signals captured by a microphone. As the human voice contains practically nothing below 50 Hz, a flat frequency response down to 20 Hz is not only useless, but can be objectionable because low frequency noises can perturb the recording chain.

The filtering is usually done at the final mixing, but if it is known that there are very low frequencies, which should be eliminated, it is better to do it within the preamplifier. Several models of plug-in preamplifier are available for doing this correction.

In the preamplifier code, the figure following the letter Y indicates the attenuation of a signal at 50 Hz in decibels.

MAGNETIC HEADS

There are four tape heads on the NAGRA 4.2, these being ERASE, RECORD, PILOT and PLAYBACK (see "CONTROLS at the front of this manual for their location).

Contact between the magnetic head and the tape must be perfect. Some tapes leave deposits on the heads. Fortunately, the deposits are clearly visible. A dirty playback head gives a muffled sound, lacking high frequencies. If the high frequencies come and go rapidly (one to ten times per second), the azimuth needs adjusting. A dirty recording head will record at a low level, and the sound will be distorted. Under the same conditions an erase head will give poor erasing. To remove the deposit, it is necessary to soften it with the aid of a solvent. The simplest method is to take some absorbent cotton or a rag, soaked in alcohol, or even water and to lightly rub. Chlorinated solvents, such as trichlorethylene, should be used with care, as it is possible they may lightly attack the resins used in the construction of the heads.

ADJUSTEMENT OF HEAD AZIMUTH

Theory

The recording and the playback of a magnetic tape is a function of gaps in the recording and playback heads. These gaps should make a certain angle, arbitrary in itself, with the tape, but which should be the same for recording and for playback. Any angular difference between the recording and playback heads will produce a loss of level. This phenomenon becomes more important as the wave length (that is to say the ratio between the tape speed and the recorded signal frequency) becomes short.

Practically, a faulty azimuth gives muffled recordings without high frequencies. To ensure the interchangeability of tapes, the azimuth angle has been standardized: the angle between the gap and the tape should be 90°. Special recorders, whose heads have been optically aligned, have been constructed in order to produce Standard Tapes whose purpose is to permit the adjustment of the azimuth on ordinary tape recorders. It is to be noted that if a recorder has been used for recording with a badly adjusted azimuth, it is perfectly possible to save the recordings: it is sufficient to adjust the playback head in consequence. This can be done by means of the ear, by orienting the playback head to obtain the sound, which is richest in high frequencies. This method is evidently also applicable to tapes, which have been deformed by a faulty spooling, or by climatic conditions. If the tape is "sabred", or curved the notion of azimuth becomes delicate, and depends upon the relative positions of the heads and the guides. Parenthetically, it is these problems, which limit the use of very low speeds, below 7½ ips, because it is difficult to ensure a sufficiently precise azimuth unless only a narrow track is used. In effect, the error tolerance of the azimuth increases as the width of the track decreases.

In reducing the width of the track, so is the signal-to-noise ratio reduced. Thus the solution of low speed and narrow track is, above all, used nowadays for amateur machines.

Variation of the High Frequency Level with Azimuth Error

When the azimuth is very slowly adjusted past the optimum position, the high frequencies are reduced at first very slowly, then their attenuation is accelerated the further the adjustment is made from the correct point. A curve, which represents this attenuation as a function of the angle of error, has a rounded summit, and sides more and more steep.

This is important, because if the azimuth is adjusted simply in looking for a maximum, it is quite possible that instead of being at the summit of the curve—that is to say at the optimum point—it could be at one side or the other. If the errors of the playback head and the recording head are additive, the tape could be recorded out of tolerance. The recording head is adjusted by referring to the playback head. Thus the azimuth of the recording head has the sum of the errors: that which is produced in adjusting the recording head, and the playback head.

It is therefore important that the azimuths should be adjusted as closely as possible to the top of the curve. This is possible by looking for two points about the maximum, which correspond to a certain attenuation of the high frequencies, and then adjusting to the midpoint.

Secondary Maxima

If the misalignment of the azimuth is continued at the same time as observing the playback of a high frequency signal, it can be seen that after having passed by a minimum, the signal will increase again to pass by another secondary maximum.

If the principal maximum corresponding to the correct angle applies equally to all frequencies, the secondary maximum applies only to one frequency, which is fixed for the particular conditions. If this frequency changes, the position of the secondary maximum is displaced. It is clear that the secondary maximum corresponds to an adjustment which can not be used and which should be avoided. If it is necessary to adjust the azimuth, it should be done by very small degrees, so that no risk exists of reaching a secondary maximum. On the other hand, if it is necessary to adjust the azimuth from scratch, it is better to make the adjustment with a fairly low frequency (1, then 3 kHz) to obtain an approximate azimuth position. At these frequencies, the secondary maxima are outside the range for adjustment of the heads.

Orientation of the Heads on the Nagra 4.2

The heads of the Nagra 4.2 are pressed down on a cam. On turning this cam, the azimuth is varied. The outside of the cam is in the form of a gear wheel meshed with a pinion, which is visible in front of each head. The pinion can be turned by means of 2½ mm "Allen" key. The Allen key should be demagnetized before using it as a magnetized tool can induce a very low frequency into the playback head, which could upset the adjustment.

Bias

To record, that is to say, to magnetize a magnetic tape, it is necessary to submit it to a magnetic field, which passes a certain threshold value. Below this value, no permanent magnetization will be produced. To reach the threshold, and to pass into the linear part of the magnetization curves, the audio frequency signal is superimposed upon it. The peaks of the high frequency signal always make an excursion into the linear region. The low frequency signal determines, in effect, to what point the excursion will be made. This is called high frequency bias. Its amplitude influences notably the quality of the recording obtained, and the determination of its level should be made precisely.

Effect of Bias Signal Amplitude on the Recording

If a low frequency signal (400 Hz) is applied to a recording head whose bias level is varied, several effects can be observed. A low level bias signal will give a weak distorted signal on playback. As the bias level increases, so the level of the signal increases, rapidly. A maximum will then be reached, after which the signal level will be very slowly reduced. The maximum can be called the "Point of Maximum Efficiency". It corresponds also to the point where the distortion is the minimum. The fact that the signal becomes too great, renders the determination of the optimum point rather difficult. A high frequency signal (e.g. 10 kHz) will give its maximum level for a bias level noticeably lower and which corresponds to a point where a low frequency signal would become distorted. This is due to the fact that the magnetic layer of the tape is not infinitely thin. The point of maximum efficiency for a low frequency corresponds to an optimum recording throughout the whole of the magnetic layer. The outside part will in fact be over-biased and, to a certain extent, even partially erased. The middle of the layer is further away from the heads, hence the loss of high frequencies. It is essential to remember that in over-biasing, not only is the efficiency of the recording of the high frequencies diminished, which can be compensated for by an increase in the recording current, but the playback signal is attenuated, thereby showing saturation of the magnetic tape. On the other hand, an over-bias will lower the noise level of the tape.

High Frequency Pre-emphasis

The signal-to-noise ratio of the magnetic tape is perhaps the least satisfactory of its characteristics. Great efforts have been made to improve this defect. It is possible to imagine, for example, a tape recorder, which sends to the recording head a current, which is proportional to the input signal, independent of the frequency (recording at constant current).

Experience shows that the tape becomes saturated for a given current in the recording head irrespective of the frequency. At high frequencies the saturation takes on special characteristics. The harmonics, which the saturation should produce, go out of the range of the spectrum, which the playback head can reproduce. Therefore, a tape saturated in the high frequencies does not give a distorted signal. Simply, an increase of the recording current does not produce an increase of the recorded signal.

In effect, the tape becomes a limiter, which, in addition, alters the sonority of the recording.

A tape recorded under these conditions (constant current) should be played back on a head followed by an amplifier fitted with frequency response correctors so that the ensemble will be linear.

It can be seen that with the sounds, which are normally recorded, the level of the high frequencies is noticeably lower than that of the middle frequencies. To be exact, the peaks of the high frequencies can have a large amplitude but their duration is very short, and a limiting will pass unnoticed.

From the idea of emphasizing the high frequencies during recording and to attenuate them during playback, the noise level of the tape, which is annoying above all in the high frequencies, is effectively reduced. This is known as pre-emphasis. It is used universally in disc recording and frequency modulation radio transmission as well as in magnetic recording. This universality is very important, for if there is a pre-emphasis in any link of a chain, it is useless not to have it in the other links, because, in any case, the high frequency peaks will be limited in the link which has the strongest pre-emphasis. On the other hand, the gain in the signal-to-noise ratio is preserved in each link. As a summary, the recourse to pre-emphasis is universal, as it has been found that the possible limiting of high frequency peaks is less annoying than the high noise level without pre-emphasis.

How much pre-emphasis can be accepted? The question is complex, for it depends upon the type of sound to record. The sound spectrum varies with different languages, and it is for this reason that the standards for pre-emphasis vary from one country to another. For practical reasons, it is not the pre-emphasis, which has been standardized in the case of magnetic recording, but the playback chain. The recorder should be adjusted so that a tape produced on it and played back on a standard playback chain should have a linear response, this is the same as standardizing the pre-emphasis for a given type of tape. There are tapes whose capacity for recording high frequencies is noticeably higher than that of standard tapes. To record on these tapes, according to the standard, it is necessary to have a lower pre-emphasis.

Relation between Pre-emphasis and Bias

The American NAB standard at 7½ ips requires a greater pre-emphasis than the European CCIR standard. In Europe, it is normal to slightly over-bias the tape. This gives a slightly better signal-to-noise ratio, but reduces the recording level of the high frequencies. The final result is practically identical to that obtained with the NAB standard without over-bias. The stronger pre-emphasis of the NAB standard gives approximately the same improvement in signal-to-noise ratio and the tapes become practically saturated at the same high frequency signal level. The NAB standard relies upon a heavier pre-emphasis and the CCIR on the higher bias level.

Practical Conclusions

The result is:

- a) It is possible to modify the pre-emphasis, within certain limits, by adjusting the bias level but still remaining within the limits of the standards.
- b) To record sounds particularly rich in high frequencies, it is possible that the use of tapes, which permit high recording level of the high frequencies, could give better results.
- c) It is necessary to determine which link in the chain gives the greatest pre-emphasis. If all links pre-emphasize to the same degree, this will produce the most rational chain. However, if one link becomes saturated, it is better for this to be the magnetic tape, for the saturation of the high frequencies does not lead to audible distortion, which is not the case with a frequency modulation transmitter (or rather, the corresponding receiver).

DETERMINATION OF THE BIAS LEVEL

Tape Characteristics

The tapes on the American market are very similar to one another from the point of view of the optimum bias level. This permits the adjustments to be made very close to the point of maximum efficiency. It would be undesirable to adjust directly on to this point, as an over-biasing is much less dangerous than an under-biasing. This working point close to the point of maximum efficiency is very convenient for the NAB standards, as shall be shown.

In Europe there is a greater range of tape characteristics. In over-biasing the ordinary tapes, the working point remains correct for the tapes, the working point remains correct for the tapes at a high bias level. This ties in with the CCIR standards and gives good results.

General Procedure

It is necessary to use a reference tape whose characteristics are well known, above all in relation to other tapes on the market. The normal reference tape is CCIR PER 368 and NAB 3M 808.

It is necessary to determine the bias level, which gives the greatest efficiency. The signal used will be of fairly low frequency (400 Hz). To locate the peak of the curve more easily, two points, E1 and E2, should be looked for. Point E1 has an underbias level which gives lowering of the playback level by 1 dB; E2 is an over-bias level, which gives a lowering of the playback signal by 0.5 dB. The asymmetry of the form of the curve justifies the difference in the playback levels of E1 and E2. It is evidently necessary to use a sufficiently regular tape so that variations of the sensitivity should not be confused with the loss of level due to under and over-biasing.

The maximum efficiency bias level E_m will be the geometric mean of E1 and E2. Multiplying E1 by E2 and taking the square root of the product find this. The working point will be $E_m \cdot k$ where k is the coefficient of over-biasing.

Variation of k

The preceding rules take into account the dispersion of the characteristics of available tapes. If a recorder is only used with one specific type of tape it is possible to use a value of k, which will be optimum for the conditions. Values of k from 1 to 1.3 are possible.

A small value of k can be used if the sounds to be recorded are rich in high frequencies, or if the tape is of a low quality for high frequencies. A value of k above average can be used in the opposite case. The value 1.2 is acceptable for the CCIR standard, and 1 to 1.1 for the NAB standard (50 μ s at 7.5"/second).

7.0 CALIBRATION AND CARE

HEIGHT OF THE NEOPILOT HEAD

The middle head of the Nagra 4.2 is used to record and playback the pilot signal. Its azimuth is not critical, but its height should be correct. The cam of this head does not vary the angle, but only its height. Before adjusting the azimuth, check and adjust (if need be) this head. Adjust the height so that the tape is exactly in the middle of the head. The eye is sufficiently accurate for this adjustment.

AZIMUTH ADJUSTMENT OF THE PLAYBACK HEAD.

Playback a Standard Tape at 7½ ips. Place the "Line and Phones" switch in the "Direct" position. The modulometer will thus indicate the playback level. Check that the microphone potentiometers are in their extreme anti-clockwise position, and adjust the "Line and Playback" potentiometer to give a convenient playback level. Standard Tapes are generally recorded at between -10 and -20 dB, so that, in general, it will be necessary to put this potentiometer in the maximum position, or nearly so, to have a playback level of about -10 dB.

Introduce the key into the pinion of the playback head and find the maximum playback level. After this, look to left and right for the points where the signal level is lowered by 1 to 2 dB, and place the pinion midway between these points.

A correct adjustment corresponds equally to a stable playback. Errors due to "sabring" of the tape are hardly perceptible at the top of the curve, and only become important on the sides.

Once the playback head has been correctly adjusted for azimuth it should not be touched again.

AZIMUTH ADJUSTMENT OF THE RECORDING HEAD.

Two methods are possible:

1. Standard Method

To use this method, it is necessary to have an audio frequency generator, which can give 1, 3, 10 and 15 kHz and an AF voltmeter or an oscilloscope. It is possible to use a second Nagra as a voltmeter, by introducing the output signal of the recorder to be adjusted into the line input of the second one, and using its modulometer as a voltmeter.

Procedure:

- a.) Introduce a signal from the generator into the line input of the Nagra, and adjust the level to -15 dB on the modulometer.
- b.) Connect the voltmeter to the line output. The signal to be measured will be approximately 0.8 V R.M.S. The "Line and Phone" switch should be put into the position "Tape".
- c.) Thread up a tape and record. The played back signal should be observed on the voltmeter.
- d.) Start with 1 kHz and increase the frequency. When the playback signal starts to be reduced in level by several dBs, adjust the record head. It should be possible to arrive at 15 kHz, always looking for the midpoint between two of equal attenuation.

2. The "Rectangular 1000" method

Whilst the classic method necessitates bulky instruments, the "Rectangular 1000" method, equally precise, can be carried out with the aid of the reference generator and good quality headphones. The ear serves in this case as detector.

In effect, the human ear cannot appreciate the absolute value of a high frequency sinusoidal signal, but, on the other hand, it can determine the harmonic content of a rectangular signal. In practice, this becomes a judgment of a tone and to render it as "hard" as possible.

Procedure

- a.) Thread a tape onto the Nagra whose playback head has already been adjusted
- b.) Press the button REF. GEN.
- c.) Record and listen to the signal played back in the headphones ("Line and Phone" switch on the position "Tape").
- d.) Adjust the azimuth of the recording head to obtain a sound as rich in harmonics as possible. The sound produced in the headphones should be the same in both positions of the "Line and Phones" switch. Look for the two points on either side of the optimum, which give a sound equally muffled, and adjust for the midpoint between them.

6.2. MAINTENANCE OF THE MOTOR COLLECTOR

The motor of the Nagra 4.2 has a collector in a special alloy, which is perfectly resistant to corrosion. This ensures good operation, even under aggressive climates. The motor brushes are of a graphite silver composition, and their pressure on the collector is ensured by gold plated beryllium bronze springs.

The brushes wear by friction on the collector and the product of their wear forms a self-lubricating layer called patina, necessary for the correct operation of the motor. The thickness of this patina depends on the specific pressure of the brushes. If this is too low, the operation will be noisy (squeaking). If it is too high, the insulation between the segments of the collector may become bridged over, resulting in an increase of current consumption.

Remedy for Motor Noise

It should be noted that by motor noise, the normal noise of the motor due to the ball bearings and the friction of the brushes on the collector segments should be discounted only a squeaking produced by the vibration of the brushes should be taken into account. Experience has shown that this can happen when the pressure of a brush falls below 12 grams. The remedy consists of an increase of the pressure by stretching the brush springs. The normal value is 25 gr \pm 5 gr.

Metalization of the Collector

During the running in period, it is possible that the brushes have not taken on the exact form of the collector. Local specific pressure can produce a very thick patina, which can short circuit the segments of the collector. In the worst case, the "SPEED & POWER" indicator on the front panel will warn the operator. It is recommended to check occasionally (every 100 hours of use) the no-load current of the motor. To do this, place the meter in the "MOT" position. The meter then measures the current taken by the motor. There is no special scale for this measurement, but the lower middle scale graduated 0 to 2 V can be used arbitrarily. With no load, that is to say, without a tape and with the pinch wheel just separated from the capstan, the needle should indicate between 0.2 and 0.3 V. If the needle indicates higher than 0.4 V, the collector probably requires cleaning.

Cleaning of the Collector

Open the Nagra and pull off the motor shielding (being careful not to deform it). Switch on the motor and clean the collector by rubbing with a rag or absorbent cotton soaked in a solvent. The insulation between the segments of the collector should be the same colour as that on the top of the collector. If the conditions are extremely bad, a very fine abrasive polishing cloth may be used, but it is essential not to use powdered abrasive, which could possibly cause damage within the motor itself.

6.3. LUBRICATION

In the case of intensive use, it may be necessary, from time to time, to lubricate the ruby pressure ball on the take-up reel clutch. This ball can be found in the middle of the pulley, which drives the take-up reel. The best grease to use is an Esso grease, but if the recorder is not to be used at very low temperatures, any mineral grease can be used.

For other oiling points, use an oil designed for aviation instruments, such as Isoflex PDP65 from Klüber-Munich, or P10 from the Bendix Aviation Corporation, USA; but once again, for recorders not to be used in very low temperatures, any good sewing machine oil should be acceptable.

8.0 MICROPHONES

INTRODUCTION

There are several different types of microphone pre-amplifiers available for the NAGRA 4.2, in order to accommodate almost all of the different types of microphones presently available. Microphone technology is not stable, and each year new models are put on to the market. Many of them require power supplies, which exist in different forms. The output voltages can vary, according to the type, in the ratio of 1 to 20. This means that it is not advisable to supply a tape recorder with only one type of microphone pre-amplifier. It is preferable to have interchangeable preamplifiers.

5.2. THE MICROPHONES

A microphone converts acoustic energy into an electrical signal. Numerous physical principles have been used to obtain this conversion and there are many different types of microphone available: Condenser, moving coil dynamic, ribbon dynamic, microphones etc. Neither the perfect nor the universal microphones exist. Each type has its defects and particular qualities, and the choice depends upon the required effect.

MICROPHONE CHARACTERISTICS

Sensitivity

Placed in a given acoustic field (e.g. μbar R.M.S.), a microphone will give a signal of X mV R.M.S. X represents the sensitivity or, in effect, its efficiency. To give this value sense, it is also necessary to state the internal impedance of the microphone and the load impedance.

A classic dynamic microphone may have a sensitivity of 0.2 mV/ μbar from 200 Ohm internal impedance. A model giving 0.25 mV is considered to be sensitive, whereas a model giving 0.1 mV is unsuitable for capturing low level sounds.

Condenser microphones always have a preamplifier in the microphone casing, otherwise their high impedance would not allow the signal to be transmitted along a cable. At the output of the preamplifier a typical sensitivity figure is 1-4 mV/ μbar with a load impedance of 200-1000 Ohm. It is difficult to produce a very low noise preamplifier capable of receiving (without overloading) a signal given by a condenser microphone placed in a strong acoustic field (100 μbars). For this reason, it is better to have a special preamplifier for condenser microphones. The use of an attenuator between a condenser microphone and a preamplifier designed for a dynamic microphone is not recommended, as the signal-to-noise ratio will be unfavorable.

Frequency Response

The frequency response represents the sensitivity of the microphone as a function of the frequency. It is possible that the response will be different according to the direction from which the sound comes. This point is very important and will be dealt with in detail later.

Microphone manufacturers pay careful attentions to the frequency response, and in general, most of the professional microphones available have a sufficiently good characteristic, at least for sound arriving along the principal axis.

Coloration. Transient Reproduction. Reverberation

An artificial reverberation chamber may have excellent frequency response, distortion and signal-to-noise characteristics, but it must also modify the signal, which passes it. It adds the reverberation. This shows that the frequency response, distortion and signal-to-noise ratio are not sufficient to describe an electro-acoustic device. A moving coil dynamic microphone makes use of resonances

to render its frequency response flat. With continuous sinusoidal signals it functions perfectly, but when a signal appears suddenly, the resonating device needs a certain time to move. When a sound disappears suddenly, the resonator continues to produce a signal. The result is that the transient signal (e.g. a percussive sound) will be colored by the inherent resonance of the microphones. This explains the difference noted by the ear between microphones with seemingly identical characteristics.

In general, condenser microphones use resonators only in the extreme high frequencies, where the coloration phenomenon has little importance. As a result, their fidelity is excellent. Ribbon microphones can colour the low frequencies. Moving coil dynamic microphones colour to the greatest extent, this coloration is not always undesirable. They can improve certain voices, and the experienced engineer will not hesitate to use them under certain conditions. He can also use any defects in the frequency response for filtering, etc.

Use at High Sound Levels

Ribbon microphones and bi-directional condenser microphones can be damaged by a large air displacement.

To record an explosion, a moving coil microphone, or better still, an omni-directional condenser microphone is recommended. A switchable microphone (uni-, bi- or omni-directional) risks the same damage as an ordinary bi-directional microphone. A microphone can be damaged under these conditions whether it is being used or not. It is advisable to place bi-directional and cardioid microphones in sealed boxes if an explosion is likely.

Independent of the risk of damage, it is possible that a microphone will not reproduce well at levels greater than a certain value, above which the signal would become distorted. In general, moving coil microphones support the highest levels. Certain condenser microphones are designed so that an attenuator can be placed between the microphone capsule and the preamplifier.

Signal-to-noise Ratio

The recording of low level sounds can be disturbed by the combination of the microphone and its preamplifier. The word "combination" is used because the background noise does not come only from the amplifier. Take the case of a dynamic microphone whose impedance is 200 Ohm. As it does not have a temperature of absolute zero (- 273° C) the electron movement in this impedance will produce a noise signal called the thermic noise. The preamplifier adds to the thermic noise its own inherent noise, but in a recorder such as the Nagra 4.2, the thermic noise is by far the most important.

The acoustic noise is measured in phons. The phons are decibels whose reference zero has been fixed by convention at 0.0002 μ bars. The measuring device is not linear, but has a frequency response similar to that of the ear. For low levels, this frequency response is called the ASA "A". It is possible to find out the equivalent acoustic noise level of a microphone and its preamplifier. Take for example a microphone of 200 Ohm having a high sensitivity (0.25 mV/ μ bar). Its noise level referred to the input will be -126 dBm ASA "A" (the dBm are decibels whose reference zero has been fixed at 1 mW). Now, 0.0002 μ bars is equivalent to 0.005 μ V (139 dBm). Therefore the equivalent noise of this microphone will be 139 - 126 = 13 phons.

This figure is correct only if the impedance of the microphone is 200 Ohm. Often, certain microphones whose nominal impedance is 200 Ohm have higher impedance's, at least in certain parts of frequency spectrum. The effect of this is to increase the equivalent noise.

A condenser microphone can also be characterized by an equivalent noise level, thereby making it possible to compare the performance of these microphones with that of dynamic ones.

Directional Characteristics

Often, when recording sound it is desirable to attenuate certain unwanted sounds, such as echoes coming from the studio walls. Certain microphones have a sensitivity, which varies greatly according to the direction from which the sounds come. In effect, these combine a pressure characteristic with a velocity characteristic. Taking into consideration the air pressure at any given point, a microphone acting as a manometer is called a pressure microphone. The direction from

which the sound comes does not affect the pressure, except at very high frequencies, when the microphone makes its own shadow.

On the other hand, the velocity of the air molecules can be used in a microphone. The word velocity implies a combination of speed and direction. A velocity microphone consists of a very light loose diaphragm, which follows the displacement of the air. It will be sensitive to waves, which strike the diaphragm perpendicularly whether they come from in front of, or behind it. Waves coming from the side will have no effect. This is the principle of velocity of bi directional microphones. Such a microphone eliminates an important fraction of the reverberation and if the source of undesirable noise is well localized, it can be placed in the dead zone of the microphone.

In combining a pressure microphone with a velocity microphone, a unidirectional, or cardioid microphone is obtained. The two elements are, of course, mounted in a common casing and electrically interconnected.

Secondary Characteristics Related to Directional Characteristics

Omni-directional microphones (pressure) are much less affected by the wind than bi-directional (velocity) or cardioid microphones (because of their velocity element). The light diaphragms of velocity microphones have a tendency to float in the wind. It has been shown that the velocity microphones are easily damaged by a sudden air displacement (explosion). The response curve of an omni-directional microphone is reasonably independent of the direction. However, sounds coming from behind will have a tendency to become muffled. Bi-directional microphones attenuate the lateral sounds in a relatively uniform manner, but cardioid microphones, and above all, dynamic ones, can have a very bad frequency response in the null directions. In other words, the attenuation varies greatly according to the frequency. If a cardioid microphone is used to eliminate undesired noises, this phenomena is not of great importance. If such a microphone is used to balance the sound, when a very loud source is placed around the null area of the microphone, it is advisable to check the results. The internal impedance of omni-directional dynamic microphones is reasonably constant. They can therefore be used to feed their preamplifier either by voltage or current. On the other hand, the majority of cardioid microphones have an impedance varying greatly with the frequency. In this case only a voltage feed is recommended. Directional microphones only function well if they are sufficiently far from other objects, which can disturb the acoustic field, because an obstacle disturbs the pressure less than the velocity.

PRACTICAL ADVICE ON THE CHOICE OF THE MICROPHONES

Omni-directional Microphones (pressure)

Robust, with low sensitivity to the wind, reproducing ambient sounds well-their price is lower than that of directional.

Principal Use: reporting

Special Uses: Lavalier microphone. For this use, special units have been created whose frequency response compensates for the perturbation of the body, and which takes into account the very low frequency sounds radiated directly from the chest. Recording music in the open air. Reverberation is non-existent and there are good microphones available - also very robust of low sensitivity, 0.1 mV/bar, which is acceptable as the sound level is reasonably high in these cases. Recording when the microphone is placed in the middle of a sound source (e.g. in the middle of an orchestra).

Bi directional Microphones (velocity)

These give a very good attenuation of reverberation, and a good fidelity for sounds coming from the null direction. They are very sensitive to wind noise, and they accentuate the low frequencies if the sound source is very close. This phenomenon gives a very "Warm" effect, which is exploited by certain "charm" singers. Principal uses: music. Dialogue in the case where the microphone is placed between two speakers. Remarks: Dynamic bi-directional microphones, i.e. ribbon microphones, are either of very low sensitivity, or very bulky. They radiate a magnetic field, which is capable of erasing a tape if placed close to it. Condenser microphones have a normal sensitivity.

Switchable Microphones

Certain condenser microphones can function as omni-, bi- or unidirectional by means of a simple switching.

Choice between Condenser or Dynamic Microphones

Condenser microphones give the best fidelity. In particular their reproduction of transient noises is excellent, but they cost more and are less robust than the dynamic microphones. They require a power supply either from the Nagra or from an auxiliary device.

They exist in two types: D.C. polarization and H.F. polarization. The performance and reliability depend, in the long run, more on the competence of the manufacturer than on the chosen system.

Dynamic microphones are reputed to be more robust, but here again, the technological level of the manufacturer seems to be more important than the chosen system. The coloration which certain moving coil microphones give can be used to advantage.

5.6. MAXIMUM GAIN OF THE RECORDING CHAIN OR SENSITIVITY OF THE MICROPHONE INPUTS

In general, the Nagra 4.2 is used to record the "master tape", that is to say, the original from which copies are made. In consequence the recording level should, in certain cases, be lower than normal so that correction can be made during transfer.

In the case where a loud sound is recorded, the noise level is that of the tape itself, the microphone noise level being lower, due to the reduced gain of the recording chain. In these conditions, it may be useful to use a high recording level so that the signal-to-noise ratio is as high as possible. In the case where the sound level is very low, the gain has to be increased to a point where the microphone/preamplifier combination noise level becomes greater than the tape noise level. Under these conditions, no advantage is obtained by recording at a high level.

If the sound to be recorded is at a still lower level, it is better to adjust the gain to the point where the noise from the microphone clearly predominates, and under record the tape. In any case, an increase of gain will not improve the signal-to-noise ratio, whereas the inconveniences of high level recording will subsist: distortion and a reduced safety margin in the case of a sudden increase of sound level.

For these reasons, the sensitivity of the microphone preamplifiers has been limited under normal conditions to 0.2 mV into 200 Ohm to enable a recording to be made at 0 dB.

However, there exist applications where a Nagra must be used to obtain a tape recorded at nominal level to avoid having to adjust the playback level. In these cases, it is probably better to use a higher gain, and there are available increased gain preamplifiers. They are recognized by the figure following the letter X in the code, which indicates the number of decibels by which the gain has been increased.

Nagra 4.2 Preamplifiers

There are three types of microphone preamplifiers:

- a) plug-in preamplifiers which are fixed inside the Nagra 4.2, but are easily interchangeable.
- b) cable preamplifiers which are placed close to the microphone and which feed a plug-in preamplifier designed for condenser microphones.
- c) auxiliary preamplifiers which transform the line input into a third microphone input. These accessories are placed between cable connecting input No 3 and the microphone.

Changing the Plug-in Preamplifiers

These preamplifiers are coupled to the rest of the Nagra by a connector. They are physically held in place by a small screw accessible from the bottom of the recorder.

On turning the Nagra over, that is, placing it on its cover with the battery compartment upwards, the screw for preamplifier No1 can be seen, on the left viewed towards the front panel. Immediately to its right is the screw for preamplifier No 2. Once these screws have been removed, the Nagra can be opened. To do this, unscrew the two fasteners, which fix the tape deck to the box (on the right-hand side of the recorder). Turn them in the direction "Open" until the tape deck disengages itself. Open the Nagra. Remove the preamplifiers, which are immediately behind the meter, simply by pulling.

Plug-in Preamplifiers

"LINEAR STANDARD -200" Code: QPSE-200-X0Y0 and "STANDARD 50" Code: QPSE-50-X0Y0

These preamplifiers are similar to "STANDARD" type but have no filter incorporated. Their frequency response is flat from 30 Hz and the attenuation at 20 Hz is in the region of 2 dB.

"HIGH GAIN STANDARD 200" Code: QPSE-200-X6Y3 and "HIGH GAIN STANDARD 50" Code: QPSE-50-X6Y3

These preamplifiers are similar to the "Standard" type but their gain is double (+6 dB) whereas their attenuation of the low frequencies is slightly greater (3 dB at 50 Hz). The maximum voltage, which they can receive, is 20 mV for 200 Ohm and 10 mV for 50 Ohm.

For the application of these preamplifiers see Section 5.6.

"STATIC 5" Code: QPM-3-5

This preamplifier is designed to receive the signal from the Sennheiser condenser microphones type MKH 105, 405 and 805, Neumann type KM 73, 74, 76 and Schoeps type CMT 40.

At the same time, these microphones are powered from the Nagra. This preamplifier is also designed to operate in conjunction with the cable preamplifier type QPLE, which is placed close to a dynamic microphone. The combination of a dynamic microphone plus a QPLE is electrically equivalent to a microphone MKH 105 etc. It is thus possible, when a Nagra is equipped with "Static 5" to place either a condenser microphone or a dynamic microphone with the QPLE at the end of the microphone cable.

Sensitivity: 2 mV gives 0 dB when the gain is maximum.

Attenuation of low frequencies: adjustable by steps of 3 dB at 50 Hz up to -15 dB by a built-in switch. To operate this switch, it is necessary to open the Nagra.

Maximum Input Voltage: 200 mV.

Distortion and noise level: negligible, compared with those of the microphone.

Temperature range: -55° to +71° C (-67° to + 160° F)

"HIGH LEVEL LINE" Code: QPM-6

This preamplifier transforms the microphone input into a symmetrical floating line input. Input Levels: 0.1 to 24 V R.M.S. Impedance: 10 k Ohm.

(on special order only)

"UNIVERSAL" Code: QPAUT & QPUT

These preamplifiers are designed to accept dynamic 200 Ohm, "Phantom" +12 V or +48 V and "T" powered +10 V condenser microphones.

The QPAUT composed of the preamplifier itself and the microphone power supply, is intended for the Mike input No 1, whereas the QPUT intended for the Mike input No 2 is composed of the preamplifier only, then it cannot be installed alone without the QPAUT.

The QPAUT is externally switchable and the QPUT internally.

Dynamic microphones: Impedance 200 Ohm, frequency response ± 1 dB 80 Hz to 20 kHz, sensitivity 0.2 mV/ μ bar, max. input level producing 1% distortion 50 mV.

Condenser microphone: "Phantom" +12 V or +48 V, "T" powered (+10 V), same frequency response as dynamic ones, sensitivity 1.5 mV/ μ bar, max. input level producing 1% distortion 640 mV.

SPECIAL PLUG-IN PREAMPLIFIERS

Filtering Versions of the QPSE

On special request, it is possible to supply "Standard" preamplifiers having a bass attenuation up to as much as 18 dB at 50 Hz or whose gain is different from the normal value.

Cable Preamplifiers

These preamplifiers are placed near a dynamic microphone. Their power supply is derived from the Nagra and is transmitted along the same cable as the signal. The Nagra should be equipped with a condenser microphone preamplifier (see above).

"CABLE SEN 5-200" Code: QPLE 200 and "CABLE SEN 5-50" Code: QPLE 50 (for 50 ? microphone)

These preamplifiers function in conjunction with the "Static 5" incorporated within the Nagra. The overall results are equivalent to using the "Standard 200 and 50" (see above)

The low frequency attenuation can be adjusted on the incorporated "Static 5" preamplifier.

LOW FREQUENCY ROLL-OFF ATTENUATORS

Why Filter?

Sound engineers have long known that in certain cases an attenuation of the low frequencies can improve the subjective quality of the recording, because:

- A)** Certain microphones (e.g. ribbon) have a frequency response which is very linear, but only if it is sufficiently distant from the sound source. Placed close to the latter (10 cm), the bass frequencies are accentuated. This gives, for example, a very "warm" voice, a phenomenon which certain singers exploit, but which diminishes the intelligibility.
- B)** A sound studio is constructed and treated in such a manner as to reflect, in the same proportion, both low and high frequency sounds. When the sound recording is made in any other room, often the low frequencies are exaggerated, the carpets, curtains and other absorbent surfaces attenuating essentially the high frequencies, whereas the low frequencies are integrally reflected.

In the two cases above, the attenuation of the low frequencies only re-establishes the linearity. In case A) this is clear, but in B) isn't the reality that which we would have heard if the ear was put in place of the microphone? The ear, however, has the facility of selecting the sounds in function of their direction and to subjectively attenuate reflected sounds. When recording in mono (and even in stereo), the microphone captures, without discrimination, all sound which reaches it. Of course, the directional properties of the microphone can be used, but the reflected bass frequencies can be behind the sound source and reach the microphone from exactly the same direction as the useful sound.

In addition to re-establishing the linearity, it has been found that in certain cases, an attenuation of the low frequencies can, although falsifying the reality, improve the subjective result. In particular, it can increase the intelligibility. On the other hand, it is sometimes necessary to have recourse to the attenuation of stage noises. In this case, choose the lesser evil.

When should Filtering be done?

Two solutions are possible, filtering during the recording, or the editing. Method comparison:

- A) In filtering during editing (dubbing) it is easy to start again, if an error is made. On the other hand, if filtering is exaggerated during the recording, the damages are practically irreparable.
- B) In recording linearly, the tape is loaded with signals, which produce a certain modulation noise. These signals will be eliminated at a later stage, but the noise will remain.
- C) Before passing to dubbing, it is necessary to listen to the sound during the "rushes". An unfiltered sound is unpleasant and the producer may judge the result in a bad light.

Conclusion

It is recommended to filter during recording, but possibly slightly less than would seem necessary. There is little chance then of over filtering. The filtering will be finished during editing. In any case, the use of very good headphones is strongly recommended. Headphones, which cut the very low frequencies, should be mistrusted as they play the role of filter and mislead the operator.

METERING

MODULOMETER OR V.U. METER

To measure the level of an electrical signal representing a sound, there are two devices available, the modulometer and the v.u. meter. Both of them are voltmeters whose needle position represents the level. Their construction and use are however different.

MODULOMETER

The modulometer measures the peak value of the signal, irrespective of the form or the level, the modulometer takes into consideration the strongest positive or negative value. It is equipped with a memory, so the signal can be very brief, but the memory ensures that the meter needle advances and stays there for sufficient time for the operator to read it. The essential advantage of the modulometer comes from the fact that the measurement it gives is that which concerns magnetic recording, in other words it is the signal peak, which saturates the tape. The average value of the signal (as much as it concerns the listener) is of no importance to the tape. In particular, while recording noise, the modulometer indication is always exact, no matter how long the duration of the noise.

The scale of a modulometer can be logarithmic, i.e. linear in decibels. In the case of the Nagra, it is possible, for example, to have a range of 70 dB. This allows the exact appreciation of even the lowest sound levels. Nevertheless, it is preferable to limit the range from -30 to +5 dB, to help operators who are used to VU meters, which are not logarithmic.

The operator, on seeing the needle move, knows that his level is greater than -20 dB.

VU METER

In the days of electronic valves (tubes), a modulometer was very costly, and the rudimentary VU meter was often preferred. Later, it was noticed that the VU meter still maintained a certain following and because of habit and standards many radio stations still use them.

A VU meter is a simple rectifier voltmeter whose response time has been standardized. If the signal to be measured is continuous, (e.g. a whistle) the VU meter will indicate a value the same as the modulometer, but if the signal is intermittent (e.g. speech) the VU meter will only indicate an average value, i.e. considerably lower than the instantaneous maximum levels.

For speech, it has been found that this average value is approximately 8 dB lower than the peak value. By increasing the VU meter sensitivity by 8 dB, an indication of 0 VU. is obtained when the peaks reach the maximum value. This works relatively well in practice. For noise, the indication of the VU meter evidently becomes very inexact, and renders it practically useless.

The v.u. meter, however, has certain advantages:

- a) Speech-music balance. If speech and music are recorded with a modulometer so that the peaks of the signal do not exceed the maximum level, subjectively the music appears stronger. This is due to the more continuous character of music signals. Therefore, in a mixed program, it is necessary to modulate the speech more strongly than the music. This can be done by modulating the music correctly and over modulating the speech or by under modulating the music.

It is to be noted that a slight over modulation of speech is not catastrophic: a transmitter is fitted with a limiter, as in the Nagra 4.2, which cuts peaks exceeding the maximum level. The subjective deterioration of the sound quality remains unnoticeable. On the other hand, a strong modulation increases the range of the transmitter and is of direct interest for commercial radio stations.

A VU meter under indicates the speech. In modulating a program to 0 VU the speech will be over modulated and the music under modulated. From this point of view, the VU meter seems to be of more interest for mixed transmissions whose quality is not of great importance, but whose range should be as large as possible.

On the other hand, for a transmission, which is wholly musical, the range of the transmitter tends not to be used to its full advantage with a VU meter.

- b) The VU meter has a scale, which is not logarithmic. For the needle to move, it is necessary that the level exceed -20 dB. This causes the operator to compress greater than is necessary, that is to increase the level of the pianissimo. This reduces the quality of a musical transmission while increasing the range. On the other hand, it is favorable if the listener is in a noisy ambience, such a car or a cinema hall.

CONCLUSIONS

The problem to be resolved is to know if the Nagra should be fitted with a modulometer or a VU meter. The modulometer allows the use of the full dynamic range of the recorder whether for noise, speech or music. The balance of the sound can, in any case, be achieved during the transfer.

If a mixed transmission of words and music should be recorded on the Nagra and transmitted as recorded, the operator can simply modulate the speech to +2 dB or even +4 dB, and the limiter takes charge of any peaks, and the music to 0 or even -2dB.

The VU meter is only justified for radio corporations where it is standardized because of operational habit.

REMARKS ON THE CALIBRATION

The term "nominal recording level" is that which is considered as the maximum level by habit. The word "nominal" has been used and not "maximum" as, in the case of the Nagra 4.2, this level can be exceeded by 4 dB due to a special recording process.

The indication of 0 dB on the modulometer corresponds to the nominal level. It is not measurable with a VU meter for the needle will exceed full scale deflection, the sensitivity of the VU meter having been increased by 10 dB to compensate for the slowness of its response.

Thus a signal of -10 dB, that is 10 dB below nominal level, produces on a VU meter an indication of 0 VU whereas on the modulometer an indication of -10 dB is obtained. The calibration generator of the Nagra 4.2 gives a signal of about -10 dB. This corresponds to 0 VU on a VU meter.

9.0 SPECIFICATIONS

DIMENSIONS AND WEIGHT

Dimensions of the case with the lid closed, without knobs, feet, carrying handle, or carrying handle mountings:

L X W X H

12.6 x 8.8 x 4.4 "
(320 x 223 x 111 mm)

Overall dimensions without handle

L X W X H

13.2 x 9.6 x 4.5 "
(335 x 243 x 114 mm)

Weight, without batteries or tape 13 lb (5.89 kg)

Weight with ordinary batteries, 5" reels of tape 15lb (6.8 kg)

POWER SUPPLY

(Supply voltage, positive ground) -10.5 to -30 V DC.
from -10.5 to -12 V some performances are slightly reduced

Current consumption

in Test	95 mA
in Line Playback	180 mA
in Loudspeaker Playback, average level	250 mA
in Record	240 mA
in Fast Rewind	280 mA

Type of batteries used (12 cells)

CEI standard	R 20
ASA standard	D and L 90

Approximate length of battery life if used 2 hours every 24 hours

Eveready 950 batteries	18 hours
Eveready E95 batteries	32 hours

Continuous use with Eveready 950 batteries 8 ½ hours
Recording time at 7½ ips (19 cm/s) with 35µm tape 45 min.

Maximum reel diameter with lid closed 5" (127 mm)	
Recording time under the same conditions	22 min.
Rewind time with 5" reel (19 cm/s) with 35µm tape	20 min.

TAPE TRANSPORT

Switchable nominal speeds

15 ips	38.10	cm/s
7½ ips	19.05	cm/s
3¾ ips	9.525	cm/s

Stability of the nominal speed with respect to the temperature (within the specified range), the position of the recorder, the distribution of the tape between the reels, and the supply voltage $\pm 0.1\%$

WOW AND FLUTTER

Weighted peak-to-peak value, in accordance with
DIN 45 507/ANSI 4372

at 15 ips	38.10 cm/s	$\pm 0.05\%$
at 7½ is	19.05 cm/s	$\pm 0.07\%$
at 3¾ ips	9.525 cm/s	$\pm 0.12\%$

AMPLIFIER CHAIN

NAGRA 4.2 with QPSE-200-XOYO preamplifiers

Overall frequency response, 200 Ohm microphone
input, line output without load from 50 Hz to 20 kHz ± 1 dB

Total distortion at 0 dB, 10 mV input, output load 600 Ohm $< 0.3\%$
Input voltage for 1% distortion at 1 kHz 65mV

Noise level of the microphone preamplifier, ASA A
Weighted, 1 mW reference -126 dBm

MAGNETIC TAPE

Width 6,25 mm
Mixer direct input, impedance 9 k Ohm,
voltage for recording at 0 dB 560mV
Pilot input, impedance 5 k Ohm,
admissible voltage 0,5 to 25 V

AUTOMATIC LEVEL CONTROL

Input voltage for recording at nominal level 0.65 to 22 mV
Average distortion at 1 kHz within this range, 3rd harmonic 0,3%
Frequency response from 55 Hz to 16 kHz ± 1.7 dB

FILTERS

LFA 1 (low frequency attenuation)	Attenuation
LFA 2	4 dB at 50 Hz
HP 1 (high-pass)	8 dB at 50 Hz
HP 2	10 dB at 50 Hz
HP 1 + LFA 1 (combination)	20 dB at 50 Hz
	14 dB at 50 Hz

REFERENCE GENERATOR

1.1 kHz sine wave signal with 10 kHz component

0 VU level= -8 dB \pm 0.1 dB

OUTPUTS

Line output voltage on 600 Ohm for 0 dB on the modulometer 4.4 V

Line output impedance	at 30 Hz	90 Ohm
	at 50 Hz	42 Ohm
	at 1 kHz	18 Ohm
	at 15 kHz	24 Ohm

Maximum output voltage on 600 Ohm,

for 1% distortion	at 1 kHz	10,5 V
	at 5 kHz	10,5 V
	at 30 Hz	7,0 V

Headphones output voltage on 50 Ohm, adjustable from 20 to 500 mV

Output voltage at MIXER connector, on 100 k Ohm, for 0 dB on the modulometer 560 mV

Output voltage of the pilot signal

with QSLI synchronizer	1 V
without synchronizer	350 mV

BUILT-IN LOUDSPEAKER

Power output of the amplifier 1 W

OPERATING CONDITIONS

Temperature

with manganese batteries	- 4 to + 160 degrees F
	-20 to + 72 degrees C
with external power	-67 to + 160 degrees F
	-55 to + 71 degrees C

The recorder operates correctly in any position.

MODULOMETER

Integration time for - 2 dB	7.5 ms
Usable scale	-30 to +5 dB
Frequency response	
from 40 Hz to 20 kHz	±0,5 dB

RECORDING AND PLAYBACK CHAIN

Nominal recording level	0 dB= 320 nWb/m
Maximum peak level (M.P.L.)	+ 4 dB

Magnetic tape used for Calibration :

CCIR	LN	PEM 468
	STD	PER 368
NAB	LN	3M 808
	STD	3M 806

Erasing efficiency

CCIR	84 dB
NAB	88 dB

Frequency response, recording at 20 dB below M.P.L.

15 ips (38 cm/s) CCIR and NAB	30 Hz to 20 kHz	±1.5 dB
7½ ips (19 cm/s) CCIR and NAB	30 Hz to 15 kHz	±1.5 dB
3¾ ips (9,5 cm/s) CCIR and NAB	30 Hz to 8 kHz	±2.0 dB

Distortion at M.P.L. :

CCIR	3rd harmonic	0,4%
	2nd harmonic	0,3%
NAB	3rd harmonic	1,0%
	2nd harmonic	0,4%

Signal-to-noise ratio of the playback chain only, with motor running and leader tape, ASA A weighted, M.P.L 83 dB

Recording-playback signal-to-noise ratio at M.P.L at 7½ ips

		Linear	ASA A Weighted
LN	NAB	64 dB	73 dB
	CCIR	62 dB	72 dB
STD	NAB	64 dB	70 dB
	CCIR	62 dB	68 dB

INPUTS

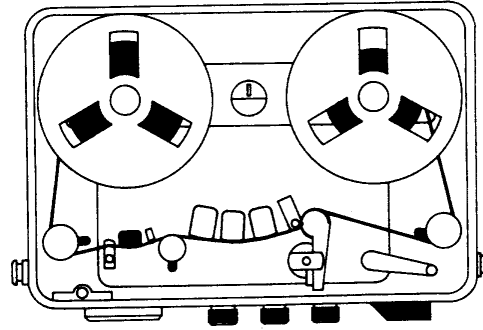
NAGRA 4.2
with QPSE-200-X0Y0 preamplifiers

Microphone input 1,200 Ohm	0.2 to 43 m V
Microphone input 2,200 Ohm	0.2 to 43 m V
Unbalanced line input, impedance 100 k Ohm admissible voltage	0.37 to 120 V
Unbalanced line input at accessory connector, admissible current	3.7 to 1,200 μ A
Mixer direct input, impedance 9 k Ohm	560 mV
Pilot input, impedance 5 k Ohm	0.5 to 25 V

NAGRA 4.2

CONFIGURATOR

Synchronization and Accessories



External electro accessories

QCA	14102	Start-stop cable for remote control
QGB	14001	10 1/2" reel adapter
QGBN	14006	NAB type reel holder
QGBA	14007	AEG type reel holder
TPBC	18907	Cine-type reel holder
DSM	14700	Field monitor and amplifier
IACC	17910	Removable power pack for DSM
QCAS	98001	Spare mains cable with Swiss-type plug
QCAW	98003	Spare mains cable without mains plug

Synchronization

SLO	13400	Automatic speed synchronizer
SLQ-3	13429	Crystal pilot generator for SLO
QCL	14450	Adapter for connecting SLO to Nagra 4.2
QSV-2	14600	Manual speed variator

Mechanical accessories

QRAC	06260	Tape cleaning blade
QLEN	14655	Tape driven metric counter
QTIM	14650	Tape driven timer
QSET-2	14130	Lid for the use of 7" reels
MAG-220V 90801		Electronically-controlled degausser 220-240V
MAG-110V 90802		Electronically-controlled degausser 110-117V

Carrying cases

QTS	99027	Standard carrying case with pocket
QTS-C	99025	Carrying case cover for QSET
QHC-2	14127	Spare carrying strap for Nagra 4.2
QHP	14120	Carrying handle
QHCP-2	14123	Special strap for carrying a recorder equipped with a QHP handle

Internal electro accessories

QGX-3	04698	Crystal pilot generator
QSLI	04750	Synchronizer
QFM-50	04701	Frequency meter for 50 Hz pilot signal
QFM-60	04702	Frequency meter for 60 Hz pilot signal

Camera cables

QCE	14107	For connecting Nagra 4.2 to an Eclair NPR camera
QCX	14108	For connecting Nagra 4.2 to an Arri ST/BL or a Bolex 16 PRO camera

Headphones

DT 48	96239	Beyer DT 48 headphones
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96239
DT 48

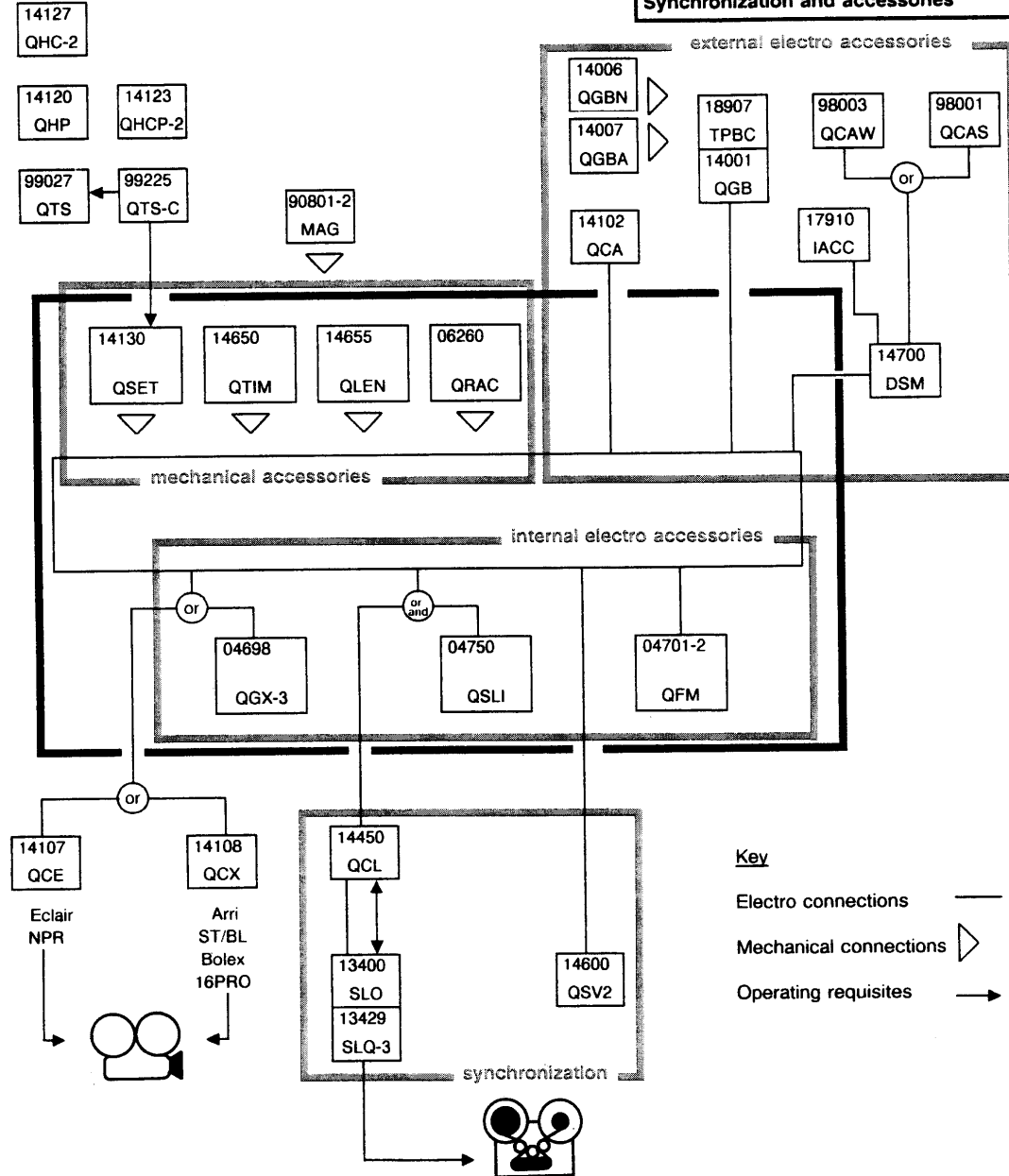
NAGRA

CH-1033 Cheseaux / Lausanne

NAGRA 4.2

Configurator

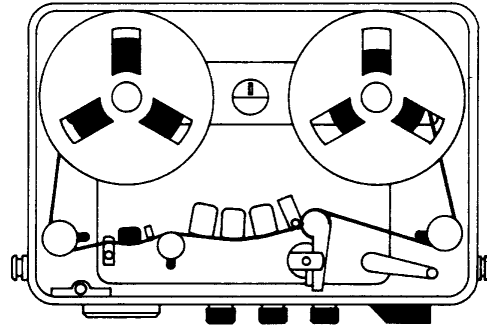
Synchronization and accessories



NAGRA 4.2

CONFIGURATOR

Input/Power supply



Input

BMT-3	14500	Mixer with 3 balanced microphones inputs and 1 line input
BS-2	13300	External preamplifier for dynamic microphone
QPSE-200	04734	Standard preamplifier for 200 Ω dynamic microphone
QPSE-050	04735	Standard preamplifier for 50 Ω dynamic microphone
QPSE-202	04743	High gain preamplifier for 200 Ω ribbon microphone
QPSE-052	04744	High gain preamplifier for 50 Ω ribbon microphone
QPM 3-5	04747	Preamplifier for condenser microphone
QPLE-200	14851	Standard advanced cable preamplifier for 200 Ω dynamic microphone
QPLE-50	14852	Standard advanced cable preamplifier for 50 Ω dynamic microphone
QPAU-T	04785	Switchable universal microphone preamplifier for input 1
QPU-T	04786	Switchable universal preamplifier for input 2 only

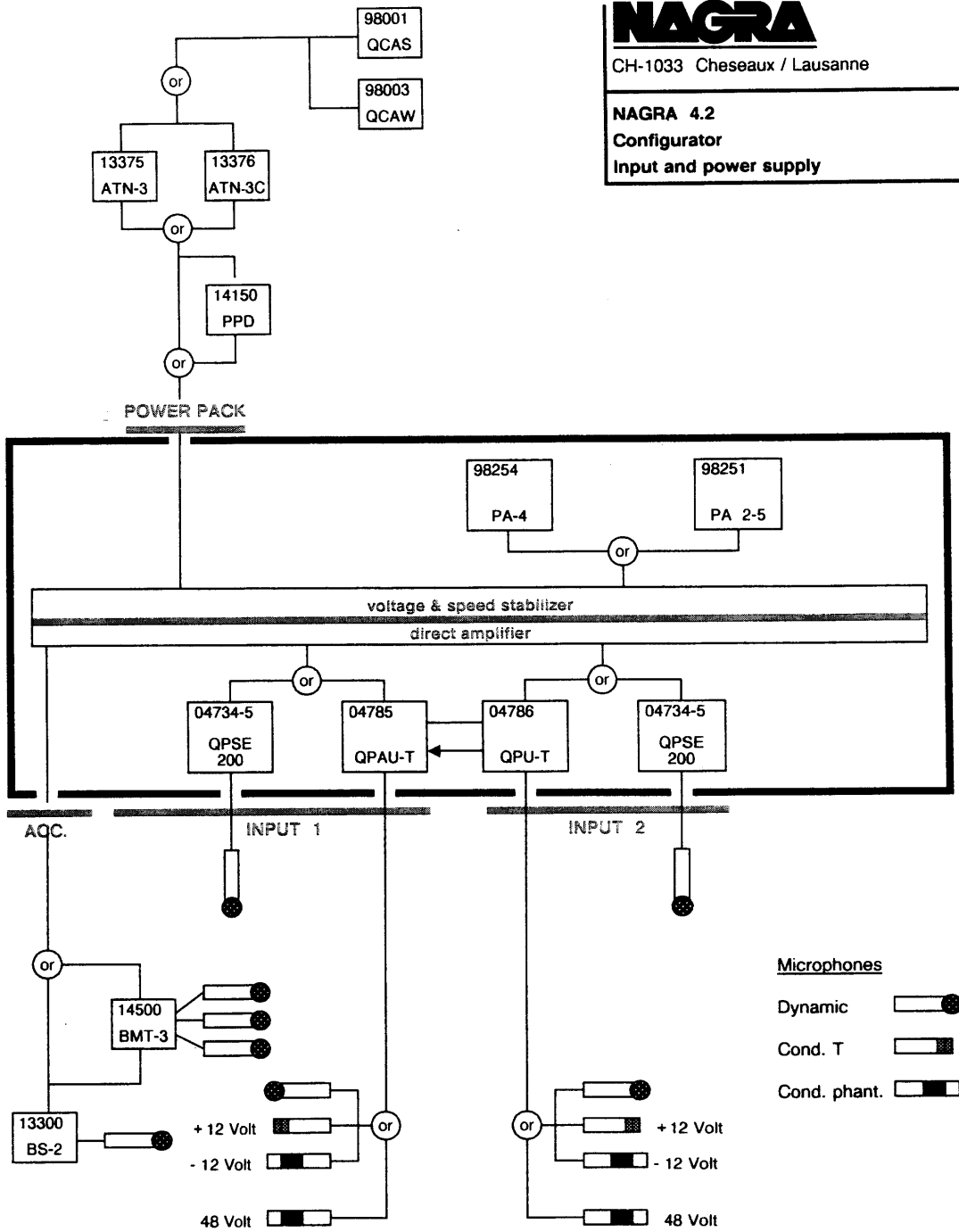
Power supply

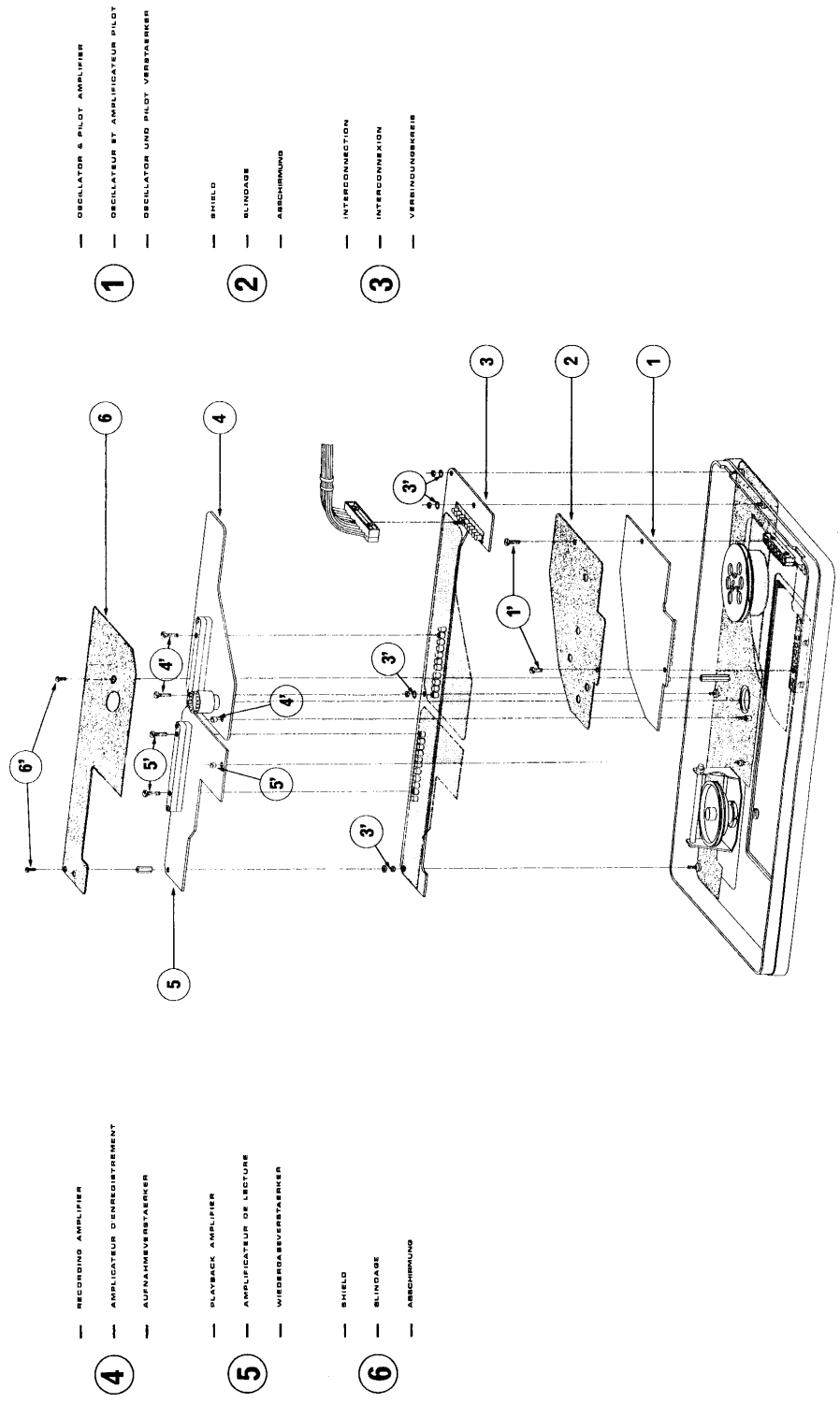
ATN-3	14375	Mains power supply
ATN-3C	14376	Mains power supply and charger
QCAS	98001	Spare mains cable with Swiss-type plug
QCAW	98003	Spare mains cable without mains plug
PPD	14150	Multiple connection box
PA 2.5	98251	Set of 15 rechargeable cells with extension 2.5 Ah
PA-4	98254	Set of 12 4 Ah rechargeable cells

NAGRA

CH-1033 Cheseaux / Lausanne

NAGRA 4.2
Configurator
Input and power supply





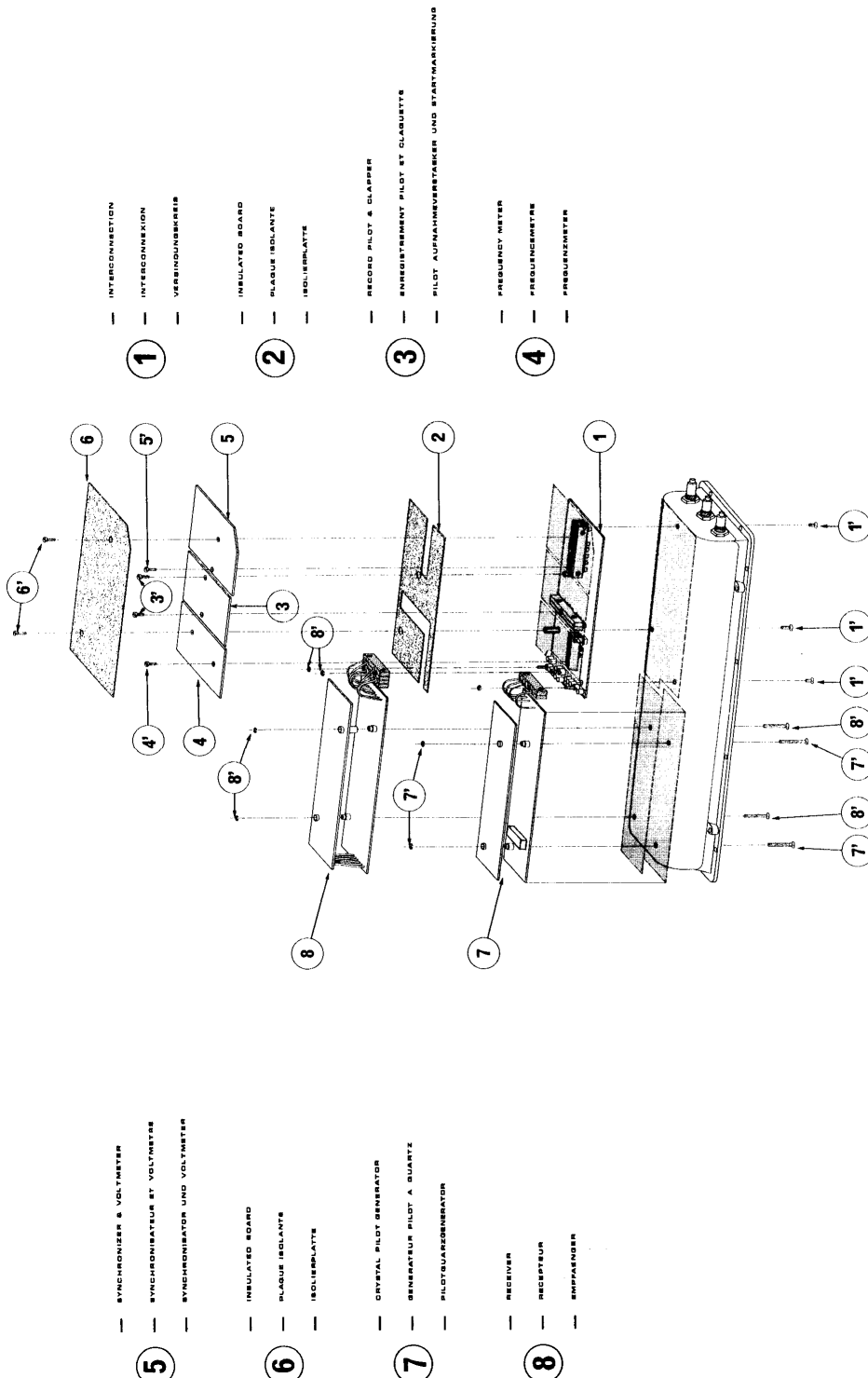
- RECORDING AMPLIFIER
- AMPLIFICATEUR D'ENREGISTREMENT
- AUFNAHMEVERSTÄRKER
- PLAYBACK AMPLIFIER
- AMPLIFICATEUR DE LECTURE
- WIEDERGABEVERSTÄRKER
- SHIELD
- BLINDAGE
- ABSCHIRMUNG

- OSCILLATOR & PILOT AMPLIFIER
- OSCILLATEUR ET AMPLIFICATEUR PILOT
- OSCILLATOR UND PILOT VERSTÄRKER
- SHIELD
- BLINDAGE
- ABSCHIRMUNG
- INTERCONNECTION
- INTERCONNEXION
- VERBINDUNGSKABEL

CIRCUIT MOUNTING UNDER THE TAPE DECK

MONTAGE DES CIRCUITS SOUS LA PLATINE

AUFBAU DER KREISE UNTER DECKPLATTE



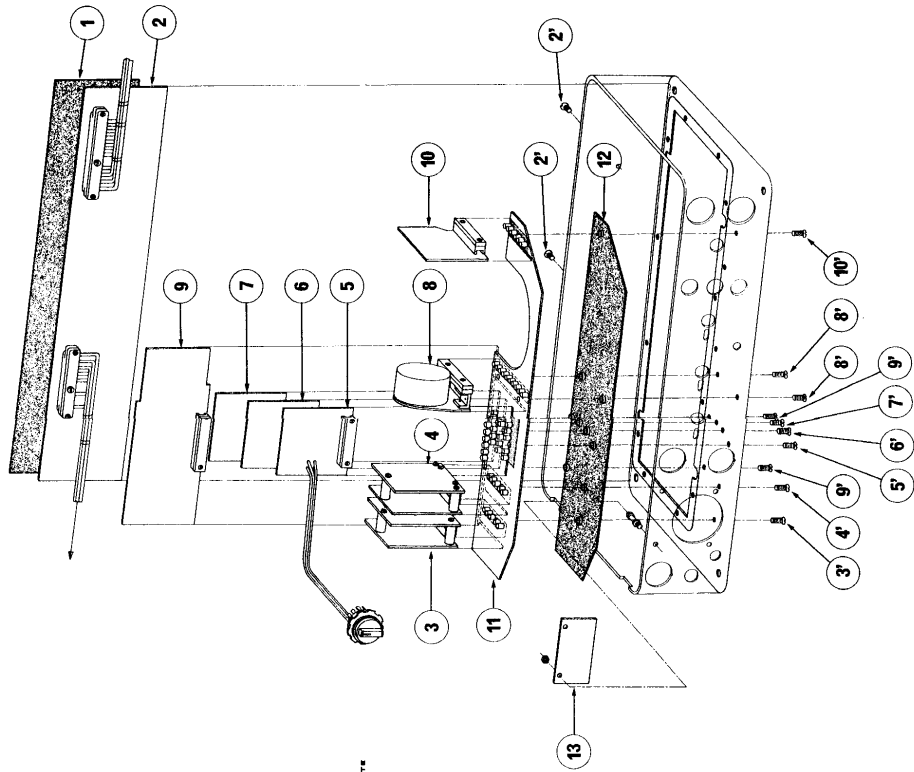
— SYNCHRONIZER & VOLTMETER
 — SYNCHRONISATEUR ET VOLTMÈTRE
 — SYNCHRONISATOR UND VOLTMETER
 — INSULATED BOARD
 — PLAQUE ISOLANTE
 — ISOLIERPLATTE
 — CRYSTAL PILOT GENERATOR
 — GÉNÉRATEUR PILOT À QUARTZ
 — PILOT/AUGENLEUCHT
 — RECEIVER
 — RÉCEPTEUR
 — EMPFÄNGER

— INTERCONNECTION
 — INTERCONNEXION
 — VERBINDERREIHE
 — INSULATED BOARD
 — PLAQUE ISOLANTE
 — ISOLIERPLATTE
 — RECORD PILOT & CLAPPER
 — ENREGISTREMENT PILOT ET CLAPETTE
 — PILOT AUFNAHMEVERSTÄRKER UND STARTMARKIERUNG
 — FREQUENCY METER
 — FRÉQUENCEMÈTRE
 — FREQUENZMETER

AUFBAU DER KREISE AUF DEM BATTERIEBOHRHAUSE

MONTAGE DES CIRCUITS SUR LE BOÎTIER À PILES

CIRCUIT MOUNTING ON THE BATTERY BOX



- INSULATED BOARD
- PLaque ISOLANTE
- ISOLIERPLATE
- VOLTAGE & SPEED STABILIZER
- STABILISATEUR DE TENSION ET VITESSE
- BESCHWINDIGKEITS UND SPANNUNGSSTABILISIERER
- MICROPHONE PREAMPLIFIER N°1
- PREAMPLIFICATEUR MICRO N°1
- MIKROPHONVORVERSTÄRKER N°1
- MICROPHONE PREAMPLIFIER N°2
- PREAMPLIFICATEUR MICRO N°2
- MIKROPHONVORVERSTÄRKER N°2
- DIRECT AMPLIFIER
- AMPLI DU DIRECT
- "DIRECT"-VERSTÄRKER
- MODULOMETER OR VU-METER
- MODULOMÈTRE DU VU-MÈTRE
- MODULOMETER ODER VU-METER

- LINE AMPLIFIER
- AMPLIFICATEUR LIGNE
- LINIENVERSTÄRKER
- LINE TRANSFORMER
- TRANSFORMATEUR LIGNE
- LINIENTRANSFORMATOR
- AUTOMATIC LEVEL CONTROL
- REGULATEUR AUTOMATIQUE DE SENSIBILITE
- AUTOMATISCHE RESELEKTYVLE
- LOUD SPEAKER AMPLIFIER
- AMPLIFICATEUR HAUFPARLEUR
- LAUTSPRECHERVERSTÄRKER
- INTERCONNECTION
- INTERCONNEXION
- VERBINDUNGSLEISTE
- INSULATED BOARD
- PLaque ISOLANTE
- ISOLIERPLATE
- REF. RES. GENERATOR
- GENERATEUR DE REFERENCE
- REF. GENERATOR

— AUFBAU DER BESCHWINDIGKEITS

— MONTAGE DES CIRCUITS DU BOTTRE

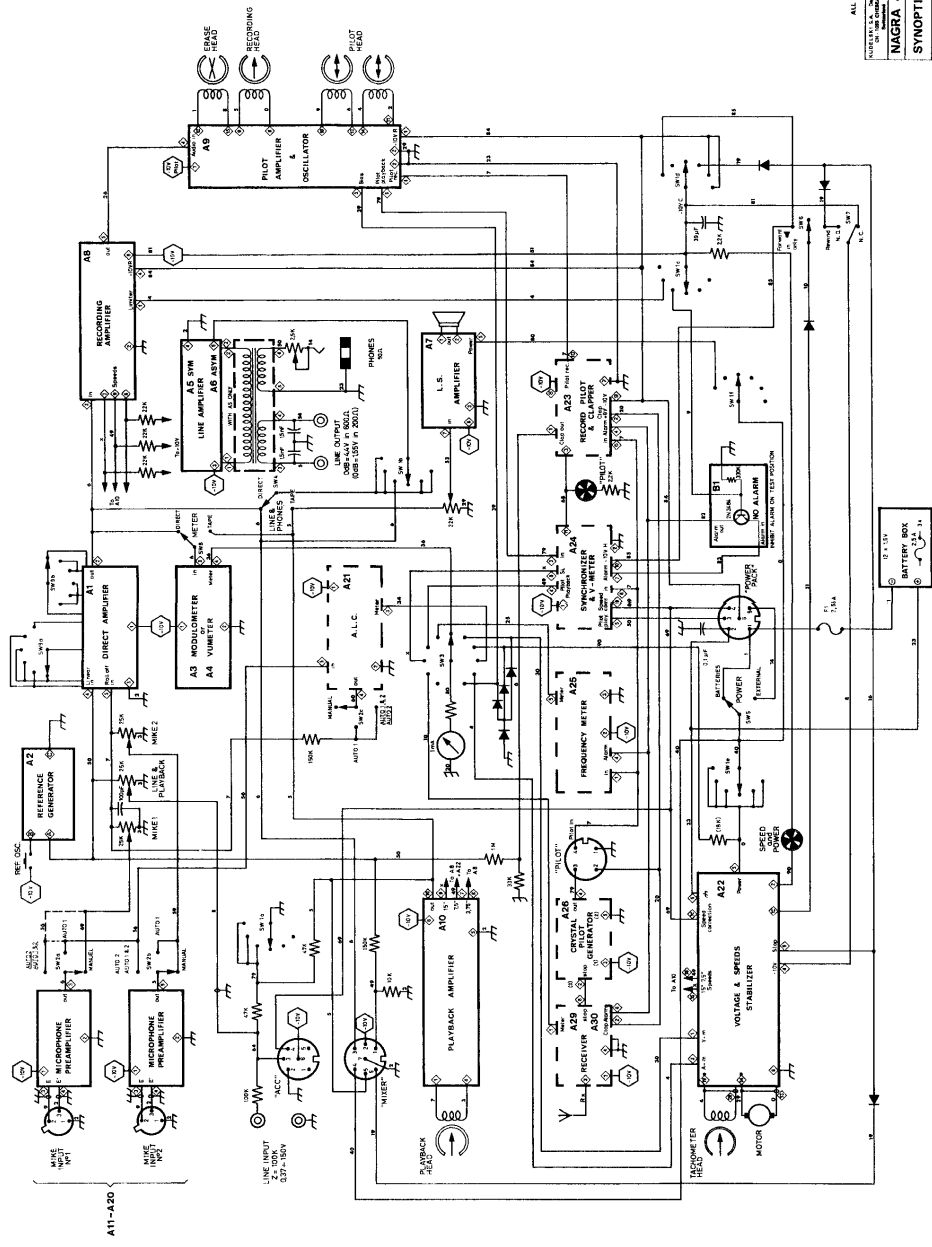
— CIRCUIT MOUNTING IN THE BOX

- CABLE COLOR CODE
- 1. RED
 - 2. BLACK
 - 3. GREEN
 - 4. YELLOW
 - 5. BLUE
 - 6. BROWN
 - 7. PURPLE
 - 8. WHITE
 - 9. BLACK
 - 0. PINK

1.5K 1/2W 5%
 1.5K 1/4W 5%
 1.5K 1/8W 5%

RECORD
 REVERSE
 STOP

PILOT LAMP
 PILOT LAMP
 SYNC*
 BATT. RESERVE
 BATT. CELL
 COMPRESSION



ALL CONNECTIONS VIEWED FROM THE OUTSIDE
 NAGRA 4.2 09.04.0010010.1 TS
 SYNOPSIS DIAGRAM